

Patterns of Surgical Antibiotic Prophylaxis in Different Hospitals: Compliance with International and National Guidelines

Dr. Dhivyaprasath P¹, Christy Immaculate. J², Abitha. P³, Anupama Sankar⁴,
Abinaya. S⁵

^{1,2,3,4,5} Department of Pharmacy Practice, Swamy Vivekanandha College of Pharmacy, Namakkal, Tamil Nadu.

ABSTRACT

Surgical site infections (SSIs) remain a significant cause of postoperative morbidity, prolonged hospitalization, increased healthcare costs, and preventable complications worldwide. Surgical antibiotic prophylaxis (SAP) is a well-established, evidence-based strategy to reduce the incidence of SSIs when appropriately indicated, correctly timed, and judiciously administered. International authorities such as the World Health Organization (WHO), American Society of Health-System Pharmacists (ASHP), Infectious Diseases Society of America (IDSA), and national bodies like the Indian Council of Medical Research (ICMR) have issued comprehensive guidelines emphasizing rational antibiotic selection, administration within 60 minutes prior to incision, appropriate dosing, and restriction of prophylaxis duration to less than 24 hours. Despite the availability of these guidelines, adherence in clinical practice remains inconsistent, particularly in low- and middle-income countries, including India. Common deviations include the unnecessary use of broad-spectrum antibiotics, improper timing of administration, and prolonged postoperative prophylaxis without clinical justification. These practices contribute to escalating antimicrobial resistance, increased healthcare expenditure, and avoidable adverse drug events. Evidence consistently demonstrates that hospitals adhering to standardized SAP protocols achieve lower SSI rates and improved surgical outcomes. Pharmacists play a pivotal role within antimicrobial stewardship programs by optimizing antibiotic selection, dosing, monitoring, education, and audit-and-feedback mechanisms. Emerging research highlights a paradigm shift toward precision-based prophylaxis through rapid molecular diagnostics, personalized antibiograms, artificial intelligence-driven risk stratification, and strict minimization of prophylaxis duration. In conclusion, effective implementation of guideline-based SAP, supported by multidisciplinary stewardship initiatives and advanced data-driven tools, is essential to improve patient outcomes while preserving antimicrobial efficacy in the face of rising global resistance.

INTRODUCTION

Postoperative infections occurring at or near the surgical incision remain a major challenge in modern surgical practice. These infections not only delay patient recovery but also increase the duration of hospitalization, healthcare expenditure, and the risk of serious complications. One of the most effective preventive measures against such infections is the judicious use of antibiotics before surgical procedures, which helps reduce microbial contamination during surgery when applied correctly¹. Despite the fact that reputable organizations have released explicit guidelines for surgical antibiotic prophylaxis, hospital compliance varies greatly. This heterogeneity is frequently caused by regional bacterial resistance trends, hospital drug formularies, locally devised protocols, and variations in surgeon prescribing practices^{2,3}. Even in operations when the risk of infection is minimal, antibiotics with a broader antimicrobial spectrum are frequently administered in place of advised narrow-spectrum medicines in a number of healthcare settings⁴. Inappropriate antibiotic selection, delivery outside of the ideal time window, and prolonged postoperative usage without clinical justification are examples of common departures from suggested practices, according to evidence from numerous research⁵. These behaviors increase the financial burden on healthcare systems, hasten the emergence of antimicrobial resistance, and expose patients to needless medication-related risks⁶. Hospitals that rigorously adhere to standardized prophylactic procedures, on the other hand, report better surgical outcomes and reduced infection rates⁷.

Concept Of Surgical Antibiotic Prophylaxis

The preventative use of antibiotics to lower the risk of surgical site infections by minimizing bacterial contamination during surgery is known as surgical antibiotic prophylaxis. In order to guarantee sufficient drug levels in tissues at the time of possible germ exposure, these antibiotics are administered prior to the surgical incision¹. Prophylaxis is only

effective if the right antibiotics are chosen, taken at the right time, dosed appropriately, and used for brief periods of time. Prolonged postoperative use of narrow-spectrum antibiotics is usually not necessary because it does not offer any additional benefits and could lead to an increase in antimicrobial resistance^{2,8}.

