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ANTIBIOTIC POLICY

REGIONAL INSTITUTE OF MEDICAL SCIENCES
IMPHAL

4th Edition | 2026

Approved by:

Hospital Infection Control Committee

In collaboration with:

Department of Microbiology & Clinical Departments

क्षेत्रीय आयुर्विज्ञान संस्थान, इंफाल: मणिपुर
REGIONAL INSTITUTE OF MEDICAL SCIENCES, IMPHAL, MANIPUR
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ORDER

Imphal, the .. March, 2026

No. HGEN/AMSP/1/2026 O/o MS: It is hereby notified to all concerned that the **Antimicrobial Stewardship Committee**, **RIMS Hospital** is re-constituted as given here under. This is in supersession of all previous notifications of this office in this regard.

Sl.No.	Name	Designation	Role
1	Prof. N. Sanjib Singh	Medical Superintendent, RIMSH	Chairman
2	Prof. Dhanaraj Chongtham	Head, Dept. of Medicine	Member
3	Prof. AK. Kaku Singh	Head, Dept. of Urology	Member
4	Prof. S. Ranita Devi	Head, Dept. of Surgery	Member
5	Prof. H. Rebachandra Singh	Head, Dept. of Microbiology	Member
6	Prof. M. Rameswar Singh	Head, Dept. of Obst. & Gynae	Member
7	Prof. Ch. Shyamsunder Singh	Head, Dept. of Paediatric	Member
8	Prof. Ng. Gunindro Singh	Head, Dept. of Pharmacology	Member
9	Prof. Ksh. Mamta Devi	Dept. of Microbiology	Member
10	Prof. Chetan Maibam	Dept. of Surgery	Member
11	Dr. Y. Arunkumar Singh	Assoc. Prof. Dept. of Anesthesiology	Member
12	Dr. L. Trinity Meetei	Assoc. Prof. Dept. of Obst. & Gynae	Member
13	Smt. Th. Sunita Devi	Nursing Superintendent, RIMSH	Member
14	Smt. Sobita Ngangbam	Nursing Officer, RIMSH	Member
15	Prof. T. Jeetenkumar Singh	Dept. of Medicine	Member Secretary

2. The term of reference of the committee shall be to oversee and transect all relevant matters, pertaining to Antimicrobial Stewardship.

3. This shall come into force with immediate effect.

Sd/-
(Prof. N. Sanjib Singh)
Medical Superintendent

Endt. No. HGEN/AMSP/1/2026 O/o MS: Imphal, the … March, 2026

Copy to –

1. The PS to Director, RIMS for kind information of the Director, RIMS, Imphal.
2. Dr. Kamini Walia, ICMR, New Delhi.
3. Principal Investigator, AMSP, RIMS, Imphal.
4. Members, AMS Committee, RIMS, Imphal.
5. Concerned file.

Signed by Nepram Sanjib Singh
Date: 02-03-2026 17:16:18

(Prof. N. Sanjib Singh)
Medical Superintendent

ANTIBIOTIC POLICY

Regional Institute of Medical Sciences
Imphal

4th edition
2026

Editorial Board

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Prof. S. Ranita Devi
Prof. Ng. Gunindro Singh
Prof. H. Rebachandra Singh
Prof. Ch. Shyamsunder Singh
Prof. M. Rameswar Singh
Dr. L. Trinity Meetei

डॉ० गुरुअरिबम सुनिल कुमार शर्मा
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MESSAGE

I am pleased to acknowledge and commend the publication of the ***RIMS Hospital Antibiotic Policy – 2026 (4th Edition)*** **by the Antimicrobial Stewardship (AMS) Committee, RIMS Hospital, Imphal**. This document represents a significant step in our commitment to the rational, safe, and effective use of antimicrobial agents across the institution.

Meticulously crafted as a comprehensive, evidence-based guideline, this policy supports clinicians in making informed and judicious decisions in antibiotic therapy. By integrating local microbial patterns, resistance trends, and clinical indications, it ensures that treatment approaches remain both scientifically sound and contextually relevant.

At a time when antimicrobial resistance poses an escalating global health challenge, the importance of prudent antibiotic use cannot be overstated. This policy plays a vital role in improving patient outcomes while helping to curb the emergence and spread of resistant organisms. All healthcare professionals are encouraged to adhere strictly to these guidelines to maintain consistency, safety, and effectiveness in antimicrobial practices.

The policy also promotes standardized prescribing practices and strengthens antimicrobial stewardship through systematic monitoring, audit and feedback. These measures are integral to enhancing accountability and advancing evidence-based clinical decision-making within the institution.

Aligned with national and global efforts to combat antimicrobial resistance, this policy delivers a structured and pragmatic framework that upholds the highest standards of patient care. Through collective responsibility, disciplined practice, and sustained commitment, we can preserve the effectiveness of existing antibiotics and safeguard public health.

Let us reaffirm our commitment to these principles as we work together to advance the well-being of our patients and the wider community.

(Prof. G. Sunil Kumar Sharma)
DIRECTOR

Imphal,
The 8th April, 2026

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MESSAGE

It gives me immense pleasure to learn about the publication of the RIMS Hospital Antibiotic Policy – 2026, Edition No. 4 (Handbook booklet reference).

The timely revision and distribution of antibiotic policy will serve as a useful guide for clinicians and healthcare professionals. It will promote responsible prescribing practices, help safeguard the effectiveness of antibiotics and will also promote judicious use of antibiotics.

This reflects the dedication and efforts of the Antimicrobial Stewardship (AMS) Committee and the editorial board in preparing clear guidelines for patient care.

I appreciate the efforts of all involved in bringing out this edition and convey my best wishes for its successful implementation.

(Prof. N. Sanjib Singh)
Medical Superintendent

सूक्ष्मजीवविज्ञान विभाग
DEPARTMENT OF MICROBIOLOGY
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27th March 2026

FOREWORD

There is a rising threat of antimicrobial misuse, overuse and resistance (AMR) globally with serious health and economic implications.

To address this problem some key aspects in framing the antibiotic policy are:

i. Laboratory based surveillance and monitoring systems to monitor the trends in infections of public health importance.
ii. Critical regulations restricting the over-the-counter sale of drugs, particularly Schedule H1 drugs.
iii. Promotion of antimicrobial stewardship by issuing guidelines about diagnosing infections correctly and relying on culture & sensitivity reports, preferring narrow spectrum antibiotics over broad spectrum when possible (de-escalation).
iv. Co-ordination among human health and interconnected ecosystems like animal husbandry, agriculture, environment etc. through a "One Health" approach as envisioned in the National Action Plan on Antimicrobial Resistance (NAP-AMR 2.0) (2025–2029).

I appreciate the effort of all the contributors to this document “RIMS Hospital Antibiotic Policy – 2026 edition no.4”. I am also confident that this document will have a significant impact on AMR containment.

(Dr. Heigrujam Rebachandra Singh)
Professor & Head
Department of Microbiology
&
Member Secretary
Hospital Acquired Infection Control Committee
Regional Institute of Medical Sciences
Imphal, Manipur.

औषधि विभाग
DEPARTMENT OF MEDICINE
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PREFACE

I am truly pleased and honoured to be associated with the timely publication of the 4th edition of the "*RIMS Hospital Antibiotic Policy*". This is a milestone achieved after the successful publication and wide dissemination of its previous three editions. While much of the effort has been collectively undertaken by the dedicated committee members under the able leadership of the Medical Superintendent and Chairman of the AMS Committee, RIMS, Imphal, the guidance of our respected Director and unfailing support of all concerned departments and valued stakeholders, especially Dr. L. Trinity Meetei, editor of this publication deserve sincere acknowledgment.

Medical profession today faces numerous and evolving challenges. Antimicrobial resistance has emerged as a global threat, and limited development of new effective antimicrobial agents further amplified this challenge. It is further exacerbated by the widespread and often irrational or unregulated use of antibiotics, both within healthcare settings and in the community. In this context, the judicious use of antibiotics remains one of the most effective strategies to combat this problem. The formulation of this institutional antibiotic policy is a step in that direction.

Frameworks such as the *Hospital Antibiotic Policy* form a key component of the Antimicrobial Stewardship Programme of ICMR. The present document compiles evidence- based practices and recommended empirical antibiotics therapies for commonly encountered infectious syndromes in both adult and paediatric patients, as suggested by various departments. In addition to antibiotics choices, this document also outlines appropriate dosage and treatment duration, recognizing that sub-optimal therapy can contribute to the emergence of resistant pathogens.

Antibiotic susceptibility patterns are rapidly evolving due to the emergence of resistance among microorganisms. Therefore, this document requires periodic review and updating in accordance with the latest institutional antibiogram and feedback from clinicians of different department. The editorial team's valuable guidance, dedication and commitment have been instrumental in bringing this work to materialization.

I do hope and pray that this policy will strengthen our collective commitment to the rational use of antibiotics within our institution and would help in curbing the growing menace of antimicrobial resistance.

Let us stand united in the fight against antibiotic resistance.

(Prof. T. Jeetenkumar Singh)
Member Secretary,
Antibiotic Stewardship Committee,
RIMS Hospital, Imphal
&
Principal Investigator,
Antimicrobial Stewardship Programme, RIMS
(A national multicentric project of ICMR, New Delhi)

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From the Editor's Desk

Antibiotic resistance has become a great threat for our patients, clinicians and humanity. We present the 4th edition of Antibiotic Policy of Regional Institute of Medical Sciences (RIMS), Imphal, a tertiary care Medical Institute in the North-Eastern corner of India and it is a significant step toward promoting rational antibiotic use to address the growing challenge of antimicrobial resistance within our institution and the region.

This policy has been developed through the collaborative efforts of clinicians, microbiologists, pharmacologists, and the Infection Control Committee based on local antibiogram, prevailing clinical practices, and standard national and international guidelines.

The objective of this policy is to optimize patient outcomes, reduce unnecessary antimicrobial exposure, limit the emergence of resistant organisms, and ensure cost-effective therapy. This Antibiotic policy will hopefully guide clinicians in the judicious selection, dosing and duration of antimicrobial therapy, while also minimizing the emergence of resistant organisms. Together, we can safeguard the effectiveness of antimicrobials for our patients today and for the future generations.

We strongly encourage all clinical departments to adhere to the recommendations outlined in this policy. Regular surveillance and periodic updates will be undertaken to keep the policy dynamic and responsive to evolving resistance trends.

Trinity

(Dr. L. Trinity Meetei) Editor
Antibiotic Policy RIMSH - 2026 Member,
AMSC
RIMS, Imphal

CONTENTS

INTRODUCTION

The Regional Institute of Medical Sciences (RIMS) Hospital Antibiotic Policy - 2026 has been developed by a multidisciplinary team to ensure a balanced and comprehensive approach to antimicrobial use. This policy takes into account antimicrobial choices for specific clinical conditions, as well as existing institutional guidelines for selected agents. The recommendations are based on the latest evidence-based guidelines and have been adapted in accordance with the local hospital antibiogram to ensure contextual relevance.

The list of drugs included in this policy comprises commonly used antibiotics for both inpatient and outpatient settings. It is anticipated that adherence to these guidelines will promote optimal patient care and ensure consistency in antimicrobial prescribing practices across the hospital. These guidelines will be periodically updated in response to emerging evidence, new recommendations, and changes in the local antibiogram within a defined timeframe.

The choice of antimicrobial therapy should ideally be guided by the susceptibility pattern of the causative organism. However, in many clinical situations, empirical therapy may be necessary. In such cases, physicians should select antimicrobials based on efficacy, safety, suitability, pharmacokinetic properties, rapidity of action, and cost. The guiding principle is to use the most effective, least toxic, and most cost-effective agent for the shortest duration necessary to treat or prevent infection.

Before initiating antimicrobial therapy, clinicians should carefully consider the following:

1. **Pathogen Identification:** What is the most likely causative organism?
2. **Diagnostic Precision:** What is the clinical diagnosis, and are further investigations required to confirm it?
3. **Spectrum of Activity:** Which antimicrobial agents are appropriate for the suspected pathogen?
4. **Patient Factors:** Consider associated co-morbidities, drug allergies, potential drug interactions, renal/hepatic function, and special conditions such as pregnancy and lactation.
5. **Dosing Accuracy:** Ensure appropriate drug selection, dose, route, and frequency. When in doubt, consult the hospital formulary or a specialist.
6. **Duration of Therapy:** Define the appropriate duration of treatment.
7. **Clinical Response:** Monitor the patient's response and modify therapy as needed.

These guidelines represent the current standard of care for the management of infections at RIMS Hospital. While they provide a structured framework for optimal antimicrobial use, clinical judgment should remain paramount and guide decision-making. Any deviation from these recommendations must be clearly documented and justified in the patient's case records.

1. GOOD PRACTICES OF ANTIMICROBIAL PRESCRIBING

a) Microbiological Culture: Clinical samples should whenever appropriate be sent for microbiological culture and sensitivity testing, before starting empiric therapy.

b) Clinical Differentiation: Careful differentiation between contamination, colonization and active infection is important to prevent overuse of antimicrobials.

c) Empiric Therapy: Empiric therapy may be initiated as per hospital policy guidelines when the causative organism is not yet known, particularly in urgent or life-threatening situations when delay in treatment is not acceptable.

d) IV-to-Oral Switch: In critical cases, the therapy may be started with injectable antibiotics for the first 48-72 hours. Subsequently, an early switch to appropriate oral therapy, de-escalation to a narrower-spectrum IV antibiotic, or discontinuation of therapy should be considered based on clinical response.

e) Treatment Adjustment: Adjust treatment (Step-down or step-up) based on the culture sensitivity report. In case of poor clinical response, consultation with a microbiologist and pharmacologist is advised.

f) Combination Therapy: Irrational antimicrobial combinations should be avoided to counter the risk of resistance and risk of toxicity.

g) Daily Review: The need for antimicrobial therapy should be reviewed daily. For most infections, 5-7 days of antimicrobial therapy may be sufficient.

h) Reserve Antibiotics: Reserve drugs like Colistin, Carbapenems and linezolid should be prescribed only when guided by culture sensitivity reports.

Monitoring treatment:

The RIMS antibiotic policy mandates daily review of antimicrobial therapy to determine whether treatment should be continued, narrowed, switched to oral therapy or discontinued. Treatment duration should be guided by clinical condition and response. IV injections are generally reserved for seriously ill patients and those unable to tolerate oral therapy. In case of treatment failure, advice from Physician and Microbiologist should be sought rather than making an empirical change to an alternative antimicrobial agent.

Hypersensitivity:

All patients should be asked about drug allergies and this should be documented by the treating doctor at the time of assessment. If a patient reports a drug allergy, clarify whether this is an allergy or drug intolerance. In some cases, there will be an overlap between drug allergy and drug intolerance.

Clinical features of drug allergy:

Drug allergy may present one or more symptoms developing during or following drug administration, including difficulty in breathing, swelling, itching, rash, anaphylaxis, swelling of the lips, loss of consciousness, seizures or congestion involving mucous membranes of eyes, nose and mouth.

Clinical features suggestive of drug intolerance:

Drug intolerance is suggested by symptoms developing during or after administration, including gastrointestinal distress (nausea, vomiting, diarrhea, abdominal pain) and giddiness. Clinicians must ensure the patient's drug chart allergy box is completed - using "NKA" for no known allergies or "History not available". Under no circumstances should the allergy box be left blank. A pharmacist or nurse may complete the allergy box if the allergy status is documented in the clerking notes. Ideally, the allergy status should be recorded before prescribing a new drug, except in exceptional circumstances. If a patient is suspected to have drug allergy, the drug and suspected reaction should be documented in both the clerking notes and the drug chart.

Some guiding principles for de-escalation/escalation:

a) For infections due to ESBL producing organisms, carbapenems are generally the drug of choice. Piperacillin-Tazobactum or Cefoperazone-Sulbactum may be used if in vitro sensitive and for mild infections.

b) Vancomycin should be reserved for suspected or confirmed MRSA infections and should not be used for MSSA when effective beta-lactam agents are available.

c) In case of Pan-drug-resistant Pseudomonas or Acinetobacter spp., combination therapy including Colistin along with β-lactams should be considered in consultation with microbiologist/Infectious disease physician.

2. ANTIBIOTIC STEWARDSHIP PROGRAMME IN RIMS HOSPITAL, IMPHAL

Introduction: The Antibiotic Stewardship Programme (AMSP) is a coordinated measure aimed at promoting the rational and judicious use of antibiotics to combat antimicrobial resistance (AMR). AMSP is implemented through structural, persuasive, enabling, and restrictive interventions.

The rapid rise in antimicrobial resistance among pathogens of public health importance, coupled with the diminishing pipeline of new antibiotics, has created a global and national health emergency. In India, hospitals are increasingly reporting high resistance to fluoroquinolones and carbapenems, along with emerging resistance to polymyxins such as colistin due to their increased usage in healthcare settings. AMR has thus become a major public health challenge.

Recognizing the urgent need to establish AMSP structures in healthcare institutions, the Indian Council of Medical Research (ICMR) organized four capacity-building workshops across the country during the second quarter of 2017. Following this, a nationwide AMSP initiative was launched in 23 hospitals to systematically implement stewardship activities. The Regional Institute of Medical Sciences, Imphal was also identified as one of the centers participating in this multicentric national project.

AMSP Phase-I (2018–2021)

Project Title: *Initiating Antimicrobial Stewardship Activities in Hospitals in India.*

Regional Institute of Medical Sciences, Imphal successfully completed Phase I with the following objectives:

First year objective –

a) Creating antibiogram for the hospital.

b) Creating antibiotic policy (HAI & choice) based on the hospital antibiogram including surgical prophylaxis.

c) Carry out culture of culture: point prevalence study 1 day in 3 months.

d) Carry out antibiotic consumption in ICUs using ICMR tools (DOTS/DDD).

e) Initiate audit: carbapenem, polymyxin prescriptions in ICU.

f) Initiate formulary restriction for polymyxins (colistin).

g) Carry out workshops for education: one event for his own hospitals and one for hospitals and practitioners in the region.