International Guidelines On Antibiotic Prophylaxis

International guidelines on antibiotic prophylaxis have been developed to promote standardized, evidence-based practices for preventing infections associated with surgical and selected invasive procedures. The primary objective of these guidelines is to reduce the incidence of surgical site infections and other procedure-related infections while avoiding unnecessary antibiotic exposure. Inappropriate or excessive use of prophylactic antibiotics is known to contribute to antimicrobial resistance, adverse drug reactions, and increased healthcare costs. Therefore, international organizations emphasize rational antibiotic use, guided by scientific evidence and global public health priorities⁹. One of the most authoritative international frameworks for surgical antibiotic prophylaxis has been jointly issued by the American Society of Health-System Pharmacists (ASHP), the Infectious Diseases Society of America (IDSA), the Society for Healthcare Epidemiology of America (SHEA), and the Surgical Infection Society (SIS). These guidelines recommend antibiotic prophylaxis only for surgical procedures where clear evidence demonstrates a reduction in postoperative infection risk, particularly clean-contaminated, contaminated, and selected clean surgeries involving prosthetic implants⁷.

A central principle emphasized in these guidelines is the timing of administration, with prophylactic antibiotics ideally given within 60 minutes prior to surgical incision to ensure optimal tissue drug concentrations at the time of potential bacterial contamination. For antibiotics requiring prolonged infusion, such as vancomycin and fluoroquinolones, administration may begin up to 120 minutes before incision. The guidelines strongly favor the use of narrow-spectrum antibiotics that target the most likely pathogens, primarily skin flora. First-generation cephalosporins, especially cefazolin, are recommended for most procedures due to their proven efficacy, safety, and cost-effectiveness. Importantly, prolonged postoperative antibiotic use is discouraged, with recommendations to discontinue prophylaxis within 24 hours after surgery, as extended use has not been shown to provide additional benefit and contributes to antimicrobial resistance⁸.

World Health Organization (Who) Recommendations

The World Health Organization (WHO) has issued global guidelines for the prevention of surgical site infections, incorporating antibiotic prophylaxis as a key preventive measure within a broader infection control framework. WHO recommendations are consistent with other international guidelines but place particular emphasis on global applicability, especially in low- and middle-income countries where resource constraints and high infection burdens coexist.

WHO advises that prophylactic antibiotics should be administered before surgical incision, rather than after wound closure, and strongly recommends against routine postoperative continuation of antibiotics in uncomplicated surgeries. Additionally, WHO highlights that antibiotic prophylaxis should not be used in isolation but must be combined with non-pharmacological measures such as proper surgical hand preparation, aseptic technique, and appropriate skin antisepsis. The organization also emphasizes tailoring prophylactic regimens based on local microbial epidemiology and resistance patterns, reinforcing the principles of antimicrobial stewardship⁹.

International Guidelines On Infective Endocarditis Prophylaxis

International recommendations for antibiotic prophylaxis in infective endocarditis have evolved significantly over recent decades. Earlier practices favored widespread prophylaxis; however, contemporary international guidelines now endorse a highly selective approach. As discussed by Shanson, this shift reflects growing evidence that routine prophylaxis provides minimal benefit in low-risk individuals while contributing to antimicrobial resistance and drug-related adverse effects.

Current international consensus recommends antibiotic prophylaxis only for patients at the highest risk of adverse outcomes, such as those with prosthetic heart valves, a previous history of infective endocarditis, or certain complex congenital heart diseases. Prophylaxis is mainly advised for invasive dental procedures involving manipulation of gingival tissue, while routine prophylaxis for gastrointestinal or genitourinary procedures is no longer recommended¹⁰.

Adherence To International Guidelines And Implementation Challenges

Despite the availability of clear and well-established international guidelines, adherence in clinical practice remains inconsistent. Multiple international reviews and hospital-based studies have reported deviations related to inappropriate antibiotic selection, incorrect timing of administration, and unnecessary extension of prophylaxis beyond recommended durations. A systematic review by Gouvea and colleagues demonstrated that overall compliance with all guideline parameters is often low, even in tertiary-care settings³. Similarly, studies from different regions, including Southeast Asia, have shown that although prophylactic antibiotics are frequently prescribed, full adherence to international recommendations is uncommon¹¹.