Second year objectives –

a) To continue antibiograms and treatment guidelines.

b) To continue to capture antimicrobial consumption. The data captured to be classified as per the AWaRe classification of WHO, 2019.

c) Include the following as restricted or high-end antibiotics (the rationale is spectrum and cost) Polymixins, Daptomycin, Linezolid, Tigecycline, Minocycline, Sulbactum, Newer beta-lactam combinations including Zavicefta.

d) Diagnosis-infection related (provisional & final) include co-morbidities (infection related) - DM, underlying malignancies, neutropenia, immunosuppressive drugs (steroids, DMARDs, Biologicals, chemotherapeutic agents) to be recorded.

e) Recording of clinical outcome in the terms of
   - Cured and discharged
   - Referred
   - Leaving against medical advice (LAMA)
   - Death

f) Monitoring adherence to policies - Do point prevalence of compliance monthly for all patients on parenteral antibiotics if the choice is right based on the presumptive diagnosis.

g) Formulary Restriction options - Prior authorization by specific physicians Prospective feedback - Based on disease states or syndrome or patient care areas
   - De-escalation criteria
   - Stopping antibiotics within 5 days
   - Changing from combination to monotherapy
   - Change to a narrower spectrum IV to oral therapy

h) Beds to be increased to include: ICU (at least 10% of total hospital beds), Non-ICU (at least 10% of total hospital beds). This is minimum number and can be increased as per the ability of principal investigator.

AMSP Phase-II (2023–2026)

Project Title: *Implementation of Antimicrobial Stewardship Programme (AMSP) in Various Tertiary Care Centres across India.*

After completion of the AMSP phase-I in the stipulated timeline set by ICMR, Phase II was initiated on **11th October, 2023** with the following objectives:

Objectives of the AMSP-II

1. To implement AMSP interventions (audit and feedback).
2. To study the impact of AMSP interventions in resistance patterns.
3. To study the impact of AMSP interventions in clinical outcomes.

Objective 1: To implement AMSP interventions (audit and feedback)

a) To create antibiotic policy based on the hospital antibiogram.

b) Monthly point prevalence of cultures to be done for beds for which AMSP is being implemented.

c) To measure antibiotic consumption for antibiotics of interest using DOT and DDD.

d) To monitor and capture duration of antibiotic therapy-
   - No. of patients who got antibiotics for more than 14 days.
   - No. of patients who got more than three antibiotics at same time for at least 5 consecutive days.

Objective 2: To study the impact of AMSP interventions in resistance patterns

To study the Microbiological- Change in resistance pattern of gram negatives (both Enterobacteriaceae and non-enterobacteriaceae) and gram positives (Staphylococcus and Enterococcus) over the time (quarterly).

Objective 3: To study the impact of AMSP interventions in clinical outcomes measures

i) Antibiotic Consumption-

a) Comparison of consumption of antibiotics of interest over the time (quarterly calculation) - using DDD and DOT

b) Compliance rates of de-escalation (monthly)

c) Compliance rates of empirical antibiotics with antibiotic policy (monthly)

d) Compliance rates of surgical antibiotic prophylaxis with antibiotics policy (monthly)

- Choice of drug
- Timing of drug
- Duration of drug prescribed

ii) Clinical Outcomes-

a) Rates of nosocomial infections (HAP/VAP/CAUTI/CLABSI/SSI) over the time (quarterly).

b) Overall mortality rates of patients on beds for which AMSP is implemented (monthly).

c) Attributable mortality to infection of patients on beds for which AMSP is implemented (monthly).

d) Median length of stay in hospital for patients who were started on antibiotics of interest (monthly).

e) Cost of therapy (only related to antibiotics) - using DDD (based on Jan Ausdahi) (quarterly).

Selection criteria for Study Beds

a) Selection of ICU beds for AMSP study should be from Medical, Surgical, Cardiothoracic, Neuro, Burns and Chest ICUs.

b) For surgical prophylaxis, only elective surgeries will be considered.

c) ICU beds selection-

- If the total number of ICU beds is more than 100, consider 50% or 50 ICU beds whichever is lower.
- If the total number of ICU beds is less than 100, consider 50% or 50 ICU beds whichever is higher.

d) Wards-For AMSP study, total number of beds should be 150. So forwards, follow 150 - ICU beds = ward beds.

e) In this study, only those wards will be selected which have either higher antibiotic consumption or higher AMR figures.

Expansion of AMSP (Phase II - Ongoing Year 3)

Following ICMR recommendations, AMSP coverage at RIMS hospital has been expanded with approval from the Medical Superintendent to male surgery ward-II/III, male medicine ward-I/III and MITU to increase the total bed strength of 250 (previously 161 bed).

Table 1. Revised ICU and Ward wise bed allocation under AMSP Phase II at RIMS Hospital, Imphal

Sl. no	Department	ICU name	Bed strength
	Intensive care units		
1	Medicine-ICU	MICU	17
2	Surgery-ICU	SICU	13
3	Neuro-ICU	NICU	14
4	Trauma- ICU	TICU	16
5	Medicine intensive treatment unit	MITU	11
	Ward name/Department		
6	Female medicine ward	FMW	45
7	Female surgery ward	FSW II/III	42
8	Post-natal ward	Gynae-ward	14
9	Male Surgery ward	MSW II/III	45
10	Male Medicine Ward	MMW I/III	33
		Grand total	250

The AMSP at RIMS, Imphal is being implemented in a structured and time-bound manner. Outcomes will be compared across participating institutions, and centres will be graded based on their performance. Successful implementation requires a multidisciplinary approach involving clinicians, microbiologists, pharmacists, nurses, and hospital administrators. All stakeholders are urged to actively participate and cooperate to effectively combat the growing threat of antimicrobial resistance.

3. APPROPRIATE CLINICAL SAMPLES COLLECTION METHODS FOR OPTIMUM OUTCOME

Introduction: A good Microbiological report needs a good specimen. Specimen collection in microbiology to isolate and identify the causative agents forms backbone of the investigative procedures. Specific procedures in collecting specimens will certainly improve the quality of services in Microbiology department.

Information derived from the results has impact on diagnosis of infectious diseases, antibiotic prescribing, and formulation of antibiotic policy and for infection control measures. Successful laboratory investigations need advance planning, collection of appropriate and adequate specimens, labelling and documentation of specimen and transportations to appropriate laboratory.

1. BLOOD

Collection and transport

Purpose: To reduce blood culture contamination rate, collection may be improved by taking the following precautions.[1,2,3,4]

Note: This is an emergency procedure. The sample should be processed and reported immediately. The results of the smear should be informed to the concerned clinician and documented in the critical alert register.

Prepare the site

- Select the site of venipuncture. If the patient is unusually dirty, wash the intended site with soap and water prior to venipuncture.
- Apply a tourniquet, 3 to 4 inches above the intended site of venipuncture. Alternatively this can be done after cleaning.
- Put on examination gloves.
- Vigorously cleanse with 70% isopropyl or ethyl alcohol to remove surface dirt and oils.

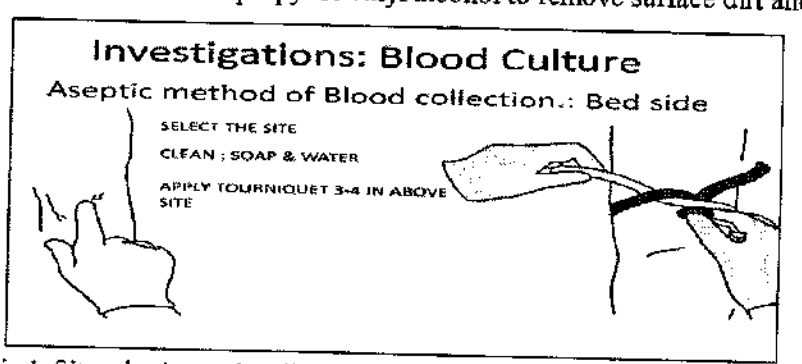

Fig 1. Site selection and preliminary preparation for blood culture collection

- Scrub the venipuncture site gently but firmly with the cotton beginning in the center and continuing in an outward direction circularly for an area of 4 to 5 inches in diameter.
- Allow to dry.
- Swab or wipe concentric circles of 2% w/v chlorhexidine with 70% isopropyl alcohol or 10% w/v povidone iodine/tincture iodine, in a similar manner as given earlier-beginning in the center and continuing in an outward direction circularly for an area of 4 to 5 inches in diameter.
- Allow the povidone iodine to dry (2 minutes). For chlorhexidine gluconate (2 % w/v)/ tincture iodine (10 % w/v), drying period is ~ 30 seconds. Do NOT touch the site after cleaning.

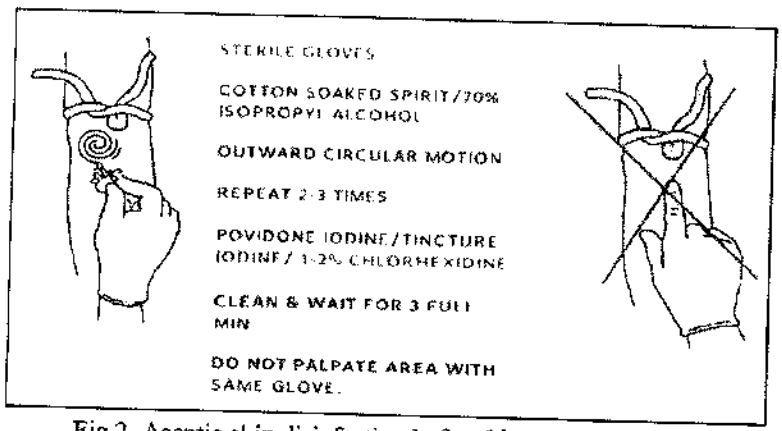

Fig 2. Aseptic skin disinfection before blood culture sampling

- Instruct patient to clench and unclench the fist.
- Perform phlebotomy using the needle and syringe.
- Release the tourniquet and withdraw the needle.

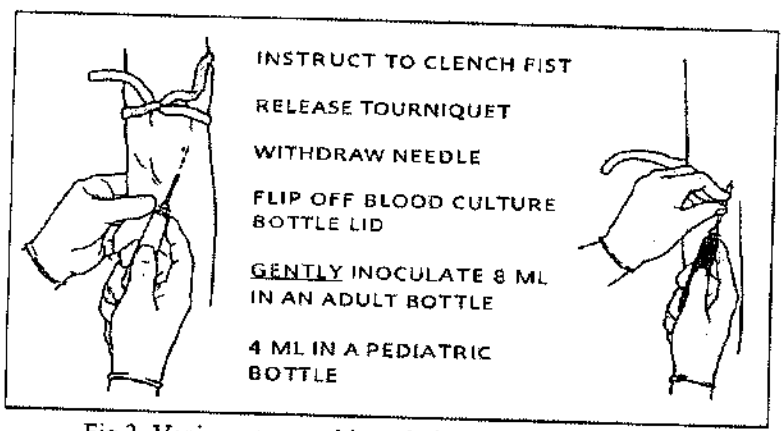

Fig 3. Venipuncture and inoculation of blood culture bottles

- Apply pressure to the site of venipuncture and place a bandage over the puncture site.
- Skin preparation with either alcohol, alcoholic chlorhexidine (2% w/v), or tincture of iodine (10% w/v) leads to lower blood culture contamination rates than does the use of povidone iodine.[1,2]

- **For pediatric patients**

< 2 months: Omit the iodine step, and clean two additional times with separate preparation pads saturated with 70 % isopropyl alcohol or ethyl alcohol.

> 2 months: Chlorhexidine gluconate as a skin antiseptic is approved for use in pediatric patients two months of age and older.[4]

Prepare the bottle

Prepare the septum of the blood culture bottle and the rubber stoppers on bottles or tubes. Label the bottles with the patient's name and the date and time of draw. Site of draw may be listed.

Note: In particular, please mention whether blood is collected from a central line or from peripheral venipuncture.

Collection through an intravenous line

- It is not necessary to discard the initial volume of blood or flush the line with saline to eliminate residual heparin or other anticoagulants.[4]
- Vigorously wipe septa with 70 % alcohol and allow drying completely, for 30 to 60 seconds.
- Pediatric bottles should not be used for adult patients except for those elderly patients in whom it's difficult to obtain larger amounts of blood.

Table 2. Recommended total volume and numbers of blood cultures[4]

Age & body weight	Amount (divided between 2 blood)	Remarks
Neonates to 1 year (< 4 Kg)	0.5–1.5ml	Atleast1ml two separate venipuctures are generally not possible
Children (< 40 Kg)	10–20ml	Blood culture volumes should be limited to <1 % of total blood volume (usually about 0.7 ml/kg). e.g. total sample limit would be 7 ml for a10 kg patient and 28 ml for a 40 kg patient
Adults & children (> 40kg)	30–40ml	Atleast10-20 ml of blood

Adult patient (50 kg): 10 to 20 ml, divided between two blood cultures from separate, peripheral venipuncture sites. Anerobic blood cultures should be taken only if there are adequate resources.[5]

Pediatric patient: 6 to 10 ml, divided between two blood cultures. Initially obtain 3 blood culture sets within a 30 min. period before administration of empiric antimicrobial agents from patients presenting with possible infective endocarditis. If those sets are negative at 24 hrs, obtain 2 more sets of cultures, for a total of 5 sets overall.[4]

Timing of blood cultures

Note: Although drawing blood cultures before or during the fever spike is optimal for recovery, *Volume is more important than* timing in the detection of agents of septicemia. Thoroughly mix bottles to avoid clotting.

Don't forget: After phlebotomy, remove residual tincture of iodine from the patient's skin by cleansing with alcohol to avoid skin irritation.

Manual blood culture inoculation

For conventional blood culture method, blood culture for bacterial infections should be carried out in two bottles containing 50 ml each of tryptone soya broth and bile broth. After removing the kraft paper, inoculate the blood culture bottles. Incubate at 37°C and examine daily for 7 days for evidence of growth, indicated by turbidity, hemolysis, gas production, discrete colonies, or a combination of these.

Transport of blood culture bottles

In case of delay between collection and processing, **never refrigerate the bottle**. Preferably keep the bottle in a 35°C incubator, if available. Otherwise, leave the bottle at room temperature.

2. CEREBRO SPINAL FLUID (CSF)

Collection and transport

Purpose: To identify the organisms causing pyogenic meningitis.

Note: This is an emergency procedure. The samples should be processed and reported immediately. The results of the smear should be informed to the concerned clinician and documented in the critical alert register.

Specimen Collection

a. Lumbar puncture

- Cap, face mask, gown and gloves for physician drawing CSF are useful adjuncts to infection prevention. Disinfect the puncture site with antiseptic solution and alcohol in a manner identical to phlebotomy skin preparation for blood culture to prevent specimen contamination and introduction of infection.
- Insert a needle with stylet at the L3-L4, L4-L5, or L5-S1 interspace. When the subarachnoid space is reached, remove the stylet; spinal fluid will appear in the needle hub.
- Measure the hydrostatic pressure with a manometer.
  Note: Lumbar puncture opening pressure should not be considered a reliable measure of intracranial pressure in children.[6]

- Collect the CSF into five calibrated sterile labeled tubes.
- Physicians should be instructed to sequentially collect 2.0 ml of CSF each into three sterile calibrated tubes if only routine chemistry (total protein and glucose), bacteriology (culture & susceptibility), and hematology (cell count) are required.

b. Ventricular shunt fluid

- Clean the reservoir site with antiseptic solution and alcohol prior to removal of fluid to prevent introduction of infection.
- Remove fluid by aspiration of CSF from the Ommaya reservoir or by collection from the ventricular drain or shunt.
- Collect CSF into a minimum of three sterile calibrated tubes if only routine chemistry (total protein and glucose, tube no.1), bacteriology (culture & susceptibility, tube no.2), and hematology (cell count, tube no.3) are required.
- An initial CSF sample should be collected prior to antimicrobial therapy for highest diagnostic sensitivity.

Specimen transport

- Submit to laboratory as soon as possible and alert laboratory that specimen is in transit.
- Do not refrigerate.
- Each sterile calibrated tube containing CSF must be properly labeled with the patient's name, unique identification number, and the date and time of collection.
- Requisition must be complete with demographic and specimen collection information. Record the patient diagnosis for proper processing of specimen.

Rejection criteria

- Call physician to prioritize requests if there is insufficient volume.
- Specimens in leaky containers must be processed, but alert the physician of the possibility of contamination.

3. BODY FLUIDS FROM STERILE SITES

Specimen collection

- Body fluids from sterile sites should be collected by percutaneous aspiration for pleural, pericardial, peritoneal, amniotic, and synovial fluids.
- Use care to avoid contamination with commensal microbiota.
- Clean the needle puncture site with alcohol, and disinfect it with an iodine solution [1-2 % tincture of iodine or a 10 % solution of povidone iodine (1 % free iodine)] to prevent specimen contamination or infection of patient (if tincture of iodine is used, remove with 70 % ethanol after the procedure to avoid burn).

- Aseptically perform percutaneous aspiration with syringe and needle to obtain pleural, pericardial, peritoneal, or synovial fluid. Use safety devices to protect from needle exposure.
- Immediately place a portion of the joint fluid or peritoneal fluid collected from patients with CAPD or SBP into aerobic and anaerobic blood culture bottles, retaining some (0.5 ml) in syringe for Gram stain and direct plating.
- Use the minimum and maximum volumes recommended by the bottle manufacturer (generally up to 10 ml is the maximum for each bottle).
- Alternatively, inoculate the blood culture bottles after receipt in the laboratory.
- Submit other fluids and the remainder of specimens after inoculation of blood culture bottles in one of the following: a sterile, gassed-out tube or a sterile blood collection tube without preservative; however, fluids in such tubes may clot during transport.

Specimen transport

- Submit to laboratory as soon as possible and, if from a normally sterile site, alert laboratory that specimen has been submitted.
- Do not refrigerate.
- Label specimens with patient demographics and date, time and site of collection. *e.g.* left knee joint fluid.
- Record the patient diagnosis for improved processing of specimen.

Note:

- If specimens inoculated into blood culture bottles are received, Gram stain cannot be performed.
- Collect specimen prior to antimicrobial therapy for greatest diagnostic sensitivity.
- Do not submit specimens from drains after they have been infused with antimicrobial agents.
- Call physician when fluid specimens are received on a swab.
- Contact physician if specimen is insufficient for the number of tests requested.
- Swabs constitute the least desirable sample for culture of body fluids and should be discouraged, since the quantity of sample may not be sufficient to ensure recovery of a small number of organisms.
- Routine bacterial culture is sufficient for culture for *Candida* species, if blood culture bottles are used or specimen is centrifuged.

Important considerations

4. OCULAR SPECIMENS [3]

Note: For detailed procedures http:// on ocular microbiology, please refer to www.ijmm.org/documents/ocular.pdf. [7]

Specimen collection and transport

Note: Most eye specimens should be collected by an ophthalmologist. These specimens should be inoculated onto culture media at the bedside, in the clinic or the physician's office. A variety of techniques are used to collect material from different parts of the eye. The conjunctiva is constantly contaminated by various bacteria from the environment and ocular adnexa. Therefore, specimens from the conjunctiva serve as a control when compared with specimens collected by more aggressive or invasive techniques.

Considerations

- Provide fresh media to the clinical areas routinely collecting ocular cultures, and instruct physicians to immediately transport inoculated media and slides to the laboratory.
- Obtain viral and chlamydial samples before topical anesthetics are instilled.
- Obtain samples for chlamydial cultures with calcium alginate swabs.
  Note: Calcium alginate swabs may be toxic for Neisseria gonorrhoeae (for which rayon or cotton swabs could be used).[8]
- For viral cultures, use Dacronor cotton swabs with non-wood shafts.[9]

COLLECTION BY ANATOMIC SITE [7]

Conjunctiva (bacterial conjunctivitis) and lid margin (blepharo conjunctivitis)

- Obtain the specimen with a sterile, pre-moistened cotton or calcium alginate swab.
- Roll the calcium alginate or cotton swab over the conjunctiva before topical medications are applied.
- Culture both eyes with separate swabs.
- Immediately inoculate the material at the bedside on to BAP and CHOC.
- Inoculate the swab from the right conjunctiva in horizontal streaks, and inoculate the swab from the left conjunctiva in vertical streaks, each on one half of the same agar plate.
- Inoculate specimens from the right and left lid margins, if collected, by making an R and an L to represent the respective sites on another agar plate.
- Obtain conjunctival scrapings for a smear preparation as follows-
  - Instill 1 or 2 drops of proparacaine hydrochloride.
  - Using a Kimura spatula, gently scrape across the lower right tarsal conjunctiva.
  - Smear the material in a circular area 1 cm in diameter on a clean glass slide.
  - Prepare at least two slides.
  - Immerse the slides in 95% methyl alcohol or 95 % methanol for 5 minutes.
  - Repeat steps for the left conjunctiva.

Cornea (bacterial keratitis)

- Instill 1 or 2 drops of proparacaine hydrochloride (local anesthetic for ophthalmic instillation).

- Obtain conjunctival samples as described above, and then obtain corneal scrapings from the advancing edge of the ulcer by scraping multiple areas of ulceration and suppuration with a sterile Kimura spatula, using short, firm strokes in one direction (keep the eyelid open, and be careful not to touch the eyelashes).
- Obtain approximately three to five scrapings per cornea.
- Inoculate each set of scrapings onto BAP and CHOC, using a 'C' formation for each scraping.
- Prepare smears by applying the scrapings in a gentle circular motion over a clean glass Slide or by compressing material between two clean glass slides and pulling the slides apart.

Bacterial endophthalmitis

- Collect an aspirate of the vitreous fluid or perform a paracentesis of the anterior chamber using a needle aspiration technique to collect intraocular fluid.
- Collect specimens for conjunctival cultures along with the fluid to determine the significance of indigenous microbiota.
- If a small volume of fluid is collected, inoculate cultures at the bedside by inoculating 1 or 2 drops of fluid onto culture media.

5. RESPIRATORY SPECIMENS[3]

Purpose: To isolate and identify the potentially pathogenic organisms from upper and lower respiratory tracts (URT and LRT) aiding in the diagnosis of infections.

Sputum cultures are done primarily to identify the pathogens that cause pneumonia or bronchopneumonia: community-acquired or hospital-acquired.

Specimen collection and transport

a) Sputum

- Spontaneous: Early morning specimen generated after a bout of cough.
- Having the patient brush his or her teeth and gargle with water immediately before obtaining the sputum specimen reduces the number of contaminating oropharyngeal bacteria.
- Collect specimen resulting from deep cough in a sterile screw-cap cup or other suitable sterile collection assembly of about 100 ml capacity.
- To prevent contamination of the outside of the container, the patient should be instructed to press the rim of the container under the lower lip to catch the entire expectorated cough sample.
- Tightly screw on the cap of the container. Wipe off any spilled material on its outside with a tissue moistened with disinfectant, but take care not to let any disinfectant enter the container. Such communication with patients can be rewarding. In addition, patients should remove dentures during the specimen collection.

- Early-morning sputum samples should be obtained because they contain pooled overnight secretions in which pathogenic bacteria are more likely to be concentrated. Twenty four hour collections should be discouraged. [1,2]
- Deliver the specimen to the laboratory as quickly as possible, preferably within 2 hours, for delicate bacterial, viral and mycoplasma pathogens may die out during longer delay.

b) Endotracheal aspirate (ETA) [8]

- Endotracheal aspiration should be done with a sterile technique using a 22 inch, 12 F suction catheter. The catheter should be introduced through the endotracheal tube for at least 30 cm. Gentle aspiration is then performed without instilling saline solution. The first aspirate is discarded.
- The second aspirate should be collected after tracheal instillation of 5 ml saline in a mucus collection tube. [If very little secretion is produced by the patient, chest vibration or percussion for 10 minutes should be used to increase the retrieved volume (> 1ml)].
- The specimens should be sent to laboratory and cultured within 1 hour of collection.

c) Broncho-alveolar-lavage (BAL) [10]

In this procedure 120 ml of saline should be infused into a lung segment through the bronchoscope to obtain cells and protein of the pulmonary interstitium and alveolar spaces. Send a portion of it to the laboratory.

d) Sinus aspirate

Collection of specimens from patients with sinusitis should be performed by otolaryngologists who perform nasal endoscopy or sinus puncture and aspiration.

Type of container

Collect in a sterile leak proof screw-cap container.

Rejection criteria

For sputum and endotracheal aspirate specimens

- Reject duplicate specimens received on the same day unless the initial sample was inappropriate for culture according to microscopic evaluation.
- Do not accept repeat cultures at intervals of less than every 48 hour.
- Reject the following specimens for diagnosis of lower respiratory tract disease –
  - 24 hours sputum collection
  - Contaminated sputum and endotracheal specimens as per Gram stain rejection criteria (see below)
  - Specimens that are visually saliva only

- Specimens that are visibly contaminated with toothpaste or other substances
- Nasal washes or swabs of nares to diagnose sinusitis
- Sputum samples are highly contaminated with normal anaerobic flora of the upper respiratory tract. Therefore, anaerobic culture should not be done.

6. PUS

Purpose: To isolate and identify bacterial etiological agent(s) in deep-seated pus/wound specimens.

Specimen collection

- Preferably collect specimen prior to initiation of therapy and only from wounds that are clinically infected or deteriorating or that fail to heal over a long period.
- Cleanse surrounding skin or mucosal surfaces.
- For closed wounds and aspirates, disinfect with 2% chlorhexidine or 70% alcohol followed by an iodine solution [1 to 2% tincture iodine or a 10% solution of povidone iodine (1% free iodine)]. Remove iodine with alcohol prior to specimen collection.
- For open wounds, debride, if appropriate, and thoroughly rinse with sterile saline prior to collection. Sample viable infected tissue, rather than superficial debris.

a) Wound or abscess aspirates

- Samples collected by using a syringe and needle should be placed in a sterile container or blood collection tube without anticoagulant (e.g., Vacutainer or similar type) for submission to the laboratory.
- A portion of the sample should also be placed in a sterile tube containing anaerobic medium like RCM if an anaerobic culture is required.

b) Open wounds

- Cleanse the superficial area thoroughly with sterile saline, changing sponges with each application. Remove all superficial exudates.
- Remove overlying debris with scalpel and swabs or sponges.
- Collect biopsy or curette sample from base or advancing margin of lesion.

c) Pus

- Aspirate the deepest portion of the lesion or exudates with a syringe and needle.
- Collect a biopsy sample of the advancing margin or base of the infected lesion after excision and drainage.
- For bite wounds, aspirate pus from the wound, or obtain it at the time of incision, drainage, or debridement of infected wound.

d) Tissues and biopsy samples

- Tissue biopsy samples should be collected from areas within and adjacent to the area of infection. Large enough tissue samples should be collected to perform all of the tests required (i.e., 3 to 4 mm biopsy samples).
- If anaerobic culture is required, a separate piece of tissue should be submitted in a sterile tube containing anaerobic medium like RCM.
- Collect swabs only when tissue or aspirate cannot be obtained.
- Limit swab sampling to wounds that are clinically infected or those that are chronic and non-healing.
- Remove superficial debris by thorough irrigation and cleansing with non-bacteriostatic sterile saline. If wound is relatively dry, collect with two cotton-tipped swabs moistened with sterile saline.
- Gently roll swab over the surface of the wound approximately five times, focusing on area where there is evidence of pus or inflamed tissue.

Note: Organisms may not be distributed evenly in a burn wound, so sampling different areas of the burn is recommended. Blood cultures should be used to monitor patient status.

Standard precautions to be followed while handling the specimen

Note: Syringes with the needle attached should not be accepted due to the sharps and biohazard risk to staff.

Grossly contaminated specimen or leaky containers and collection containers of doubtful sterility must be noted and mentioned. Deliver aspirates and tissues to the laboratory within 30 minutes for best recovery. Keep tissues moist to preserve organism viability. Do not refrigerate or incubate before or during transport. If there is a delay, keep sample at room temperature, because at lower temperature there is likely to be more dissolved oxygen, which could be detrimental to anaerobes.

Rejection criteria

- For anaerobic culture, avoid swab collection if aspirates or biopsy samples can be obtained.
- Do not accept specimens for microbiological analysis in container with formalin.

7. URINE [11,12]

The most common urine specimen received is the per-urethral voided urine. Healthy urethra is unsterile and it is extremely critical that urine specimens be collected carefully to minimize urethral contamination. There are several types of urine specimens and the results of each type are determined by different guidelines. Therefore, it is essential that each urine specimen received by the laboratory is clearly labeled as to the type of collection of urine specimen.

Collection of Urine

a) Midstream clean catch urine

- The midstream clean catch urine is the most common type of urine specimen.
- The technique involved in collection is based on voiding the first portion of urine, which is most likely to be contaminated by urethral commensals.
- It is recommended that the first voided morning specimen be collected, as bacteria would have multiplied to high levels after overnight incubation in the bladder.
- If not possible, the urine can be collected during the day, preferably 4 hours after the last void, keeping in mind that the counts may be lower, yet significant.
- Midstream clean catch urine should be collected in a sterile, wide mouth, screw capped bottle after very thorough preliminary cleaning of external genitalia with soap and water. Antiseptics should not be used for this purpose.

b) Indwelling catheter

- Hospitalized patients with indwelling catheter are especially at risk of developing UTI.
- To avoid contamination, the specimen should be collected by disinfecting a portion of the catheter tubing with alcohol & puncturing the tubing directly with a sterile syringe with needle and aspirating the urine.
- The urine must not be collected from the drainage bag.

c) Suprapubic collection

- The suprapubic collection avoids urethral contamination but is invasive.
- This procedure is usually reserved for infants and adults, from whom it is difficult to obtain a midstream clean catch urine specimen.
- Disinfect the skin above the bladder and plunge a sterile needle with syringe into the bladder; aspirate the urine and transfer to a sterile container.

d) Percutaneous nephrostomy (PCN) aspirate

- Percutaneous nephrostomy aspirate is urine collected directly from renal pelvis.
- If the sample is a PCN catheter sample, collection must be done as explained for indwelling catheters and not from the drainage bag.

e) Cystoscopy specimens

- Cystoscopy specimen is urine collected from the bladder during cystoscopy.

f) Ileal conduit specimen

- Ileal conduit specimen is collected after cleaning stoma site.
- A fresh drain of urine is collected. It must not be collected from the urine drainage bag.

g) Intermittent catheter specimen

- A red rubber catheter should be introduced into the urethra periodically to drain urine from the bladder.

- It should be collected directly into a specimen container.

Specimen transport

- Urine must be transported to the lab as soon as possible.
- It should be cultured as early as possible after collection, preferably within 2 hours.
- In case of delay, it may be refrigerated up to a maximum of 24 hours before plating.

8. FECAL SPECIMENS

Specimen collection and transport

- A small quantity of solid/semisolid stool or one third of the container in case of watery stool is collected in a sterile screw-capped disposable 40 ml container.
- A rectal swab is not recommended as the material obtained is never adequate for all the tests or for inoculating all the media used for culture.
- The sample should be collected preferably prior to initiation of antibiotics in the container directly, taking care not to soil the outside of the container. Samples should not be collected from bedpan.
- The sample should be immediately transported to the laboratory on collection.
- If there is a delay in transporting faecal specimens or if samples need to be sent by post, one of the following transport media may be employed-
    - Phosphate buffered glycerol saline solution
    - Stuart's transport medium
    - Cary and Blair transport medium

Note: Wasfy et al., study confirms that Cary-Blair medium (CB) is suitable for the preservation of Salmonella and Shigella isolates for more than 2 weeks at 25℃, 4℃, or - 70℃.[13] Campylobacter jejuni was not recovered after 2 days of storage in CB at 25℃ when an inoculum of 12 x 10 (8) cells per ml was used.

SPECIMEN COLLECTION [14]

Table 3. Types of infections and recommended specimens for microbiological investigations

Type of infections	Specimens collected
Blood stream infection, sepsis, endocarditis	Paired blood culture specimens Collected aseptically by two - step disinfection of skin; first with alcohol followed by chlorhexidine 8-10 ml of blood (for adults) collected in blood culture bottles
Infectious diseases requiring serology	Blood (2 ml/investigation) Collected by minimal a sepsis (one-step skin disinfection with alcohol) collected in vacutainer
Diarrheal diseases	Stool (mucus flakes), rectal swab

Meningitis	Cerebro-spinal fluid (CSF)
Infections of other sterile body area	Sterile body fluids; e.g. Pleural fluid, synovial fluid, peritoneal fluid
Skin and soft tissue infection	Pus or exudate, wound swabs, aspirates from abscess and tissue bites
Anaerobic culture	Aspirates tissue specimens blood and sterile body fluids, bone marrow (swabs, sputum not satisfactory)
Upper respiratory tract infection	Throat swab with membrane over the tonsil, nasopharyngeal swab, per nasal swab
Lower respiratory tract infection	Sputum, endotracheal aspirate, broncho-alveolar lavage (BAL), protected specimen brush (PSB) and lung biopsy
Pulmonary tuberculosis	i. Sputum early morning and spot ii. Collected in well ventilated area iii. Gastric aspirate for infants
Urinary tract infections	Midstream urine, Suprapubic aspirated urine, Catheterized patient collected from the catheter tube, not from urobag
Genital specimens	Urethral swab, cervical swab for urethritis exudate from genital ulcers
Eye infections	Conjunctival swabs, Corneal scrapings, Aqueous or vitreous fluid
Ear infections	Swabs from outer ear, Aspirate from inner ear

General Principles

Following principles should be followed while collecting the specimen-

a) Standard precautions
b) Before starting antibiotics
c) Contamination with indigenous flora should be avoided
d) Swabs-convenient but considered inferior to tissue, aspirate and body fluids
e) Container: sterile, tightly sealed, leak proof, wide-mouth
f) Labelling: All specimens-labeled with name, age, gender, treating physician, diagnosis etc.
g) Rejection: Specimens contaminated or improperly labeled may be rejected
h) Anaerobic culture-proper anaerobic collection containers with media should be used.

Specimen Transport

Most specimens-transport time should not exceed *2 hours*. However, there are some exceptions-

a) Immediate transport (< 15 minutes) – CSF and body fluids, ocular specimens, tissue specimens, suprapubic aspirate and bone specimen.
b) Urine (midstream) - added with preservative (boric acid) - transported within 2 hours.
c) Stool culture - transported within 1 hour.
d) Rectal swabs - upto 24 hours is acceptable.
e) For anaerobic culture - Robertson's cooked meat broth or any specialized anaerobic transport system.

Most specimens stored *at room temperature up to 24 hours*. There are some exceptions

a) Blood cultures - incubated at 37°C immediately upon receipt.
b) Sterile body fluids - immediately plated upon receipt - incubated at 37°C.

Corneal scrapping – plated at bed-side

a) Stool culture - stored up to 72 hours at 4°C
b) Urine (mid-stream and from catheter), lower respiratory tract specimen, gastric biopsy (for Helicobacter pylori) - stored up to 24 hours at 4°C.