Barriers to adherence include lack of awareness, reliance on outdated prescribing habits, fear of postoperative infections, and absence of institutional antimicrobial stewardship programs. These findings underscore the need for continuous education, standardized hospital protocols, regular audit-and-feedback systems, and multidisciplinary collaboration to ensure effective implementation of international guidelines¹².

National Guidelines For Surgical Antibiotic Prophylaxis

ICMR Guidelines on Antibiotic Prophylaxis

The Indian Council of Medical Research (ICMR), in collaboration with the National Centre for Disease Control (NCDC), has issued national recommendations on antibiotic prophylaxis as part of the National Treatment Guidelines for Antimicrobial Use in Infectious Diseases. These guidelines aim to ensure rational, evidence-based use of antibiotics for the prevention of surgical and procedure-related infections while minimizing unnecessary exposure that contributes to antimicrobial resistance and adverse drug reactions¹³. According to the ICMR guidelines, antibiotic prophylaxis should be used selectively and only for surgical procedures where evidence demonstrates a clear reduction in postoperative infection rates. Prophylaxis is primarily indicated for clean-contaminated surgeries and selected clean surgeries involving prosthetic materials or implants. The guidelines explicitly state that prophylactic antibiotics should not be administered routinely for all surgical procedures and should never substitute for essential infection prevention measures such as aseptic technique, sterilization, and proper surgical practices¹⁴.

The timing of antibiotic administration is emphasized as a critical determinant of prophylactic effectiveness. The ICMR recommends that prophylactic antibiotics be administered within 60 minutes before surgical incision to ensure adequate serum and tissue drug concentrations at the time of potential bacterial contamination. For antibiotics requiring prolonged infusion, such as vancomycin, administration should begin earlier so that infusion is completed prior to incision. Administration after surgical incision is discouraged, as delayed dosing significantly reduces the effectiveness of prophylaxis¹⁵. With regard to antibiotic selection, the ICMR guidelines advocate the use of narrow-spectrum antibiotics that are effective against the most likely pathogens associated with the specific surgical procedure. Selection should be based on the type of surgery, wound classification, and expected microbial flora. The routine use of broad-spectrum antibiotics for prophylaxis is strongly discouraged, as it increases the risk of antimicrobial resistance without providing additional clinical benefit. The guidelines recommend using local hospital antibiogram data to guide antibiotic selection and ensure relevance to regional resistance patterns¹⁶⁻²⁰.

The dose of prophylactic antibiotics should be sufficient to maintain effective tissue concentrations throughout the surgical procedure. The guidelines recommend appropriate weight-based dosing and advise intraoperative redosing when the duration of surgery exceeds two half-lives of the antibiotic used or when there is excessive blood loss. These recommendations aim to maintain adequate antimicrobial coverage during periods of highest infection risk²¹.

A major principle of the ICMR guidelines is the restriction of prophylaxis duration. In most surgical procedures, antibiotic prophylaxis should be limited to a single preoperative dose or discontinued within 24 hours after surgery. The guidelines clearly state that prolonged postoperative antibiotic administration does not reduce surgical site infection rates and is associated with increased risks of antimicrobial resistance, *Clostridioides difficile* infection, and adverse drug reactions. Routine postoperative continuation of antibiotics in the absence of clinical infection is therefore not recommended²².

The ICMR guidelines also emphasize the importance of documentation and protocol-based practice. Healthcare institutions are encouraged to develop procedure-specific antibiotic prophylaxis protocols aligned with national recommendations. Proper documentation of the indication, antibiotic chosen, dose, timing, and duration is recommended to facilitate monitoring, audit, and quality improvement initiatives. Integration of antibiotic prophylaxis practices into institutional antimicrobial stewardship programs is strongly advocated. Overall the ICMR guidelines on antibiotic prophylaxis provide a structured, evidence-based framework for preventing surgical and procedure-related infections while supporting antimicrobial stewardship in India. By emphasizing appropriate indication, correct timing, rational antibiotic selection, adequate dosing, and minimal duration, these guidelines play a critical role in improving patient outcomes and addressing the growing challenge of antimicrobial resistance²¹.