"Good quality specimens are the cornerstone for high quality diagnosis"

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4 A. RIMS HOSPITAL ANTIBIOGRAM 2024-25

Table 4. Distribution of top 10 pathogens isolated in different healthcare areas during 2024-25

Organism	Total
Escherichia coli	2029
Klebsiella pneumoniae	1508
Staphylococcus aureus	736
Acinetobacter baumannii	634
Pseudomonas aeruginosa	597
Enterococcus spp.	438
Enterococcus faecalis	295
Klebsiella oxytoca	290
Staphylococcus spp.	277
Enterococcus faecium	260
Others	658
TOTAL	7722

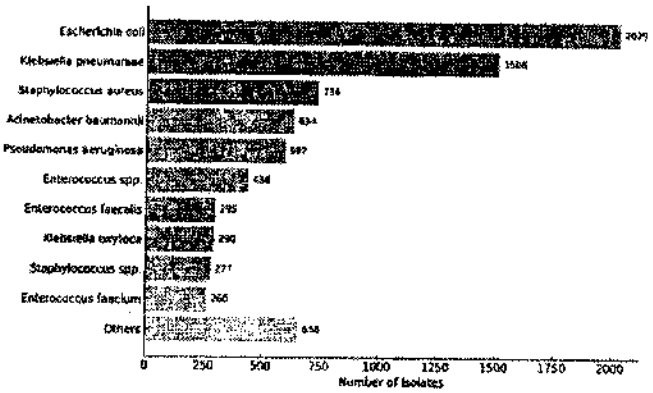

Fig 4. Top 10 bacterial pathogens isolated during 2024-25

The data shows the prevalence of various bacterial pathogens: A total of 7,722 clinical isolates were processed during the period. *Escherichia coli* was the most commonly isolated pathogen (2,029; 26.3%), followed by *Klebsiella pneumonia* (1,508; 19.5%) and *Staphylococcus aureus* (736; 9.5%). Other major isolates included *Acinetobacter baumannii* (634; 8.2%), *Pseudomonas aeruginosa* (597; 7.7%), and *Enterococcus spp.* (438; 5.7%). Less frequently encountered organisms were *Enterococcus faecalis* (295; 3.8%), *Klebsiella oxytoca* (290; 3.8%), *Staphylococcus spp.* (277; 3.6%), and *Enterococcus faecium* (260; 3.4%). The remaining group of organisms collectively contributed 658 isolates (8.5%).

MONTHLY DISTRIBUTION OF SAMPLES AND CULTURE POSITIVITY:

Table 5. Monthly distribution of samples received, culture positive cases, and positivity rates in the Microbiology Laboratory (July 2024–June 2025)

Month	Sample count	Culture positive cases	Positivity Rate (%)
Jul-24	1,770	790	44.60%
Aug-24	1,699	705	41.50%
Sep-24	1,805	750	41.60%
Oct-24	1,667	730	43.80%
Nov-24	1,458	600	41.20%
Dec-24	1,380	565	40.90%
Jan-25	1,517	520	34.30%
Feb-25	1,288	430	33.40%
Mar-25	1,260	600	47.60%
Apr-25	1,500	705	47.00%

May-25	1,634	620	37.90%
Jun-25	1,403	707	50.40%
TOTAL	18,381	7,722	42.00%

Total Samples Received (Jul-24 to Jun-25): **18,381**
Total Cultures Isolated (Jul-24 to Jun-25): **All: 7,722**
Overall Isolation Rate: **42 %**

DENOMINATOR DATA: Table 6. Specimen-wise distribution of culture positive isolates during July 2024 to June 2025

Specimen type	**No. culture positive**
Blood	414
Urine	3638
LRT	1146
Superficial Infection	2037
Deep Infection	5
CSF	2
SS	70
Faeces	186
Others*	224
TOTAL	**7722**

**LRT=Lower respiratory tract; CSF=Cerebrospinal fluid; SS=Surgical site*
**Note: :Bile, Bone fragments, Bone Marrow, Brain abscess, Cervical Swab, Drain Fluid, Ear Swab, Ethmoidal tissue, FNAC, Gastric fluid, Genital tract Hair, ICTD fluid, Instrument, Intestinal fluid, Intra operative bile, Intra op. fluid, Joint Fluid, Maxillary alveolar tissue, Maxillary sinus, Nail Nasal scrapping, Nasal tissue, Needle aspirate, Ocular specimens, Oral cavity crust, Palatal mucosa, Palatal scrapping, Placental Membrane, PTBD fluid, Semen, Sinus mass, Skin biopsy, Throat swab, Vaginal swab. Vascular Catheter tip, Vitreous fluid, etc.*

Urine specimens had the highest number of culture-positive isolates (3,638; 47.1%), followed by superficial infection samples (2,037; 26.4%) and lower respiratory tract specimens (1,146; 14.8%). Blood cultures accounted for 414 isolates (5.4%), while faecal samples (2.4%) and other specimens (2.9%) contributed smaller proportions. Deep infection (0.06%) and CSF (0.03%) specimens showed the lowest numbers of isolates.

Table 7. Isolation rates of pathogens by specimen type and clinical location:-

Following table presents the distribution of culture-positive isolates according to specimen type and clinical location

Isolate	Culture positive																	
	Total		Blood		Urine		LRT		Superficial Infection		Deep Infection		CSF		SS		Faeces		Others	
	n=Total		n=Blood		n=Urine		n=LRT		n=SI		n=DI		n=CSF		n=SS		n=Faeces		n=Others	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Culture positive isolates	7722 (100)	100	414 (100)	5.36	3638 (100)	47.1	1146 (100)	14.8	2037 (100)	26.38	5 (100)	0.06	2 (100)	0.03	70 (100)	0.9	186 (100)	2.41	224 (100)	2.9
Ward (non-ICU) incl HDU	3873 (50.16)	100	244 (58.94)	6.3	1808 (49.7)	46.7	425 (37.09)	11	1156 (56.75)	29.8	4 (80)	0.1	1 (50)	0	42 (60)	1.1	61 (32.8)	1.6	132 (58.93)	3.4
OPD	2754 (35.66)	100	71 (17.15)	2.6	1581 (43.46)	57.4	230 (20.07)	8.4	698 (34.27)	25.3	1 (20)	0	0 (0)	0	13 (18.57)	0.5	122 (65.59)	4.4	38 (16.96)	1.4
ICU	1095 (14.18)	100	99 (23.91)	9	249 (6.84)	22.7	491 (42.84)	44.8	183 (8.98)	16.7	0 (0)	0	1 (50)	0.1	15 (21.43)	1.4	3 (1.61)	0.3	54 (24.11)	4.9
Enterobacterales	4212 (54.55)	100	119 (28.74)	2.8	2467 (67.81)	58.6	602 (52.53)	14.3	849 (41.68)	20.2	2 (40)	0	0 (0)	0	45 (64.29)	1.1	4 (2.15)	0.1	124 (55.36)	2.9
Enterococci	993 (12.86)	100	12 (2.9)	1.2	763 (20.97)	76.8	26 (2.27)	2.6	160 (7.85)	16.1	1 (20)	0.1	0 (0)	0	11 (15.71)	1.1	2 (1.08)	0.2	18 (8.04)	1.8
Diarrheal bacterial isolates	181 (2.34)	100	2 (0.48)	1.1	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	179 (96.24)	98.9	0 (0)	0
Fungi	2 (0.03)	100	2 (0.48)	100	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0
NFGNB	1243 (16.1)	100	100 (24.15)	8	234 (6.43)	18.8	425 (37.09)	34.2	436 (21.4)	35.1	2 (40)	0.2	2 (100)	0.2	8 (11.43)	0.6	0 (0)	0	36 (16.07)	2.9
Invasive Salmonella	4 (0.05)	100	3 (0.72)	75	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	1 (0.54)	25	0 (0)	0
Staphylococci	1078 (13.96)	100	176 (42.51)	16.3	174 (4.78)	16.1	92 (8.03)	8.5	587 (28.82)	54.5	0 (0)	0	0 (0)	0	6 (8.57)	0.6	0 (0)	0	43 (19.2)	4
Streptococcus	9 (0.12)	100	0 (0)	0	0 (0)	0	1 (0.09)	11.1	5 (0.25)	55.6	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	3 (1.34)	33.3

Notes:

1. Percentages are out of particular specimen (column).
2. Percentages in rows below Culture positive are out of Culture positive in respective columns.
3. **Blood** includes: Blood-central catheter, Blood- peripheral and Peripheral catheter-blood.
4. **LRT** (Lower Respiratory Tract) includes: BAL, Sputum, Lung aspirate, Endo-tracheal aspirate (ETA) and Lobectomy tissue (Lung tissue).
5. **Superficial Infection** includes: SST (Skin & Soft Tissue), Pus/exudate, Wound swab, Superficial Biopsy and Superficial Tissue.
6. **Deep Infection** includes: Abscess aspirate, Pus aspirate, Deep Biopsy and Deep Tissue.
7. SS (Sterile sites) includes: Fluid from sterile spaces, Abdominal fluid, Intracostal tube fluid,Pancreatic drain fluid, Pericardial fluid, Peritoneal fluid and Pleural fluid.

SPECIMEN WISE DISTRIBUTIONS OF MAJOR GROUPS ORGANISMS:

A: Table 8. Distribution of major organisms in all specimens

Species	Total	Percentage (%)
Escherichia coli	2029	26.27
Klebsiella pneumoniae	1508	19.53
Staphylococcus aureus	736	9.53
Acinetobacter baumannii	634	8.21
Pseudomonas aeruginosa	597	7.73
Enterococcus spp.	438	5.67
Enterococcus faecalis	295	3.82
Klebsiella oxytoca	290	3.76
Staphylococcus spp.	277	3.59
Enterococcus faecium	260	3.37
Others	658	8.52

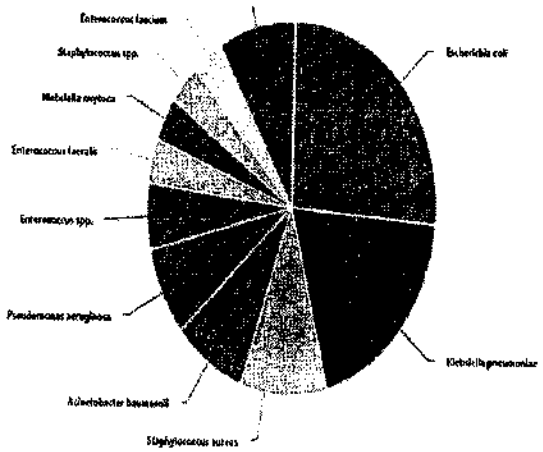

Fig 5. Distributions of all specimens

B: Table 9. Distribution of major organisms in blood specimens *(n= 414)*

Species	Total	Percentage (%)
Staphylococcus aureus	68	16.42
Klebsiella pneumoniae	59	14.25
Pseudomonas aeruginosa	58	14.01
Staphylococcus spp.	57	13.77
Acinetobacter baumannii	39	9.42
Escherichia coli	33	7.97
Staphylococcus epidermidis	23	5.56
Staphylococcus hominis	17	4.11
Klebsiella oxytoca	15	3.62
Staphylococcus haemolyticus	10	2.42
Others	35	8.45

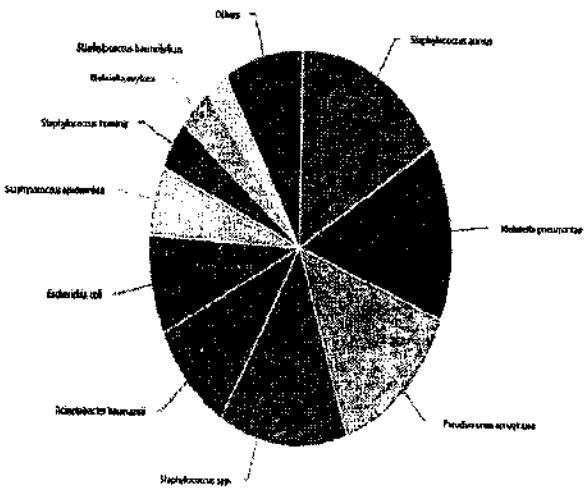

Fig 6. Distributions of organisms in blood specimens

C: Table 10. Distribution of bacterial isolates from urine samples (n=3638)

Species	Total	Percentage (%)
Escherichia coli	1489	40.92
Klebsiella pneumoniae	646	17.76
Enterococcus spp.	324	8.91
Enterococcus faecalis	233	6.4
Enterococcus faecium	206	5.66
Klebsiella oxytoca	147	4.04
Pseudomonas aeruginosa	137	3.77
Staphylococcus aureus	109	3
Acinetobacter baumannii	97	2.67
Proteus mirabilis	76	2.09
Others	174	4.78

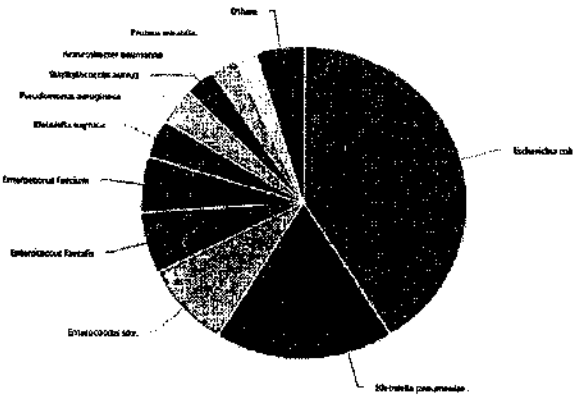

Fig 7. Distribution of bacterial isolates from urine samples

D. Table 11. Distribution of bacterial isolates from lower respiratory tract samples (n=1146)

Species	Total	Percentage (%)
Klebsiella pneumoniae	425	37.08
Acinetobacter baumannii	241	21.02
Pseudomonas aeruginosa	177	15.45
Escherichia coli	82	7.16
Staphylococcus aureus	69	6.02
Klebsiella oxytoca	59	5.15
Staphylococcus spp.	21	1.83
Enterococcus faecium	11	0.96
Enterococcus spp.	9	0.79
Proteus mirabilis	8	0.7
Others	44	3.84

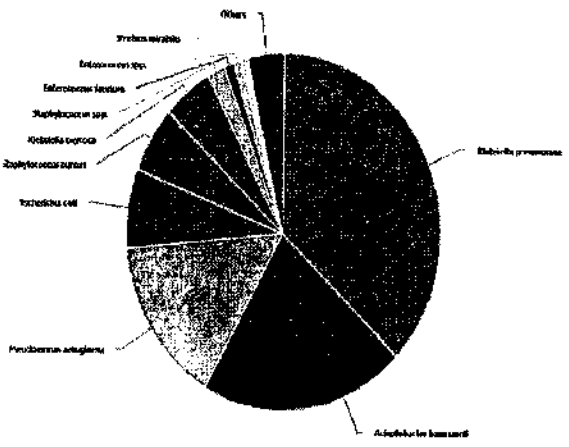

Fig 8. Distribution of bacterial isolates from LRT samples

E: Table 12. Distribution of bacterial isolates from superficial infection samples (n=2037)

Species	Total	Percentage (%)
Staphylococcus aureus	466	22.88
Escherichia coli	356	17.48
Klebsiella pneumoniae	290	14.24
Acinetobacter baumannii	228	11.19
Pseudomonas aeruginosa	207	10.16
Staphylococcus spp.	113	5.55
Enterococcus spp.	83	4.07
Klebsiella oxytoca	61	2.99
Proteus mirabilis	56	2.75
Proteus vulgaris	49	2.41
Others	128	6.28

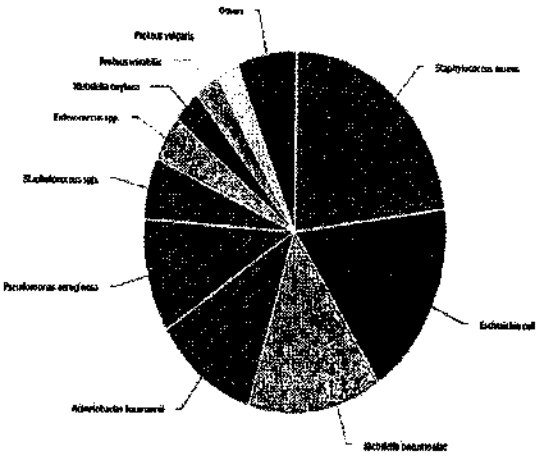

Fig 9. Distribution of bacterial isolates from superficial infection samples

F: Table 13. Distribution of bacterial isolates from faecal samples (n=186)

Species	Total	Percentage (%)
Escherichia coli Diarrhoeagenic	165	88.72
Shigella sonnei	7	3.76
Shigella flexneri	6	3.22
Escherichia coli	2	1.08
Salmonella spp.	1	0.54
Shigella dysenteriae	1	0.54
Citrobacter spp.	1	0.54
Enterococcus spp.	1	0.54
Enterococcus faecium	1	0.54
Klebsiella pneumoniae	1	0.54

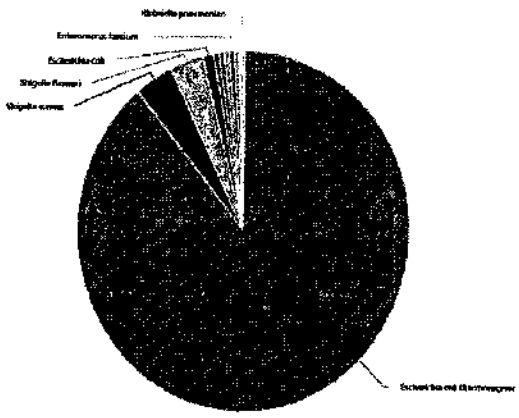

Fig 10. Distribution of bacterial isolates from faecal samples

G: Table 14. Distribution of bacterial isolates from sterile site samples (n=70)

Species	Total	Percentage (%)
Escherichia coli	26	37.14
Klebsiella pneumoniae	14	20
Enterococcus faecalis	5	7.14
Staphylococcus aureus	5	7.14
Pseudomonas aeruginosa	4	5.71
Acinetobacter baumannii	4	5.71
Enterococcus spp.	4	5.71
Klebsiella oxytoca	3	4.29
Enterococcus faecium	2	2.86
Enterobacter spp.	1	1.44
Others	2	2.86

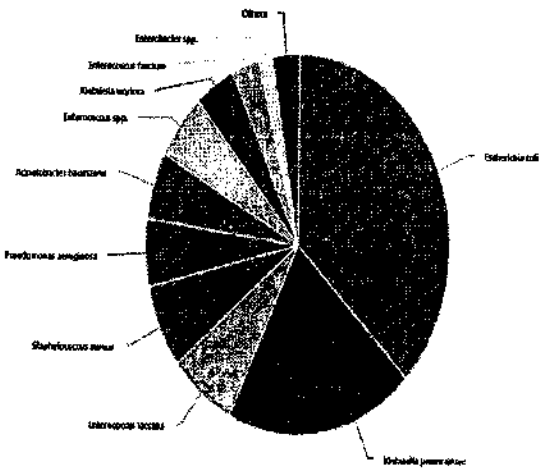

Fig 11. Distribution of bacterial isolates from sterile site samples

Table 15. Distribution of bacterial isolates from OPD, Ward and ICU patients

Organism	Total	OPD	Ward	ICU
Escherichia coli	2029	958	933	138
Klebsiella pneumoniae	1508	429	804	275
Staphylococcus aureus	736	416	284	36
Acinetobacter baumannii	634	72	336	226
Pseudomonas aeruginosa	597	112	324	161
Enterococcus spp.	438	123	273	42
Enterococcus faecalis	295	101	174	20
Klebsiella oxytoca	290	81	163	46
Enterococcus faecium	260	50	159	51
Staphylococcus spp.	277	103	135	39

Escherichia coli was the most common isolate (2029), followed by *Klebsiella pneumoniae* (1508) and *Staphylococcus aureus* (736). Most isolates were from ward patients, while *E. coli* and *S. aureus* were frequently seen in OPD. *Acinetobacter baumannii* and *Pseudomonas aeruginosa* were notable in the ward and ICU, indicating their association with hospital-acquired infections.