Role Of Pharmacists In Antimicrobial Stewardship: Ashp/Sidp Joint Statement

The American Society of Health-System Pharmacists (ASHP) and the Society of Infectious Diseases Pharmacists (SIDP) jointly emphasize the critical role of pharmacists in antimicrobial stewardship programs (ASPs) through their 2023 position statement. This guideline recognizes pharmacists as essential members of multidisciplinary stewardship teams and highlights their responsibility in optimizing antimicrobial use to improve patient outcomes, reduce antimicrobial resistance, and ensure cost-effective therapy²².

According to the ASHP/SIDP statement, pharmacists play a central role in the design, implementation, and sustainability of antimicrobial stewardship programs across healthcare settings. Their expertise in pharmacotherapy, pharmacokinetics, and pharmacodynamics enables them to ensure appropriate antimicrobial selection, dosing, route of administration, and duration of therapy. The guideline underscores that pharmacist-led stewardship interventions are

associated with improved antimicrobial appropriateness, reduced adverse drug events, and enhanced compliance with evidence-based guidelines. The statement highlights the pharmacist's responsibility in prospective audit and feedback, where antimicrobial prescriptions are reviewed and recommendations are provided to prescribers to optimize therapy. Pharmacists are also involved in formulary management, including restriction of certain antimicrobials, development of institutional treatment guidelines, and implementation of pre-authorization strategies. These activities are considered essential for controlling inappropriate antimicrobial use and limiting the emergence of resistant organisms. Another key area outlined in the guideline is the pharmacist's role in dose optimization and therapeutic drug monitoring (TDM). Pharmacists ensure appropriate dosing based on patient-specific factors such as renal and hepatic function, age, body weight, and severity of infection. The guideline particularly emphasizes pharmacist-led monitoring of antimicrobials with narrow therapeutic indices, such as vancomycin and aminoglycosides, to maximize efficacy while minimizing toxicity²³.

The ASHP/SIDP joint statement also recognizes the pharmacist's contribution to education and training. Pharmacists are encouraged to provide ongoing education to healthcare professionals on antimicrobial resistance, stewardship principles, and guideline-based prescribing. In addition, pharmacists play a key role in educating patients regarding appropriate antimicrobial use, adherence, and potential adverse effects. The guideline highlights pharmacist involvement in data collection, analysis, and reporting as part of stewardship activities. Pharmacists contribute to monitoring antimicrobial utilization metrics, resistance trends, and clinical outcomes, which are essential for evaluating the effectiveness of stewardship interventions. The statement also encourages pharmacist participation in quality improvement initiatives and research related to antimicrobial stewardship. Overall, the ASHP/SIDP joint statement strongly supports the integration of pharmacists as core leaders in antimicrobial stewardship programs. By leveraging their clinical expertise and collaborative role within healthcare teams, pharmacists significantly contribute to optimizing antimicrobial therapy, improving patient safety, and addressing the global challenge of antimicrobial resistance²⁴.

Antibiotic Selection In Surgical Prophylaxis

The prevention of surgical site infections (SSIs) depends heavily on the appropriate choice of antibiotics for surgical prophylaxis; nevertheless, a number of Indian studies have shown significant variation in prescription practices and inadequate adherence to conventional standards. The selection of prophylactic antibiotics frequently deviates from advised protocols in both public and private tertiary care facilities.²⁵

Numerous Indian studies have documented the extensive use of broad-spectrum antibiotics for regular surgical prophylaxis, especially third-generation cephalosporins like cefuroxime and ceftriaxone.²⁶ Even for clean and clean-contaminated procedures, where narrower-spectrum antibiotics would be enough, these drugs are often recommended. In tertiary care facilities, this pattern has been seen in obstetric, orthopedic, and general surgery procedures.²⁷