1. Enterobacterales

Among the 7722 culture-positive isolates analysed, members of the Enterobacterales accounted for overhalf (≈ 54%). The predominant pathogens identified were *Escherichia coli* (26.3%) and *Klebsiella pneumonia* (19.5%), which were mainly from urine and respiratory samples. Other contributors included *Klebsiella oxytoca* (3.8%), *Proteus mirabilis* (1.8%), and *Proteus vulgaris* (1.5%), with smaller proportions of *Citrobacter, Enterobacter, Serratia, Morganella, and Providencia* species (<1% each). Overall, *E. coli and K. pneumoniae* together constituted the majority of the Enterobacterales isolate, highlighting their dominant role in urinary and respiratory infections.

Table 16: Distributions of Enterobacterales isolates across different clinical samples

Isolate	Culture positive																			
	Total		Blood		Urine		LRT		Superficial Infection		Deep Infection		CSF		SS		Faeces		Others	
	n=7722		n=414		n=3638		n=1146		n=2037		n=5		n=2		n=70		n=186		n=224	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
No. culture positive	7722 (100)	100	414 (100)	5.36	3638 (100)	47.11	1146 (100)	14.84	2037 (100)	26.38	5 (100)	0.06	2 (100)	0.03	70 (100)	0.91	186 (100)	2.41	224 (100)	2.9
Escherichia coli	2029 (26.28)	100	33 (7.97)	1.6	1489 (40.93)	73.4	82 (7.16)	4	356 (17.48)	17.5	2 (40)	0.1	0 (0)	0	26 (37.14)	1.3	2 (1.08)	0.1	39 (17.41)	1.9
Citrobacter freundii	29 (0.38)	100	3 (0.72)	10.3	8 (0.22)	27.6	6 (0.52)	20.7	10 (0.49)	34.5	0 (0)	0	0 (0)	0	1 (1.43)	3.4	0 (0)	0	1 (0.45)	3.4
Citrobacter koseri	22 (0.28)	100	0 (0)	0	10 (0.27)	45.5	2 (0.17)	9.1	9 (0.44)	40.9	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	1 (0.45)	4.5
Citrobacter spp	5 (0.06)	100	0 (0)	0	1 (0.03)	20	3 (0.26)	60	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	1 (0.54)	20	0 (0)	0
Klebsiella pneumoniae	1508 (19.53)	100	59 (14.25)	3.9	646 (17.76)	42.8	425 (37.09)	28.2	290 (14.24)	19.2	0 (0)	0	0 (0)	0	14 (20)	0.9	1 (0.54)	0.1	73 (32.59)	4.8
Klebsiella oxytoca	290 (3.76)	100	15 (3.62)	5.2	147 (4.04)	50.7	59 (5.15)	20.3	61 (2.99)	21	0 (0)	0	0 (0)	0	3 (4.29)	1	0 (0)	0	5 (2.23)	1.7
Klebsiella spp	9 (0.12)	100	0 (0)	0	0 (0)	0	5 (0.44)	55.6	2 (0.1)	22.2	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	2 (0.89)	22.2
Klebsiella (Enterobacter) aerogenes	(0)	300	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0
Enterobacter cloacae	4 (0.05)	100	0 (0)	0	0 (0)	0	1 (0.09)	25	3 (0.15)	75	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0
Enterobacter spp	17 (0.22)	100	2 (0.48)	11.8	3 (0.08)	17.6	4 (0.35)	23.5	5 (0.25)	29.4	0 (0)	0	0 (0)	0	1 (1.43)	5.9	0 (0)	0	2 (0.89)	11.8
Serratia marcescens	12 (0.16)	100	5 (1.21)	41.7	6 (0.16)	50	1 (0.09)	8.3	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0
Proteus mirabilis	141 (1.83)	100	0 (0)	0	76 (2.09)	53.9	8 (0.7)	5.7	56 (2.75)	39.7	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	1 (0.45)	0.7
Proteus vulgaris	119 (1.54)	100	1 (0.24)	0.8	67 (1.84)	56.3	2 (0.17)	1.7	49 (2.41)	41.2	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0
Morganella morganii	12 (0.16)	100	1 (0.24)	8.3	6 (0.16)	50	1 (0.09)	8.3	4 (0.2)	33.3	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0
Providencia rettgeri	11 (0.14)	100	0 (0)	0	6 (0.16)	54.5	2 (0.17)	18.2	3 (0.15)	27.3	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0
Providencia stuartii	4 (0.05)	100	0 (0)	0	2 (0.05)	50	1 (0.09)	25	1 (0.05)	25	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	0

Susceptible Pattern (Enterobacterales)

Table17. Antimicrobial susceptibility pattern of Enterobacterales isolates from blood samples (n=119)

AMA (Susceptibility %)	Isolates	Amikacin	Cefoperazone-sulbactam	Cefotaxime	Ceftazidime	Ceftazidime-avibactam	Ceftriaxone	Ciprofloxacin	Ertapenem	Imipenem	Levofloxacin	Meropenem	Minocycline	Piperacillin-tazobactam	Tigecycline
Escherichia coli	n=33	85	55.6	19	27	72.7	19	27	78	36	30	76	71	24.2	100
Citrobacter freundii	n=3	100	0	0	0	0	0	100	0	0	0	0	100	0	0
Klebsiella pneumoniae	n=59	49	28.6	17	17	33.3	24	20	34	11	39	44	50	11.9	13
Klebsiella oxytoca	n=15	33	11.1	13	20	9.1	13	47	20	13	33	20	57	13.3	0
Enterobacter spp.	n=2	50	0	50	50	0	50	50	100	0	50	100	0	50	0
Serratia marcescens	n=5	80	0	20	40	100	40	60	80	50	60	80	25	20	0
Proteus vulgaris	n=1	100	0	100	100	0	100	100	100	0	100	100	0	100	0
Morganella morganii	n=1	100	0	0	0	0	0	0	0	0	0	0	100	0	0

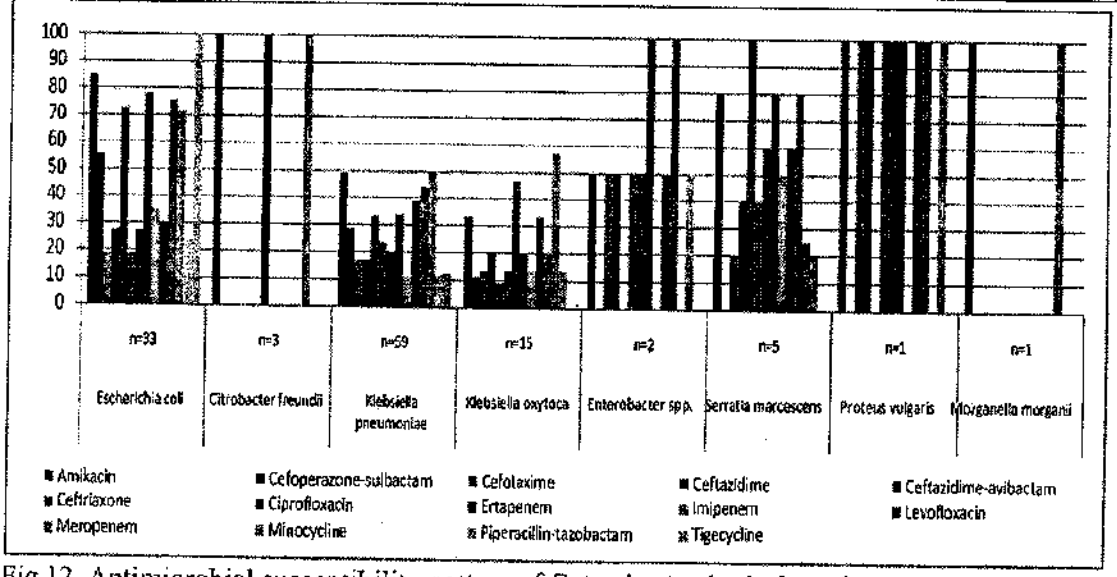

Fig 12. Antimicrobial susceptibility pattern of Enterobacterales isolates from Blood samples

Table18.Antimicrobial susceptibility pattern of Enterobacterales isolates from urine samples (n=2467)

AMA (Susceptibility%)	Isolates	Amikacin	Cefoperazone-sulbactam	Cefotaxime	Ceftazidime	Ceftazidime-avibactam	Ceftriaxone	Ciprofloxacin	Ertapenem	Fosfomycin	Imipenem	Levofloxacin	Meropenem	Minocycline	Nitrofurantoin	Norfloxacin	Piperacillin-tazobactam	Tigecycline	Trimethoprim-sulfamethoxazole
Escherichia coli	n=1489	82	66	16	23	74	28	27	64	93	27	32	74	66	68	39	17	38	50
Citrobacter freundii	n=8	88	0	50	50	0	75	63	75	63	50	75	88	50	43	0	13	0	71.4
Citrobacter koseri	n=10	80	67	30	50	100	70	40	78	60	25	60	90	50	70	100	30	0	70
Citrobacter spp.	n=1	100	0	0	100	0	100	100	100	100	100	0	100	0	100	0	0	0	100
Klebsiella pneumoniae	n=646	58	50	21	21	60	31	29	41	45	13	36	51	46	18	47	9.7	27	48.7
Klebsiella oxytoca	n=147	69	67	27	24	52	33	33	49	59	15	42	63	56	33	40	20	33	49.7
Enterobacter spp.	n=3	67	0	0	67	0	67	67	100	67	0	67	100	0	67	0	33	0	100
Serratia marcescens	n=6	50	100	33	67	100	67	83	67	50	20	83	83	80	0	100	67	100	100
Proteus mirabilis	n=76	76	75	47	58	77	59	49	59	58	21	51	74	54	0	62	41	0	50
Proteus vulgaris	n=67	73	43	36	51	71	60	48	67	21	11	42	82	18	0	53	36	0	44.8
Morganella morganii	n=6	50	0	0	0	0	50	17	67	17	20	20	83	40	0	0	33	0	16.7
Providencia rettgeri	n=6	100	100	33	33	100	50	67	50	50	0	50	83	33	0	100	50	0	66.7
Providencia stuartii	n=2	50	100	50	50	100	50	0	50	0	0	50	50	0	0	0	0	0	50

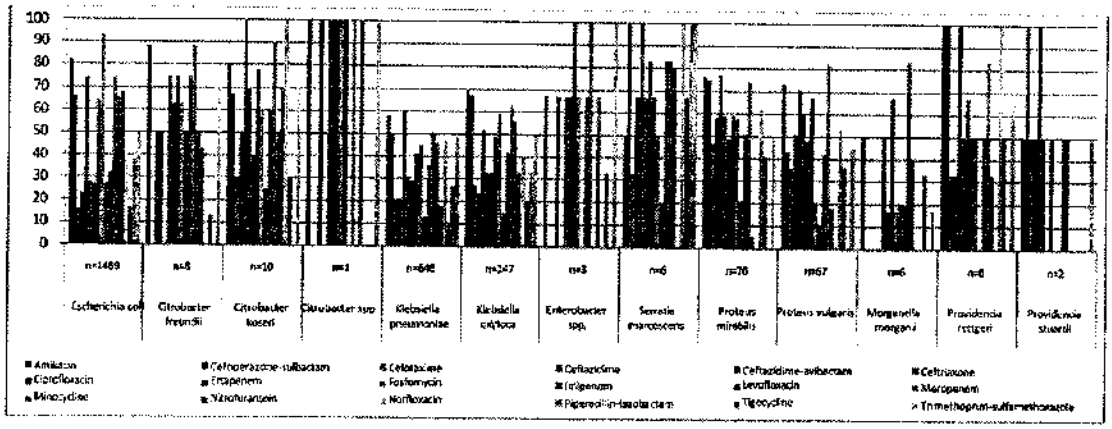

Fig 13. Antimicrobial susceptibility pattern of Enterobacterales isolates from urine samples

Table 19. Antimicrobial susceptibility pattern of Enterobacterales isolates from lower respiratory tract (LRT) samples (n=602)

AMA (Susceptibility %)	Isolates	Amikacin	Cefoperazone-sulbactam	Cefotaxime	Ceftazidime	Ceftazidime-avibactam	Ceftriaxone	Ciprofloxacin	Ertapenem	Imipenem	Levofloxacin	Meropenem	Minocycline	Piperacillin-tazobactam	Tigecycline
Escherichia coli	n=82	82	38	8.5	12	56	13	13	38	24	16	56	52	9.8	39
Citrobacter freundii	n=6	100	0	33	33	100	83	67	83	40	50	100	67	33	0
Citrobacter koseri	n=2	100	0	50	50	0	50	100	50	100	50	50	50	0	0
Citrobacter spp.	n=3	100	0	100	67	0	100	33	100	100	100	100	0	67	0
Klebsiella pneumoniae	n=425	57	46	21	25	51	30	32	41	19	40	48	40	12	21
Klebsiella oxytoca	n=59	73	50	24	22	46	27	31	41	16	34	53	35	10	40
Klebsiella spp.	n=5	60	0	40	40	0	40	33	60	67	60	80	40	40	0
Enterobacter cloacae	n=1	100	0	100	0	0	100	100	0	0	100	100	100	100	0
Enterobacter spp.	n=4	75	0	33	50	0	75	50	50	33	75	75	67	25	0
Serratia marcescens	n=1	100	0	100	0	0	100	100	100	0	100	100	100	0	0
Proteus mirabilis	n=8	38	0	25	25	0	25	13	50	13	25	75	25	0	0
Proteus vulgaris	n=2	100	0	0	50	0	50	0	50	50	50	100	0	0	0
Morganella morganii	n=1	0	0	0	0	0	0	100	0	0	100	0	0	100	0
Providencia rettgeri	n=2	100	100	50	50	100	50	100	50	0	100	100	0	0	0
Providencia stuartii	n=1	100	0	0	100	0	100	100	100	100	100	100	0	100	0

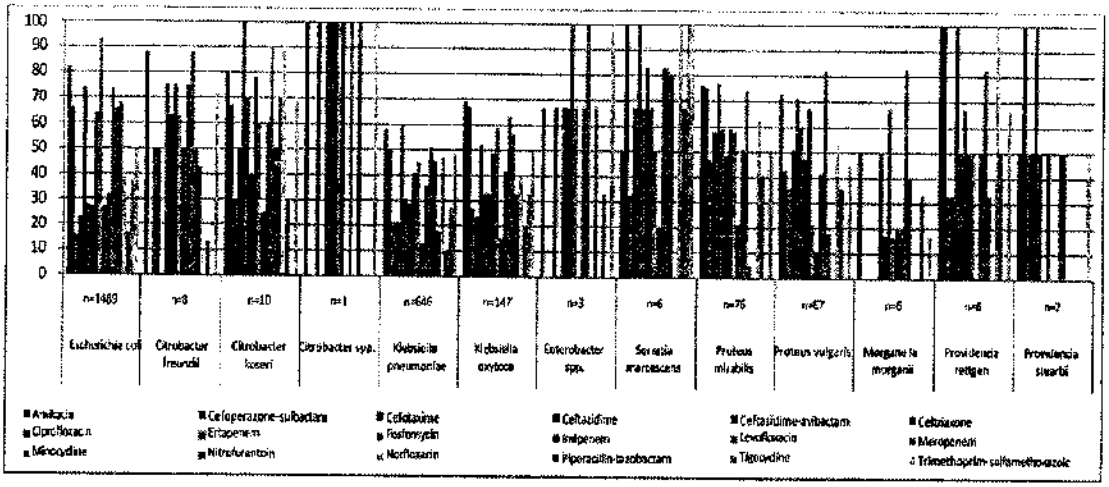

Fig14. Antimicrobial susceptibility pattern of Enterobacterales isolates from LRT samples

Table 20. Antimicrobial susceptibility pattern of Enterobacterales isolates from Superficial Infection (SI) samples (n=849)

AMA (Susceptibility %)	#Isolates	Amikacin	Cefoperazone-sulbactam	Cefotaxime	Ceftazidime	Ceftazidime-avibactam	Ceftriaxone	Ciprofloxacin	Ertapenem	Imipenem	Levofloxacin	Meropenem	Minocycline	Piperacillin-tazobactam	Plazomicin	Tigecycline
Escherichia coli	n=356	77	53	9.6	19	62	20	21	55	24	24	66	58	12	0	37
Citrobacter freundii	n=10	80	100	10	40	100	40	40	80	13	70	70	50	0	0	0
Citrobacter koseri	n=9	78	100	11	33	0	56	67	67	57	67	67	11	0	0	0
Klebsiella pneumoniae	n=290	49	39	21	24	54	27	29	37	18	37	45	40	10	0	22
Klebsiella oxytoca	n=61	53	56	21	30	78	31	25	43	19	34	56	37	13	0	0
Klebsiella spp.	n=2	50	0	50	100	0	100	50	100	100	100	100	50	50	0	0
Enterobacter cloacae	n=3	67	0	0	0	0	0	67	0	0	67	0	67	0	0	0
Enterobacter spp.	n=5	80	100	40	40	100	40	60	60	40	80	60	60	20	0	0
Proteus mirabilis	n=56	86	93	48	60	88	54	61	66	25	64	79	12	32	0	0
Proteus vulgaris	n=49	88	20	41	61	43	71	45	71	21	43	84	13	27	0	0
Morganella morganii	n=4	100	100	50	50	100	50	50	75	0	75	100	33	50	0	0
Providencia rettgeri	n=3	67	0	33	33	0	67	33	100	0	33	100	33	33	0	0
Providencia stuartii	n=1	100	0	0	0	0	100	100	100	0	100	100	100	0	0	0