Due to their efficacy against common skin flora, favorable pharmacokinetic profile, and reduced potential to promote antimicrobial resistance, first-generation cephalosporins like cefazolin are recommended for the majority of surgical procedures by both national recommendations from the Indian Council of Medical Research (ICMR) and international guidelines, such as those from the American Society of Health-System Pharmacists (ASHP). Despite these recommendations, cefazolin remains underutilized in many Indian hospitals.²⁸

The scarcity of guidelines-recommended medications, such as cefazolin, in hospital formularies is one of the causes of improper antibiotic selection, forcing physicians to turn to broader-spectrum substitutes.²⁵ Higher-generation antibiotic use is further encouraged by the lack of institution-specific antibiotic policy, ignorance of revised guidelines, and fear of postoperative infections.²⁶ The necessity for antimicrobial stewardship treatments is highlighted by studies evaluating the suitability of surgical antibiotic prophylaxis in India that found improper antibiotic selection rates ranging from 60% to over 75%.²⁷

Concerns about rising healthcare expenses, the development of antimicrobial resistance, and disruption of normal flora are raised by the persistent preference for broad-spectrum antibiotics for prophylaxis. These results highlight the need of standardizing prophylactic measures and promoting guideline-based antibiotic selection in Indian healthcare settings.²⁸

Timing Of Administration Of Prophylactic Antibiotics

Since sufficient serum and tissue concentrations must be present at the time of surgical incision, the timing of prophylactic antibiotic treatment is a crucial factor in determining their efficacy in preventing surgical site infections. Increased rates of postoperative infections have been linked to the failure to provide antibiotics within the specified time interval.²⁹

Most prophylactic antibiotics should be given 30 to 60 minutes before surgical incision, according to clinical practice recommendations; however, medicines that need longer infusion periods can be given up to 120 minutes before incision. These suggestions are supported by data showing the ideal tissue concentration during microbial exposure.³⁰

Numerous Indian studies have shown low adherence to the proper timing of antibiotic delivery, despite explicit guidelines. A large percentage of patients received preventive antibiotics either too soon or after the surgical incision, according to an observational study carried out in a teaching hospital, suggesting deficiencies in perioperative coordination. Similar results were found at tertiary care hospitals, where over half of surgical cases had improper scheduling.³¹

In Indian hospital settings, delayed antibiotic treatment has been linked to increased rates of surgical site infections (SSIs), especially following skin incision.³² On the other hand, prospective observational studies have shown that patients who received prophylactic antibiotics inside the advised pre-incision window had far lower incidence of surgical site infections (SSIs) than patients who received antibiotics outside of this window. These results emphasize how crucial it is to include antibiotic scheduling in surgical safety checklists.³¹

Lack of established procedures, poor communication between the anesthesia and surgical teams, and the absence of monitoring systems are some of the factors that lead to improper timing.²⁹ Reducing SSI rates in Indian hospitals and greatly increasing adherence to suggested time can be achieved by addressing these gaps through education, protocol enforcement, and antimicrobial stewardship initiatives.³⁰

Future Perspectives And Research Direction For Use Of Antibiotics Prophylaxis In Different Hospital

The paradigm for Surgical Antibiotic Prophylaxis (SAP) is undergoing a transformative shift toward precision-based, data-driven strategies. As of 2025, the global medical community is moving away from generic, "one-size-fits-all" protocols in favour of highly personalized approaches that prioritize both infection prevention and the preservation of the global "antibiotic commons."³³ The future of SAP is anchored in the integration of Rapid Molecular Diagnostics, which allow clinicians to screen for multidrug-resistant organism (MDRO) colonization preoperatively. This enables "targeted prophylaxis" choosing an antibiotic specific to the patient's existing flora rather than relying on broad-spectrum agents that drive resistance. Furthermore, the emergence of Machine Learning (ML) and Artificial Intelligence (AI) is revolutionizing risk stratification. By utilizing "Personalized Antibigrams," ML models can analyze years of electronic health record (EHR) data including a patient's prior antibiotic exposure, age, and comorbidities to predict an individual's specific risk of harboring resistant strains, thus optimizing the choice of the initial preoperative dose.³⁴

Research directions are increasingly focused on Implementation Science to bridge the persistent "guideline-to-practice" gap. Despite decades of evidence, many hospitals still struggle with improper timing and excessive duration of SAP.³⁵ Future research is prioritizing the development of multidisciplinary Antimicrobial Stewardship (AMS) frameworks that utilize "Audit and Feedback" mechanisms to ensure adherence. A critical research frontier is the strict reduction of prophylaxis duration; current 2024-2025 studies strongly support a "single-dose" or "under 24-hour" protocol, even for high-risk procedures like cardiac or orthopedic surgery, as extended use has been definitively linked to increased rates of *C. difficile* and kidney injury without providing additional protection against Surgical Site Infections (SSIs). Additionally, there is a growing interest in non-pharmacological adjuncts, such as antimicrobial-coated implants and the optimization of host factors like perioperative blood glucose and oxygenation, to reduce the overall systemic antibiotic burden.³⁷

CONCLUSION

Surgical antibiotic prophylaxis (SAP) remains a cornerstone in preventing surgical site infections when applied judiciously and in line with evidence-based recommendations. Its success depends on sound clinical judgment rather than indiscriminate or prolonged antibiotic use. Global and national authorities such as the WHO, ASHP, and ICMR highlight essential principles: selecting the right antibiotic, administering it before incision, ensuring proper dosing, and restricting therapy duration. Failure to follow these standards leads to unnecessary drug exposure, higher treatment costs, adverse reactions, and escalating antimicrobial resistance.

Despite well-established guidelines, adherence is uneven, especially in resource-constrained regions like India. Frequent issues include reliance on broad-spectrum agents, delayed dosing, and extended postoperative prophylaxis. These practices often stem from limited awareness, lack of uniform protocols, and heightened concern about infection risks. Overcoming these barriers requires ongoing professional education, institutional adoption of standardized guidelines, and consistent audit-and-feedback systems.

Pharmacists play a pivotal role in antimicrobial stewardship, helping optimize antibiotic use and guiding healthcare teams. Looking ahead, advances will emphasize individualized, technology-driven approaches such as rapid diagnostics, machine learning, and AI-supported decision tools to enhance surgical outcomes while safeguarding antibiotic effectiveness.