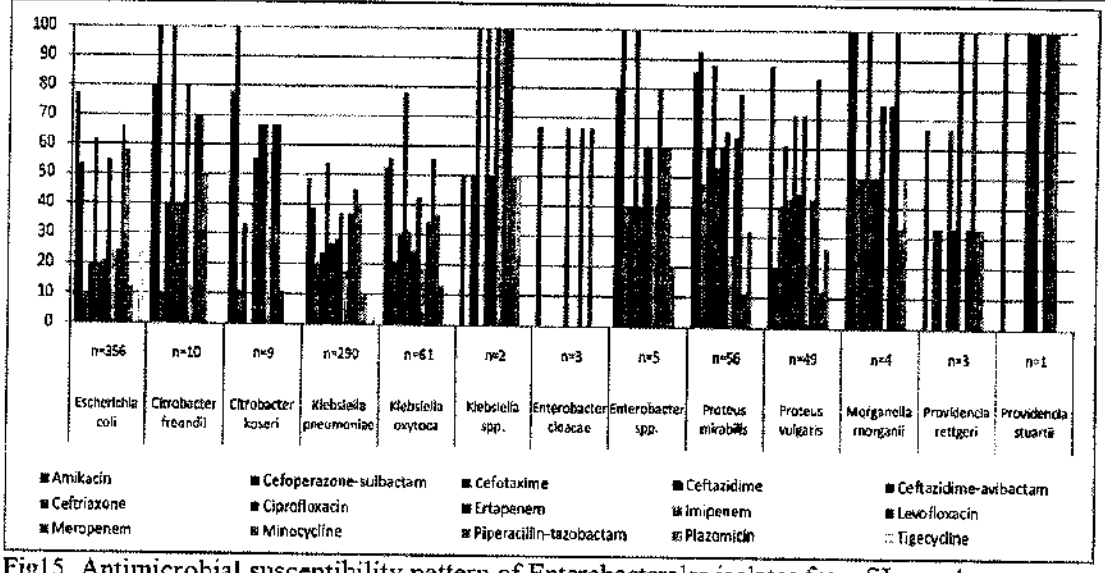

Fig15. Antimicrobial susceptibility pattern of Enterobacterales isolates from SI samples

Table 21. Antimicrobial susceptibility pattern (ASP) of Enterobacterales isolates from Sterile Site (SS) samples (n=45)

AMA (Susceptibility %)	#Isolates	Amikacin	Cefoperazone-sulbactam	Cefotaxime	Ceftazidime	Ceftazidime-avibactam	Ceftriaxone	Ciprofloxacin	Ertapenem	Imipenem	Levofloxacin	Meropenem	Minocycline	Piperacillin-tazobactam	Tigecycline
Escherichia coli	n=26	77	50	19	15	67	19	27	46	20	28	62	65	15	0
Citrobacter freundii	n=1	100	0	0	0	0	100	0	100	100	0	100	0	0	0
Klebsiella pneumoniae	n=14	57	71	29	36	86	36	43	64	14	50	64	39	71	33
Klebsiella oxytoca	n=3	100	100	33	0	100	33	33	33	0	33	67	67	0	0
Enterobacter spp.	n=1	100	0	0	0	0	0	100	0	0	0	0	0	0	0

Table 22. Susceptibility Pattern (SP) of Escherichia coli according to location

AMA (Susceptibility %)	Total	OPD	Ward	ICU
	n=2029	n=958	n=933	n=138
Amikacin	80.5	83.5	78.3	73.9
Cefoperazone-sulbactam	60.9	73.3	52.8	30.8
Cefotaxime	14.3	16.4	13.1	7.2
Ceftazidime	21.9	25.7	20	8.7
Ceftazidime-avibactam	70.8	82.3	63.2	37.5
Ceftriaxone	25.2	30.5	21.8	11.6
Ciprofloxacin	24.8	29.6	21.8	11.6
Ertapenem	60.5	69.2	54.7	39.9
Fosfomycin	92.7	94.8	90.9	78
Imipenem	26.1	30.1	23.4	19.2
Levofloxacin	29.6	36	25.5	13.9
Meropenem	71.5	81.4	65.1	46.4
Minocycline	63.7	68.1	61.7	47.8
Nitrofurantoin	68.3	70.7	65.7	58.5
Norfloxacin	39.4	40.7	38.8	0
Piperacillin-tazobactam	15.7	18.2	14.2	9.4
Tigecycline	37.4	36.1	37.5	42.9
Trimethoprim-sulfamethoxazole	50	55.1	44.4	29.3

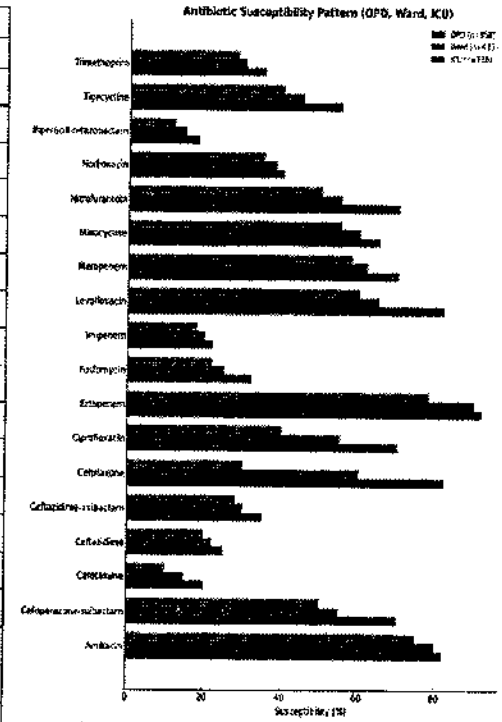

Fig16. Antibiotic SP of E. coli by location

Table 23. Susceptibility Pattern of Klebsiella pneumonia according to location

AMA (Susceptibility %)	Total	OPD	Ward	ICU
	n=1508	n=429	n=804	n=275
Amikacin	55.2	76	51.2	34.5
Cefoperazone-sulbactam	44.9	67.6	43.9	20.3
Cefotaxime	20.2	35.4	16.9	6.2
Ceftazidime	22.3	35.4	20.1	8
Ceftazidime-avibactam	53.6	77.5	52.4	30.8
Ceftriaxone	29.2	50.8	24.4	9.5
Ciprofloxacin	29.8	46.6	27	12
Ertapenem	39.8	60.2	36.5	18.2
Fosfomycin	44.7	47.9	44.1	35.1
Imipenem	15.6	23.3	14.8	7.3
Levofloxacin	37.7	57.5	33.5	19.3
Meropenem	48.4	73.2	43.4	24.4
Minocycline	43.4	53	42.2	32.2
Nitrofurantoin	18.3	22.1	17.5	7
Norfloxacin	47.1	59.5	46.4	8.3
Piperacillin-tazobactam	10.4	17.5	8.9	3.6
Tigecycline	15.8	27.3	13.5	12.2
Trimethoprim-sulfamethoxazole	48.7	58	48	14

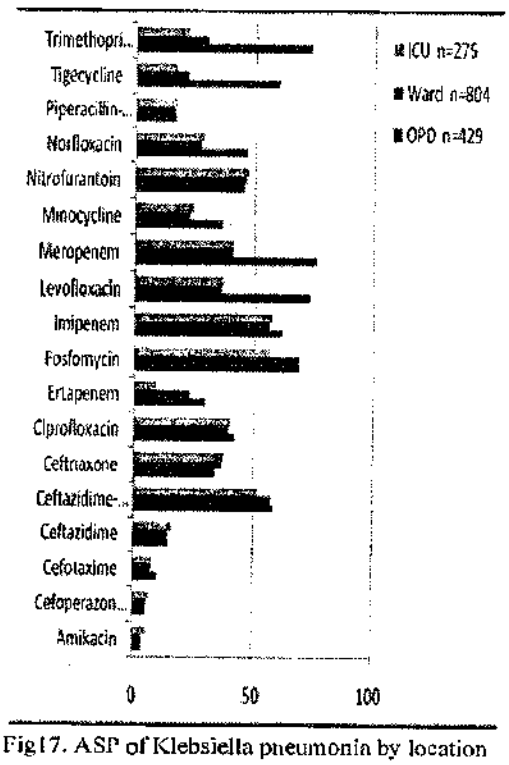

Fig17. ASP of Klebsiella pneumonia by location

Table 24. Year wise antimicrobial susceptibility trends of Enterobacterales from 2020-25

AMA (Susceptibility %)	Year-2020 (%) n=982	Year-2021 (%) n=1324	Year-2022 (%) n=2305	Year-2023 (%) n=3213	Year-2024 (%) n=4388	Year-2025 (%) n=1940
Amikacin	76.54	77.87	81.34	37.04	63.7	68.45
Cefoperazone-sulbactam	0	0	0	0	0	56.74
Cefotaxime	21.62	15.99	11.85	4.2	13.85	22.18
Ceftazidime	27	12.87	13.17	9.22	15.19	35.74
Ceftazidime-avibactam	0	0	0	0	0	64.51
Ceftriaxone	0	0	17.2	17.04	25.25	29.29
Ciprofloxacin	29.65	29.95	18.31	11.17	22.61	29.57
Ertapenem	65.32	62.12	58.64	46.03	44.02	58.09
Fosfomycin	97.77	93.76	86.88	86.87	76.51	80.48
Imipenem	62.44	62.1	44.36	35.81	22.78	22.01
Levofloxacin	33.91	29.87	30.89	24.41	30.51	34.31
Meropenem	76.88	71.02	68.94	59.41	57.77	64.02
Minocycline	0	0	73.79	63.68	55.36	50.09
Nitrofurantoin	73.85	72.37	81.9	63.26	55.35	54.02
Norfloxacin	0	0	0	0	0	45.36
Piperacillin-tazobactam	55.17	32.18	11.32	10.03	11.49	20.58
Tigecycline	0	0	0	0	0	21.95
Trimethoprim-sulfamethoxazole	41.63	38.83	45.08	45.47	49.61	50.56

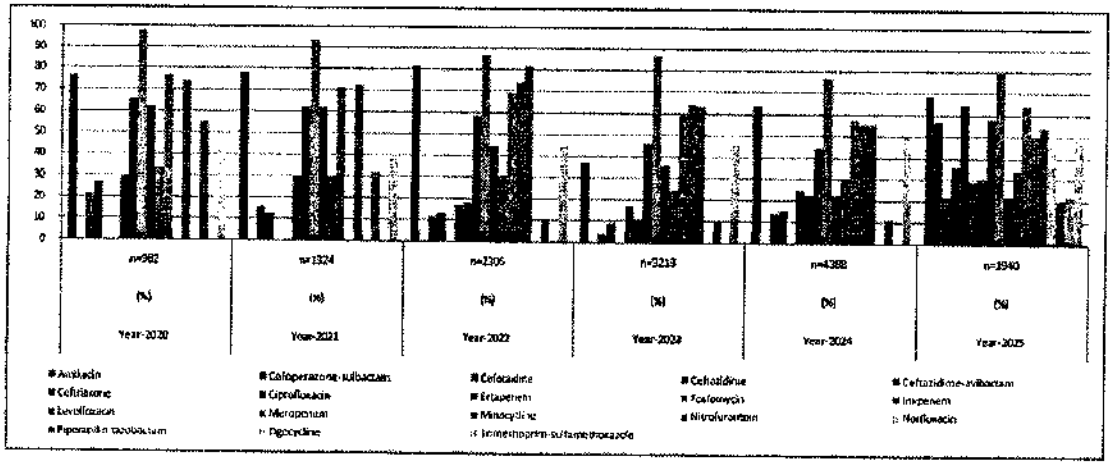

Fig 18. Graphical representation of year wise susceptibility pattern of Enterobacterales (2020-25)

From 2020 to 2025, fosfomycin remained the most consistently active antimicrobial agent, although its susceptibility declined from 97.8% to 80.5%. Amikacin and meropenem initially demonstrated high activity (>75%), but a gradual reduction in susceptibility was observed over the years, with partial recovery in later years (68.5% and 64.0% in 2025, respectively). In contrast, imipenem showed a marked decline in activity, reaching 22.0% susceptibility by 2025, whereas ertapenem exhibited a moderate decrease to 58.1%. Among oral agents, nitrofurantoin demonstrated a decline in susceptibility from 81.9% in 2022 to 54.0% in 2025, while trimethoprim–sulfamethoxazole showed gradual improvement, reaching 50.6%. Third-generation cephalosporins, such as cefotaxime and ceftazidime, exhibited poor activity overall, though some improvement was noted in 2025 (22.2% and 35.7%). Ceftriaxone susceptibility also increased gradually to 29.3%.

Fluoroquinolones remained largely ineffective, with low susceptibility to ciprofloxacin (29.6%) and levofloxacin (34.3%), indicating only modest recovery. Notably, newly added antimicrobial agents tested in 2025, including cefoperazone–sulbactam (56.7%) and ceftazidime–avibactam (64.5%), demonstrated comparatively better activity. In contrast, norfloxacin, a fluoroquinolone introduced for testing in the same year, showed moderate susceptibility (45.4%).

2. Staphylococci: Table 25. Species-wise distribution of Staphylococcal isolates (n=1078)

Organism	Number of isolates (n)	Percent (%)
Staphylococcus aureus	736	68.2
Staphylococcus epidermidis	27	2.5
Staphylococcus haemolyticus	18	1.7
Staphylococcus hominis	17	1.6
Staphylococcus saprophyticus	3	0.3
CoNS	277	25.7
Total	1078	100

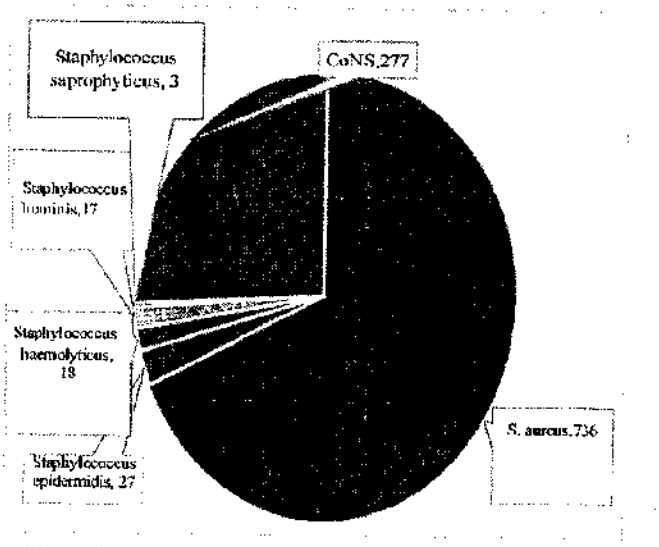

Fig19. Species-wise distribution of Staphylococcal isolates

**CoNS=Coagulase-negative staphylococci*

The majority of isolates were Staphylococcus aureus (68.3%), making it the most common species identified. Other coagulase-negative staphylococci (CoNS) were less frequent, including Staphylococcus epidermidis (2.5%), S. haemolyticus (1.7%), S. hominis (1.6%), and S. saprophyticus (0.3%). A notable portion (25.7%) was reported as CoNS without species-level identification. Overall, the dataset highlights a strong predominance of S. aureus, while non-aureus staphylococci collectively form about one-third of the isolates.

Table 26. Source-wise distribution of staphylococci isolates

Isolate	Culture positive													
	Total n=7722		Blood n=414		Urine n=3638		LRT n=1146		Superficial Infection n=2037		SS n=70		Others n=224	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
No. culture positive	7722 (100)	100	414 (100)	5.4	3638 (100)	47	1146 (100)	15	2037 (100)	26.4	70 (100)	0.9	224 (100)	2.9
Staphylococci	1078 (14)	100	176 (42.5)	16	174 (4.8)	16	92 (8)	8.5	587 (28.8)	54.5	6 (8.6)	0.6	43 (19.2)	4
CoNS	342 (4.4)	100	108 (26.1)	32	65 (1.8)	19	23 (2)	6.7	121 (5.9)	35.4	1 (1.4)	0.3	24 (10.7)	7
Staphylococcus aureus	736 (9.5)	100	68 (16.4)	9.2	109 (3)	15	69 (6)	9.4	466 (22.9)	63.3	5 (7.1)	0.7	19 (8.5)	2.6

Susceptible Pattern - *All specimens*

Among Staphylococcus aureus (n=736) isolates, high susceptibility was observed to vancomycin (100%), tetracycline (85.8%), and trimethoprim–sulfamethoxazole (81%), with moderate activity of linezolid, tigecycline, and clindamycin, while erythromycin and ciprofloxacin showed lower susceptibility. MSSA (n=216) demonstrated generally higher susceptibility to most antibiotics compared with MRSA (n=520), although vancomycin remained fully active against both groups. Among CoNS (n=342), vancomycin also showed complete activity, with relatively better susceptibility to tigecycline and tetracycline, while erythromycin and cefoxitin exhibited lower susceptibility.