REFERENCES

- [1] Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR, Hospital Infection Control Practices Advisory Committee. Guideline for prevention of surgical site infection, 1999. *Infection Control & Hospital Epidemiology*. 1999 Apr;20(4):247-80.
- [2] Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, Fish DN, Napolitano LM, Sawyer RG, Slain D, Steinberg JP. Clinical practice guidelines for antimicrobial prophylaxis in surgery. *American journal of health-system pharmacy*. 2013 Feb 1;70(3):195-283.
- [3] Allegranzi B, Bischoff P, De Jonge S, Kubilay NZ, Zayed B, Gomes SM, Abbas M, Ateama JJ, Gans S, van Rijen M, Boermeester MA. New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective. *The Lancet Infectious Diseases*. 2016 Dec 1;16(12):e276-87.
- [4] Steinberg JP, Braun BI, Hellinger WC, Kusek L, Bozikis MR, Bush AJ, Dellinger EP, Burke JP, Simmons B, Kritchevsky SB, Trial to Reduce Antimicrobial Prophylaxis Errors (TRAPE) Study Group. Timing of antimicrobial prophylaxis and the risk of surgical site infections: results from the Trial to Reduce Antimicrobial Prophylaxis Errors. *Annals of surgery*. 2009 Jul 1;250(1):10-6.
- [5] Classen DC, Evans RS, Pestotnik SL, Horn SD, Menlove RL, Burke JP. The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. *New England Journal of Medicine*. 1992 Jan 30;326(5):281-6.
- [6] Ventola CL. The antibiotic resistance crisis: part 1: causes and threats. *Pharmacy and therapeutics*. 2015 Apr;40(4):277.
- [7] Leaper DJ, Edmiston CE. World Health Organization: global guidelines for the prevention of surgical site infection. *Journal of Hospital Infection*. 2017 Feb 1;95(2):135-6.
- [8] Anderson DJ, Podgorny K, Berríos-Torres SI, Bratzler DW, Dellinger EP, Greene L, Nyquist AC, Saiman L, Yokoe DS, Maragakis LL, Kaye KS. Strategies to prevent surgical site infections in acute care hospitals: 2014 update. *Infection Control & Hospital Epidemiology*. 2014 Sep;35(S2):S66-88.
- [9] Kulkarni AP, Sengar M, Chinnaswamy G, Hegde A, Rodrigues C, Soman R, Khilnani GC, Ramasubban S, Desai M, Pandit R, Khasne R. Indian antimicrobial prescription guidelines in critically ill immunocompromised patients. *Indian Journal of Critical Care Medicine: Peer-reviewed, Official Publication of Indian Society of Critical Care Medicine*. 2019 Jan;23(Suppl 1):S64.
- [10] Shanson D. New guidelines and the development of an international consensus on recommendations for the antibiotic prophylaxis of infective endocarditis. *International Health*. 2010 Dec 1;2(4):231-8.
- [11] Gouvêa M, de Oliveira Novaes C, Pereira DM, Iglesias AC. Adherence to guidelines for surgical antibiotic prophylaxis: a review. *The brazilian journal of infectious diseases*. 2015 Sep 1;19(5):517-24.
- [12] Nabor MI, Buckley BS, Lapitan MC. Compliance with international guidelines on antibiotic prophylaxis for elective surgeries at a tertiary-level hospital in the Philippines. *Healthcare infection*. 2015 Oct 28;20(4):145-51.
- [13] Ravi G, Chikara G, Bandyopadhyay A, Handu S. Compliance of surgical antimicrobial prophylaxis practices in the departments of general surgery and orthopaedics at a tertiary care centre in India. *International Journal of Advances in Medicine*. 2020 Oct;7(10):1492.
- [14] Gurunthalingam MP, Keche YN, Gaikwad NR, Dhaneria S, Singh MP, Prakash MG, Keche Y. Appropriateness of surgical antibiotic prophylaxis in a tertiary care teaching hospital in central India: a retrospective analysis. *Cureus*. 2023 May 10;15(5).
- [15] Murugesan M, Jothi SM, Murugan P. Impact of a Standardized Institutional Policy on Surgical Antimicrobial Prophylaxis in a Tertiary Care Hospital. *International Journal for Healthcare Quality, Patient Centeredness & Safety*. 2025 Jul 1;6(2):53-8.
- [16] Misra KH, Pattanaik KP, Tarai A, Pradhan BS. Knowledge, Attitude, Practice (KAP) study regarding antimicrobial use guidelines of ICMR among doctors working in primary, secondary, tertiary healthcare facilities in a tribal area of North Odisha. *Journal of Dr. YSR University of Health Sciences*. 2022 Jul 1;11(3):186-92.
- [17] Chandy SJ, Michael JS, Veeraraghavan B, Abraham OC, Bachhav SS, Kshirsagar NA. ICMR programme on antibiotic stewardship, prevention of infection & control (ASPIC). *Indian Journal of Medical Research*. 2014 Feb 1;139(2):226-30.
- [18] Padmanabhan R. Rational Antibiotic Use in Office Practice. *Indian Journal of Pediatrics*. 2025 Jul 2:1-8.
- [19] Panda PK, Tulsian V. Medical Antimicrobial Prophylaxis in Indian Settings—What to Practice. *JASPI*. 2025;3(2):14-25.
- [20] Chavhan VB, Jaju JB, Jadhav AD. A Study of Antibiotics Prescription Pattern in Pre, Intra & Post Operative Period to Patients Who Later Developed Surgical Site Infections in a Tertiary Care Centre.
- [21] Tumati A, Singh HK, Kewalramani D, Joshi M, Barie PS, Narayan M, Surgical Infection Society. Gaps and Opportunities in Antimicrobial Stewardship and Surgical Site Infection Surveillance Across India. *Surgical Infections*. 2025 Jun 30.
- [22] Collins CD, Dumkow LE, Kufel WD, Nguyen CT, Wagner JL. ASHP/SIDP joint statement on the pharmacist's role in antimicrobial stewardship. *American Journal of Health-System Pharmacy*. 2023 Nov 1;80(21):1577-81.
- [23] Aroworade O, Khudeira Z. Evaluation of the adherence to American health-systems pharmacists (ASHP) stress prophylaxis and society for healthcare epidemiology of America (SHEA) and infectious diseases society of

- America (IDSA) Clostridium difficile infection treatment guidelines.: 5E. Pharmacotherapy: The Journal Of Human Pharmacology & Drug Therapy. 2014 Jun;34(6):e75.
- [24] Ponto JA. ASHP statement on the pharmacist's role in antimicrobial stewardship and infection prevention and control. *Am. J. Health Syst. Pharm.* 2010 Apr 1;67(7):575-7.
- [25] Rehan HS, Kakkar AK, Goel S. Pattern of surgical antibiotic prophylaxis in a tertiary care teaching hospital in India. *Int J Infect Control.* 2009;5(1):1-6.
- [26] Naik R, Chitre M, Kulkarni V, et al. Compliance with surgical antibiotic prophylaxis guidelines in a private tertiary care hospital in India. *J Clin Diagn Res.* 2012;6(9):1483-1486.
- [27] Murthy R, Sengupta S, Hegde R. Evaluation of antibiotic prophylaxis in surgical patients in a tertiary care hospital. *J Pathol Med.* 2018;5(2):123-129.
- [28] Gupta R, Malik A, Rizvi M. Evaluation of antimicrobial prophylaxis in surgical wards of a teaching hospital. *Asian J Pharm Clin Res.* 2017;10(6):231-234.
- [29] Ganguly NK, Arora NK, Chandy SJ, et al. Rationalizing antibiotic use to limit antibiotic resistance in India. *Indian J Pharmacol.* 2011;43(3):281-288.
- [30] Indian Council of Medical Research. Treatment guidelines for antimicrobial use in common syndromes. New Delhi: ICMR; 2017.
- [31] Khan FA, Singh VK, Sharma S. Assessment of timing and duration of surgical antibiotic prophylaxis in a teaching hospital. *Int J Basic Clin Pharmacol.* 2019;8(5):1035-1040.
- [32] Sharma R, Kumar S, Gupta A. Effect of timing of prophylactic antibiotics on surgical site infections: a prospective observational study. *J Neonatal Surg.* 2021;10(2):12-16.
- [33] Sartelli M, Labricciosa FM, Casini B, et al. Optimizing Surgical Antibiotic Prophylaxis in the Era of Antimicrobial Resistance: A Position Paper from the Italian Multidisciplinary Society for the Prevention of Healthcare-Associated Infections (SIMPIOS). *Pathogens.* 2025;14(10):1031. Published 2025 Oct 11. doi:10.3390/pathogens14101031
- [34] Dhole S, Mahakalkar C, Kshirsagar S, Bhargava A. Antibiotic Prophylaxis in Surgery: Current Insights and Future Directions for Surgical Site Infection Prevention. *Cureus.* 2023;15(10):e47858. Published 2023 Oct 28. doi:10.7759/cureus.47858
- [35] Brown L. Personalised medicine: the future of combatting antibiotic resistance? [Internet]. The British Society for Antimicrobial Chemotherapy. British Society for Antimicrobial Chemotherapy; 2022 [cited 2026 Jan 6].
- [36] Abdullah Almotowa H, Mahzary OM, Barnawi ZO, AlFalah DA, Albloushi FM, Alluhaybi AM, Aljumaah AA, Alotaibi KT, AlMutair AH, Alharbi MA. Surgical site infection prevention: best practices and new approaches. *Int J Community Med Public Health* [Internet]. 2025 Jan. 24 [cited 2026 Jan. 6];12(2):974-81.
- [37] Rink M, Gladstone BP, Nikolai LA, Bitzer M, Tacconelli E, Göpel S. The Impact of Antibiotic Prophylaxis on Antibiotic Resistance, Clinical Outcomes, and Costs in Adult Hemato-Oncological and Surgical Patients: A Systematic Review and Meta-Analysis. *Antibiotics.* 2025; 14(9):853