Table 27. Susceptibility pattern of Staphylococci isolates

AMA (Susceptibility %)	*S. aureus* n=736	MSSA n=216	MRSA n=520	CoNS n=342
Cefoxitin	29.3	100	0	20.5
Ciprofloxacin	41.8	61.1	33.8	45.9
Clindamycin	67.5	82.9	61.2	52.3
Erythromycin	26	36.3	21.7	17.5
Linezolid	73.4	76.4	72.1	71.9
Tetracycline	85.8	91	83.7	76
Tigecycline	73.2	76.4	71.8	79.8
Trimethoprim-sulfamethoxazole	81	86.6	78.7	60.8
Vancomycin	100	100	100	100

Table 28. Susceptibility pattern of Staphylococci isolates - ***BLOOD***

AMA (Susceptibility %)	S. aureus n=68 (S %)	MSSA n=*18 (S %)	MRSA n=50 (S %)	CoNS n=108 (S %)
Cefoxitin	26.5	-	0	13
Ciprofloxacin	47.1	-	34	45.4
Clindamycin	63.2	-	56	50
Erythromycin	27.9	-	28	12
Linezolid	79.4	-	80	78.7
Tetracycline	81.8	-	79.2	74.1
Tigecycline	70.6	-	68	86.1
Trimethoprim-sulfamethoxazole	77.9	-	74	51.9
Vancomycin	100	-	100	100

Table 29. Susceptibility pattern of Staphylococci isolates - ***URINE***

AMA (Susceptibility %)	S. aureus n=109 (S %)	MSSA n=40 (S %)	MRSA n=69 (S %)	CoNS n=65 (S %)
Cefoxitin	36.7	100	0	29.2
Ciprofloxacin	63.3	75	56.5	53.8
Clindamycin	64.2	72.5	59.4	58.5
Erythromycin	29.4	27.5	30.4	26.2
Linezolid	78	82.5	75.4	75.4
Tetracycline	81.7	90	76.8	73.8
Tigecycline	76.1	80	73.9	76.9
Trimethoprim-sulfamethoxazole	82.6	87.5	79.7	75.4
Fosfomycin	76.7	50	91.4	67.5
Nitrofurantoin	68.4	50	78.7	78.3
vancomycin	100	100	100	100

Table 30. Susceptibility pattern of Staphylococci isolates - ***LRT***

AMA (Susceptibility %)	S. aureus	MSSA	MRSA	CoNS
	n=69	n=24	n=45	n=23
	(S %)	(S %)	(S %)	(S %)
Cefoxitin	34.8	100	0	21.7
Ciprofloxacin	50.7	79.2	35.6	26.1
Clindamycin	58	87.5	42.2	43.5
Erythromycin	20.3	37.5	11.1	13
Linezolid	75.4	79.2	73.3	82.6
Tetracycline	72.1	87.5	63.6	82.6
Tigecycline	75.4	85.7	70.5	69.6
Trimethoprim-sulfamethoxazole	69.6	79.2	64.4	52.2
Vancomycin	100	100	100	100

Table 31. Susceptibility pattern of Staphylococci isolates - ***SUPERFICIAL INFECTION***

AMA (Susceptibility %)	S. aureus	MSSA	MRSA	CoNS
	n=466	n=126	n=340	n=121
	(S %)	(S %)	(S %)	(S %)
Cefoxitin	27	100	0	21.5
Ciprofloxacin	33.9	49.2	28.2	47.1
Clindamycin	70.2	86.5	64.1	54.5
Erythromycin	25.4	40	20	16.5
Linezolid	70.4	73.8	69.1	60.3
Tetracycline	89.3	92.6	88.2	77.5
Tigecycline	72	73.6	71.4	77.5
Trimethoprim-sulfamethoxazole	82.2	87.3	80.3	62
Vancomycin	100	100	100	100

Table 32. Location wise distribution of Staphylococci isolates

Organism	OPD	Ward	ICU
Staphylococci	536	453	89
	19.46%	11.70%	8.13%

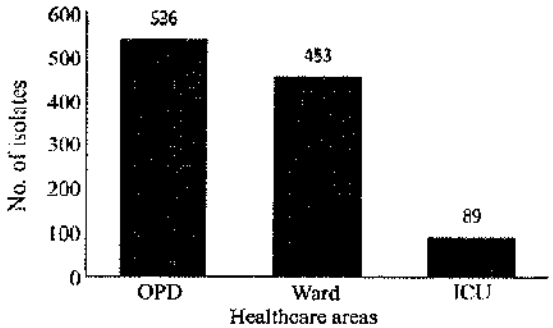

Fig 20. Location wise distribution of Staphylococci isolates

Staphylococci were most frequently isolated from OPD samples (536; 19.46%), followed by Ward samples (453; 11.70%), while the lowest proportion was observed in ICU cases (89; 8.13%).

Susceptible pattern of Staphylococci isolated in different healthcare areas from all specimens *(except urine)*.

Table 33. Location-wise susceptibility pattern of Staphylococcus aureus and CoNS isolates

AMA	*Staphylococcus aureus*				*CoNS*			
	Total	OPD	Ward	ICU	Total	OPD	Ward	ICU
	n=736	n=411	n=290	n=36	n=342	n=92	n=135	n=50
	S%	S%	S%	S%	S%	S%	S%	S%
Cefoxitin	28	29.6	28.1	11.4	18.4	27.2	17.8	4
Ciprofloxacin	37.8	34.6	41.3	45.7	44	54.3	46.7	18
Clindamycin	67.9	73.2	63.2	45.7	50.9	69.6	46.7	28
Erythromycin	25.2	26.6	24.8	14.3	15.5	16.3	18.5	6
Linezolid	72.3	67.9	78.5	74.3	71.1	73.9	68.1	74
Tetracycline	86.7	87.5	85.2	88.6	76.4	87	73.9	64
Tigecycline	72.5	72.4	71.5	80	80.4	83.5	80.7	74
Trimethoprim-sulfamethoxazole	80.5	83.7	76.9	74.3	57.4	66.3	58.5	38
Vancomycin	100	100	100	100	100	100	100	100

A total of 736 Staphylococcus aureus and 342 CoNS isolates were studied. Vancomycin showed 100% susceptibility, while Tetracycline (86.7%), Trimethoprime-sulfamethaxazole (80.5%), Tigecycline (72.5%) and Linezolid (72.3%) also showed notable susceptibility. Lower susceptibility was observed with Clindamycin (67.9%), Ciprofloxacin (37.8%) and Erythromycin (25.2%). Methicillin sensitivity (cefoxitin) was 28% in S. aureus and 18.4% in CoNS.

MRSA & MSSA Trends for last five Years (2020-25)

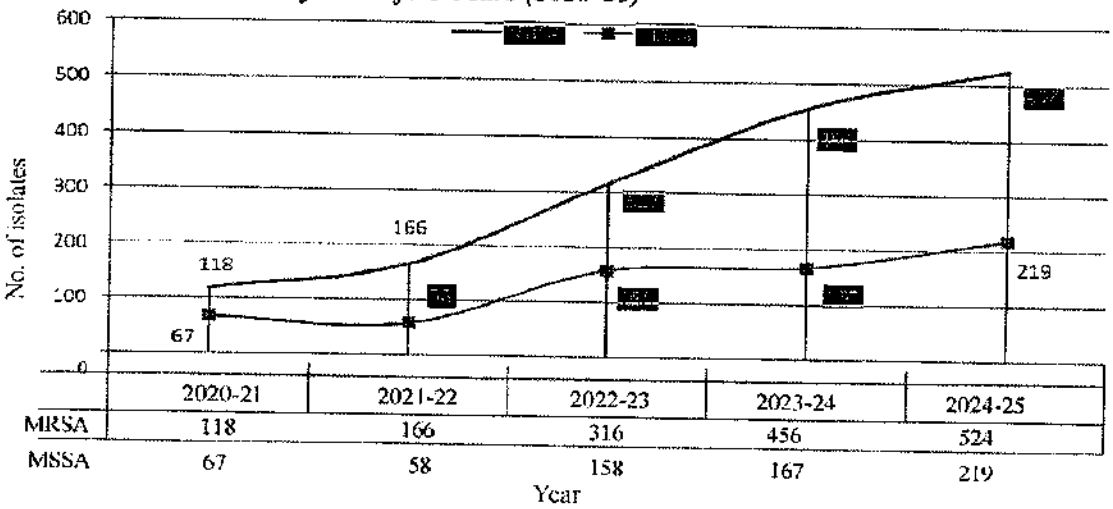

Fig 21. Five year trends of MRSA and MSSA isolates (2020-25)

Staphylococci Yearly trends

Table 34.Year wise antimicrobial susceptibility trends of Staphylococci isolates (2020- 25)

AMA	Year-2020 (%) n=222	Year-2021 (%) n=292	Year-2022 (%) n=561	Year-2023 (%) n=271	Year-2024 (%) n=908	Year-2025 (%) n=1072
Cefoxitin	31.53	22.97	29.08	42.8	21.92	23.4
Ciprofloxacin	27.65	28.28	27.09	31	34.91	49.35
Clindamycin	77.83	72.76	60.36	54.98	55.73	67.4
Erythromycin	28.18	34.38	15.54	16.97	17.84	22.5
Linezolid	98.58	99.65	99.82	99.63	84.58	80.3
Oxacillin	0	40	50	0	0	0
Teicoplanin	0	100	83.33	0	0	100
Tetracycline	81.51	76	66.91	85.98	81.96	83
Tigecycline	0	100	58.33	82.68	87.82	61.7
Trimethoprim-sulfamethoxazole	68.12	64.23	58.29	77.12	75.11	76.9
Vancomycin	100	98.78	99.82	100	100	100

The antimicrobial susceptibility pattern of staphylococcal isolates demonstrated variation over the study period (n=222 in 2020, n=292 in 2021, n=561 in 2022, n=271 in 2023, n=908 in 2024, and n=1072 in 2025). Cefoxitin susceptibility ranged from 21.9% to 42.8%, with the highest rate observed in 2023 (42.8%) and the lowest in 2024 (21.9%). Ciprofloxacin susceptibility showed a gradual increase from 27.7% in 2020 to 49.4% in 2025. In contrast, clindamycin susceptibility declined from 77.8% in 2020 to around 55–56% during 2023–2024, with a partial recovery to 67.4% in 2025. Erythromycin susceptibility remained consistently low, ranging from 15.5% to 34.4% throughout the study period. Vancomycin maintained excellent activity (≈100%) across all years, while linezolid also showed high susceptibility, although a decline was observed in recent years (99–100% during 2020–2023 to 80.3% in 2025). Tetracycline and tigecycline demonstrated relatively high susceptibility, ranging between 66–88% across most years. Trimethoprim–sulfamethoxazole showed moderate to good activity with a gradual increase, reaching 76.9% in 2025. Variability in oxacillin and teicoplanin susceptibility was observed, likely reflecting differences in testing practices and sample size. Overall, vancomycin, linezolid, tetracycline, and tigecycline remained among the most effective agents, whereas erythromycin and cefoxitin showed lower susceptibility over the study period.

3. NFGNB

Out of 7,722 total culture-positive isolates, 1,243 (16.1%) were identified as non fermenting Gram-negative bacilli (NFGNB). The majority were recovered from superficial infections (436; 35.1%) and lower respiratory tract (LRT) samples (425; 34.2%), followed by urine (234; 18.8%) and blood (100; 8%). Smaller numbers were obtained from other samples (36; 2.9%), surgical site infections (8; 0.6%), deep infections (2; 0.2%), and cerebro spinal fluid (2; 0.2%), while no isolates were recovered from stool samples. Overall, NFGNB were

most frequently isolated from superficial infections and LRT specimens, with comparatively fewer isolates from urine and blood.

Species distribution showed *Acinetobacter baumannii* as the predominant isolate (635; 51%), followed by *Pseudomonas aeruginosa* (597; 48%). *Stenotrophomonas maltophilia* was much less frequent (11; 1%).

Table 35. Species-wise distribution of non fermenting gram-negative bacilli (NFGNB)

Organism	Number of isolates (n)	Percent
Acinetobacter baumannii	635	51
Pseudomonas aeruginosa	597	48
Stenotrophomonas maltophilia	11	1
TOTAL	1243	100

Table 36. Isolation rates of different NFGNB from various clinical specimens

Isolate	Culture positive																			
	Total n=7764		Blood n=414		Urine n=5652		LRT n=1148		Superficial infection n=2050		Deep infection n=*5		CSF n=*2		SS n=71		Faeces n=197		Others n=225	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
No. culture positive	7764 (100)	100	414 (100)	5.5	3652 (100)	47	1148 (100)	14.8	2050 (100)	26.4	*5(-)	0.1	*2(-)	0	71 (100)	0.9	197 (100)	2.5	225 (100)	2.9
NFGNB	1244 (16)	100	100 (24.2)	8	234 (6.4)	18.8	425 (37)	34.2	437 (21.3)	35.1	*2(-)	0.2	*2(-)	0.2	8 (11.3)	0.6	0 (0)	0	36 (16)	2.9
Pseudomonas aeruginosa	597 (7.7)	100	58 (14)	9.7	137 (3.8)	22.9	177 (15.4)	29.6	207 (10.1)	34.7	*1(-)	0.2	*0(-)	0	4 (5.6)	0.7	0 (0)	0	13 (5.8)	2.2
Acinetobacter	635 (8.2)	100	59 (9.4)	6.1	97 (2.7)	15.3	241 (21)	38	229 (11.2)	36.1	*1(-)	0.2	*2(-)	0.3	4 (5.6)	0.6	0 (0)	0	22 (9.8)	3.5
Stenotrophomonas maltophilia	12 (0.2)	-	3 (0.7)	-	0 (0)	-	7 (0.6)	-	1 (0)	-	*0(-)	-	*0(-)	-	0 (0)	-	0 (0)	-	1 (0.4)	-

Acinetobacter baumannii:

Table 37. Antimicrobial Susceptibility pattern of Acinetobacter baumannii isolates from different clinical specimens

AMA	Blood	LRT	Superficial Infection	Deep Infection	CSF	Urine
	n=39	n=241	n=229	n=1	n=2	n=97
	(S %)	(S %)	(S %)	(S %)	(S %)	(S %)
Amikacin	66.7	22	22.3	-	-	60.8
Cefepime	23.1	5.4	7	-	-	15.6
Cefoperazone-sulbactam	-	10.9	16.3	-	-	-
Ceftazidime	51.3	5.4	7.4	-	-	16.5
Imipenem	28.2	4.6	4.8	-	-	15.5
Levofloxacin	79.5	17.1	19.7	-	-	59.8
Meropenem	56.4	12.9	15.7	-	-	49.5
Minocycline	78.9	34.9	33	-	-	71.6
Piperacillin-tazobactam	71.8	16.2	17	-	-	50.5
Tigecycline	-	4.3	14.3	-	-	-

Among the bloodstream isolates (n=39), the highest susceptibility was observed with levofloxacin (79.5%), minocycline (78.9%), and piperacillin–tazobactam (71.8%), while amikacin (66.7%) and meropenem (56.4%) demonstrated moderate activity.

In lower respiratory tract (n=241) and superficial infection isolates (n=229), overall resistance was high across most antibiotics. Minocycline showed comparatively better activity (34.9% and 33% susceptible), followed by levofloxacin (17.1% and 19.7%) and piperacillin–tazobactam (16.2% and 17%), whereas carbapenems and cephalosporins exhibited very low susceptibility (<16%).

Among urine isolates (n=97), minocycline (71.6%), amikacin (60.8%), levofloxacin (59.8%), and piperacillin– tazobactam (50.5%) demonstrated the highest susceptibility, while carbapenems showed only moderate activity, particularly meropenem (49.5%) and imipenem (15.5%).

No significant data were available for deep infections (n=1) and CSF (n=2).

Susceptible pattern of isolated Acinetobacter baumannii in different healthcare areas from all specimens.

Table 38. Location wise susceptibility pattern of isolated Acinetobacter baumannii isolates

AMA	Total	OPD	Ward	ICU
	n=635	n=72	n=337	n=226
	S%	S%	S%	S%
Amikacin	31.8	65.3	35.3	15.9
Cefepime	9	18.3	11	3.1
Cefoperazone-sulbactam	22	43.8	24.6	13
Ceftazidime	11	18.1	12.8	6.2
Imipenem	8.2	20.8	8.3	4
Levofloxacin	29.5	72.2	31.8	12.4
Meropenem	23	59.7	24.6	8.8
Minocycline	43.2	81.7	45.4	27.6
Piperacillin-tazobactam	26.1	58.3	28.8	11.9
Tigecycline	21.7	22.2	24.4	17.2

The antimicrobial susceptibility profile of Acinetobacter isolates (n=635) demonstrated considerable variation across OPD, ward, and ICU settings. Overall, the highest susceptibility was observed with minocycline (43.2%), followed by amikacin (31.8%), levofloxacin (29.5%), and piperacillin–tazobactam (26.1%). In contrast, carbapenems showed poor activity, with susceptibility rates of 8.2% for imipenem and 23% for meropenem.

Location-wise analysis revealed that OPD isolates exhibited comparatively higher susceptibility, particularly to minocycline (81.7%), levofloxacin (72.2%), amikacin (65.3%), and meropenem (59.7%). Ward isolates demonstrated moderate susceptibility, with minocycline (45.4%) and amikacin (35.3%) showing relatively better activity. In contrast, ICU isolates displayed the lowest susceptibility across most antibiotics, with minocycline (27.6%) and amikacin (15.9%) remaining the relatively more active agents, while carbapenem susceptibility was extremely low (imipenem 4% and meropenem 8.8%).

Pseudomonas aeruginosa:

Table 39. Specimen wise susceptibility pattern of Pseudomonas aeruginosa isolates

AMA	Blood	LRT	Superficial Infection	Deep Infection	Urine
	n=58	n=177	n=207	n=1	n=137
	(S%)	(S%)	(S%)	(S%)	(S%)
Amikacin	82.8	71.2	67.1	-	54
Cefepime	35.1	28.2	22.8	-	29.2
Cefoperazone-sulbactam	72.2	59	65.4	-	-
Ceftazidime	65.5	48	30	-	40.1
Ceftazidime-avibactam	70	76.2	85.7	-	94.1
Imipenem	51.7	20.3	13.5	-	9.5
Levofloxacin	82.8	48.9	42	-	41.6
Meropenem	75.9	52.5	52.2	-	51.1
Piperacillin-tazobactam	91.4	70.1	58	-	62.8
Tobramycin	91.1	71.2	71.4	-	59.1

The antibiotic susceptibility pattern of Pseudomonas aeruginosa varied across different clinical specimens among 580 isolates (Blood = 58, LRT = 177, Superficial = 207, Deep = 1, Urine = 137). Bloodstream isolates showed the highest susceptibility to piperacillin–tazobactam (91.4%) and tobramycin (91.1%), followed by amikacin and levofloxacin (82.8% each), while meropenem (75.9%) and ceftazidime (65.5%) also demonstrated good activity. In lower respiratory tract (LRT) samples, susceptibility was moderate, with ceftazidime–avibactam (76.2%), amikacin (71.2%), tobramycin (71.2%), and piperacillin–tazobactam (70.1%) showing the best activity. Superficial infection isolates demonstrated relatively variable susceptibility, where ceftazidime–avibactam (85.7%) was the most effective agent, followed by tobramycin (71.4%), amikacin (67.1%), and cefoperazone–sulbactam (65.4%).

Among urine isolates, the highest susceptibility was observed with ceftazidime–avibactam (94.1%), followed by piperacillin–tazobactam (62.8%), tobramycin (59.1%), amikacin (54%), and meropenem (51.1%). Overall, ceftazidime– avibactam demonstrated the most consistent and highest activity across specimen types, while cefepime and imipenem showed comparatively lower susceptibility, particularly in respiratory and urinary isolates.

Table 40. Location wise susceptibility pattern of *Pseudomonas aeruginosa* isolates

AMA	Total	OPD	Ward	ICU
	n=597	n=112	n=324	n=161
	S%	S%	S%	S%
Amikacin	67.3	86.6	67.3	54
Cefepime	27.9	41.4	27.6	19.3
Cefoperazone-sulbactam	66	73.3	72.7	50
Ceftazidime	41.7	54.5	40.4	35.4
Ceftazidime-avibactam	81.2	88.9	87.5	65.7
Ciprofloxacin	59.5	75	60.8	46
Imipenem	18.6	33	19.1	7.5
Levofloxacin	48.8	67.9	46.7	39.8
Meropenem	54.6	76.8	55.6	37.3
Piperacillin-tazobactam	66.5	85.7	66	54
Tobramycin	68.9	88.8	71.8	50

From a total of 597 isolates analyzed across different hospital settings, antibiotic susceptibility varied widely. Amikacin showed high overall effectiveness (67.3%), with the highest susceptibility in OPD isolates (86.6%) and lower rates in ICU (54%). Cefepime had low overall susceptibility (27.9%), particularly in ICU (19.3%). Cefoperazone-sulbactam was effective in 66% of total isolates, showing good activity in wards (72.7%) but lower in ICU (50%). Ceftazidime and Ceftazidime-avibactam showed moderate to high activity overall, with the latter being more effective (81.2% total). Fluoroquinolones - Ciprofloxacin and Levofloxacin - had intermediate susceptibility, higher in OPD (75% and 67.9%) and lower in ICU (46% and 39.8%). Carbapenems, Imipenem (18.6%) and Meropenem (54.6%), displayed variable effectiveness, with Meropenem performing better across all settings. Piperacillin-tazobactam (66.5%) and Tobramycin (68.9%) showed strong overall activity, particularly in OPD, but reduced effectiveness in ICU. Overall, susceptibility was generally highest in OPD isolates and lowest in ICU isolates, reflecting greater resistance in critical care settings.

Table 41. NFGNB yearly antimicrobial susceptibility trends (2020-25)

AMA	Year-2020 (%) n=284	Year-2021 (%) n=378	Year-2022 (%) n=545	Year-2023 (%) n=482	Year-2024 (%) n=1204	Year-2025 % N=978
Amikacin	53.24	62.75	62.38	57.29	53.48	57.4
Cefepime	28.06	16.29	20.83	22.55	22.78	11
Ceftazidime	35.87	11.97	12.06	26.88	17.83	44
Ciprofloxacin	54.17	62.09	36.46	42.34	47.54	64.5
Imipenem	34.07	36.84	43.95	32.85	17.22	16.8
Levofloxacin	40.16	35.47	34.02	31.54	35.89	49.3
Meropenem	50	58.21	59.74	48.33	38.96	48.3
Minocycline	83.33	74.71	77.1	53.46	45.7	52.7
Piperacillin-tazobactam	36	23.03	48.67	43.54	40.75	60.2
Tobramycin	84.38	83.85	77.04	87.84	74.29	78
Trimethoprim-sulfamethoxazole	66.67	81.82	92.31	100	100	60.2

Between 2020 and 2025, the antimicrobial susceptibility profile of Gram-negative bacilli (GNB) at AMA demonstrated variable trends across different antimicrobial agents. Amikacin showed relatively stable activity, with susceptibility ranging from 53.2% in 2020 to 62.8% in 2022, and remaining around 57.4% in 2025. Cefepime and ceftazidime demonstrated poor activity overall, with susceptibility rates largely remaining below 30%, although ceftazidime showed a transient improvement in 2025 (44%).

Among the fluoroquinolones, ciprofloxacin displayed fluctuating susceptibility, increasing from 54.2% in 2020 to 62.1% in 2021, followed by a decline in subsequent years and a rise again in 2025 (64.5%). Levofloxacin demonstrated relatively stable but moderate activity, with susceptibility ranging from approximately 31% to 49% over the study period.

With respect to carbapenems, imipenem and meropenem showed variable susceptibility patterns. Imipenem susceptibility ranged from 34.1% in 2020 to 43.9% in 2022 but declined markedly to 16.8% by 2025. Meropenem susceptibility peaked at 58.2% in 2021 and subsequently declined to 38.9% in 2024, with partial recovery to 48.3% in 2025.

Minocycline exhibited a gradual decline in susceptibility from 83.3% in 2020 to 45.7% in 2024, with a slight increase to 52.7% in 2025. Piperacillin–tazobactam demonstrated moderate activity, improving from 36% in 2020 to 60.2% in 2025. Tobramycin consistently maintained high susceptibility rates (74–88%) across most years. Trimethoprim–sulfamethoxazole showed the highest susceptibility overall, reaching 100% in 2023 and 2024 before declining to 60.2% in 2025.

4. Enterococci

Table 42. Species wise distribution of Enterococcus isolates (n=993)

Bacteria	Number of isolates (n)	Percent (%)
Enterococcus faecalis	290	29.2
Enterococcus faecium	260	26.2
Enterococcus spp.	443	44.6
Total	993	100

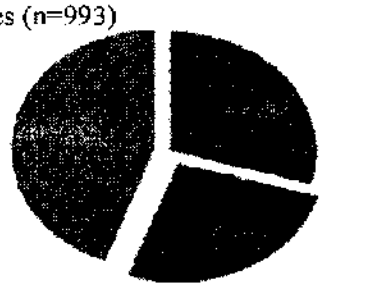

Fig 22. Proportion of Enterococcus species isolated from culture positive samples

A total of 993 Enterococcal isolates (12.86%) were recovered from 7722 culture-positive samples. Among the 993 Enterococcal isolates, Enterococcus spp., without species level identification, constituted the largest proportion (443; 44.6%). This was followed by Enterococcus faecalis, accounting for 290 isolates (29.2%), and Enterococcus faecium, which comprised 260 isolates (26.2%). Overall, Enterococcus spp. represented nearly half of all isolates, while E. faecalis and E. faecium together accounted for the remaining majority of identified species.

Table 43. Antimicrobial susceptibility of Enterococci isolated from different specimen types (excluding urine)

AMA	All Specimens (except urine)		LRT	Superficial Infection	
	Enterococcus faecalis	*Enterococcus faecium*	*Enterococcus faecium*	*Enterococcus faecalis*	*Eterococcus faecium*
	n=62	n=54	n=*11	n=46	n=31
	(S %)	(S %)	(S %)	(S %)	(S %)
Ampicillin	21	9.3	-	21.7	9.7
Gentamicin HL	66.1	53.7	-	60.9	58.1
Linezolid	96.8	96.3	-	97.8	93.5
Penicillin	22.6	5.6	-	23.9	6.5
Teicoplanin	100	88.9	-	100	87.1
Vancomycin	100	94.4	-	100	93.5

Among Enterococcus isolates from all specimens (excluding urine), E. faecalis (n=62) showed higher susceptibility to most antibiotics compared to E. faecium (n=54). E. faecalis demonstrated good activity to Linezolid (96.8%), Teicoplanin (100%), and Vancomycin (100%), while susceptible was noted to Ampicillin (21%) and Penicillin (22.6%). E. faecium showed lower susceptibility across most agents, with Linezolid (96.3%) and Vancomycin (94.4%) being the most effective. In lower respiratory tract (LRT) isolates, E. faecium (n=11) was identified.

In superficial infections, E. faecalis (n=46) again showed high susceptibility to Linezolid (97.8%), Teicoplanin (100%), and Vancomycin (100%), whereas E. faecium (n=31) maintained slightly lower rates - Linezolid (93.5%), Teicoplanin (87.1%), and Vancomycin (93.5%). Overall, glycopeptides (Vancomycin, Teicoplanin) and Linezolid remained highly effective against both species, while β-lactams (Ampicillin, Penicillin) showed limited activity, particularly against E. faecium.

Table 44. Antibiotic Susceptibility profile of Enterococci isolated from urine samples

AMA	Urine	
	Enterococcus faecalis	***Enterococcus faecium***
	n=233	**n=206**
	(S %)	**(S %)**
Ampicillin	26.6	5.3
Ciprofloxacin	21	5.9
Gentamicin_HL	68	52.7
Linezolid	96.1	90.3
Nitrofurantoin	72.1	35.9
Penicillin	19.3	2.9
Teicoplanin	94	90.8
Vancomycin	97.4	91.7

Note: Analysis is not performed for samples sizes lesser than 20 isolates

In urinary isolates, *Enterococcus faecalis* (n=233) and *Enterococcus faecium* (n=206) showed distinct susceptibility patterns. *E. faecalis* demonstrated high sensitivity to vancomycin (97.4%), linezolid (96.1%), and teicoplanin (94%), followed by nitrofurantoin (72.1%) and gentamicin high-level (68%).

Moderate susceptibility was observed with ampicillin (26.6%) and ciprofloxacin (21%), while penicillin showed the lowest activity (19.3%). In contrast, *E. faecium* exhibited overall lower susceptibility, with vancomycin (91.7%), teicoplanin (90.8%), and linezolid (90.3%) remaining effective, whereas nitrofurantoin (35.9%), gentamicin highlevel (52.7%), and ampicillin (5.3%) showed limited activity.

Table 45. Antimicrobial susceptibility (%) of *Enterococci* isolated from different healthcare settings (excluding faecal amples)

AMA	*Enterococcus faecalis*				*Enterococcus faecium*			
	Total	OPD	Ward	ICU	Total	OPD	Ward	ICU
	n=295	n=101	n=174	n=20	n=259	n=49	n=159	n=51
	S %	S %	S %	S %	S %	S %	S %	S %
Ampicillin	25.4	32.7	23	10	6.2	16.3	4.4	2
Ciprofloxacin	21	23.3	21.5	0	5.9	10	6	0
Fosfomycin	29.3	24.7	31.9	33.3	0	0	0	0
Gentamicin_HL	67.6	71.3	68	45	52.7	75	52.1	31.9
Linezolid	96.3	98	96	90	91.5	93.9	92.5	86.3
Nitrofurantoin	72.1	80.2	68.9	50	35.9	55	32.8	25
Penicillin	20	31.7	14.4	10	3.5	6.1	3.8	0
Teicoplanin	95.2	95	95.4	95	90.3	93.9	91.8	82.4
Vancomycin	98	99	97.7	95	92.3	100	93.1	82.4

A total of 295 *Enterococcus faecalis* and 259 *Enterococcus faecium* isolates were analyzed from OPD, ward and ICU settings. Among *E. faecalis* isolates, susceptibility was highest to vancomycin (98%) Linezolid (96.3%) and Teicoplanin (95.2%). Susceptibility to Nitrofurantoin and high-level Gentamicin was observed in 72.1% and 67.6 % of isolates, respectively. Lower susceptibility was noted with Fosfomycin (29.3%), Ampicillin (25.4%), Ciprofloxacin (21%) and Penicillin (20%). Among *E. faecium* isolates, susceptibility was observed in 92.3% to Vancomycin, 91.5% to Linezolid and 90.3% to Teicoplanin. Susceptibility to High -level Gentamicin and Nitrofurantoin was seen in 52.7% and 35.9% of isolates, respectively. Susceptibility to Ampicillin (6.2%), Ciprofloxacin (5.9%) and Penicillin (3.5%) was markedly lower while no isolates were susceptibility to Fosfomycin. Across Healthcare settings, isolates from the ICU showed comparatively lower susceptibility to several antibiotics than those from OPD and Ward settings.

Table 46. Year wise antimicrobial susceptibility trends (%) of *Enterococci* isolates from all samples (2021-25)

AMA	Year-2021	Year-2022	Year-2023	Year-2024	Year-2025
	(%)	(%)	(%)	(%)	(%)
	n=253	n=387	n=529	n=840	n=727
Ampicillin	22.82	16.84	32.14	25.86	8.12
Ciprofloxacin	26.47	13.73	12.5	13.66	14.34
Fosfomycin	86.26	70.81	62.5	33.46	26.32
Gentamicin_HL	57.09	64.34	63.95	60.48	61.27
Linezolid	96.36	88.63	85.82	96.55	95.05
Nitrofurantoin	67.19	71.13	59.8	58.71	49.37
Penicillin	0	0.83	17.77	23.1	10.04
Teicoplanin	92.77	86.49	87.9	95.11	91.47
Vancomycin	92.13	92.4	83.92	99.05	94.5

Vancomycin-resistant Enterococci yearly trends (2021 to 2025)

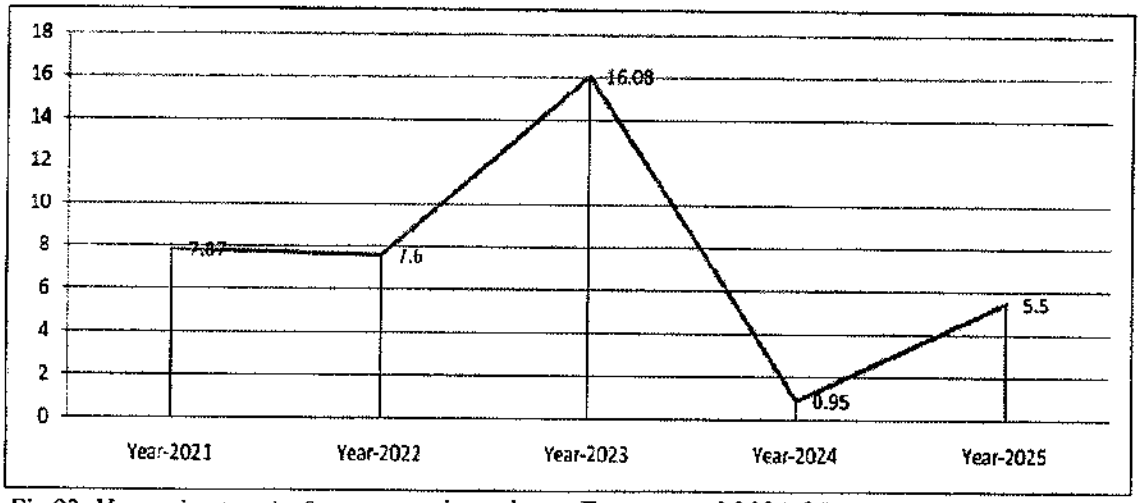

Fig 23. Year-wise trend of vancomycin-resistant Enterococci 2021-25

4 B. Key Highlights of Surveillance Data (July 2024 – June 2025)

• This surveillance report summarizes microbiological data from July 2024 to June 2025, during which 18,381 clinical specimens were processed in the microbiology laboratory. Of these, 7,722 samples were culture positive, giving an overall culture positivity rate of 42%.

• Gram-negative bacteria, particularly members of the Enterobacterales, constituted the majority of isolates, accounting for approximately 54.5% of all culture-positive organisms, highlighting their dominant role in clinical infections.

• *Escherichia coli* was the most frequently isolated pathogen (26.3%), followed by *Klebsiella pneumoniae* (19.5%), Staphylococcus aureus (9.5%), *Acinetobacter baumannii* (8.2%), and *Pseudomonas aeruginosa* (7.7%), together representing the major causative organisms in this surveillance dataset.

• Urine specimens contributed the largest proportion of isolates (47.1%), indicating urinary tract infections as the most common source of bacterial isolation, followed by superficial infections (26.4%) and lower respiratory tract infections (14.8%).

• *Staphylococcus aureus* was the leading pathogen in superficial and soft-tissue infections, while *Escherichia coli* and *Klebsiella pneumoniae* predominated in urinary tract infections, reflecting specimen-specific pathogen distribution.

• *Acinetobacter baumannii* and *Pseudomonas aeruginosa* were more frequently isolated from ICU settings, suggesting their strong association with healthcare-associated infections, particularly respiratory and device-related infections.

• Among faecal isolates, diarrhoeagenic *Escherichia coli* was the predominant pathogen (91.9%), with Shigella spp. and Salmonella spp. detected in smaller proportions.

1. Enterobacterales

Highlights of AMR trends

• Enterobacterales constituted 4212 (54.6%) of the 7,722 culture-positive isolates processed during the study period.

• *Escherichia coli* (2029; 26.3%) and *Klebsiella pneumoniae* (1508; 19.5%) were the most frequently isolated pathogens among Enterobacterales.

• The majority of Enterobacterales isolates were obtained from urine samples (58.6%), followed by superficial infection samples (20.2%) and lower respiratory tract specimens (14.3%).

• *E. coli* isolates showed high susceptibility to fosfomycin (92.7%) and amikacin (80.5%). Susceptibility was 71.5% to meropenem and 60.5% to ertapenem, while nitrofurantoin showed 68.3%.

• Lower susceptibility among *E. coli* was observed for third-generation cephalosporins-cefotaxime (14.3%) and ceftazidime (21.9%) - as well as fluoroquinolones, including ciprofloxacin (24.8%) and levofloxacin (29.6%).

• *K. pneumoniae* isolates demonstrated reduced susceptibility to several commonly used antibiotics, including piperacillin-tazobactam (10.4%), imipenem (15.6%), and cefotaxime (20.2%).

• Moderate susceptibility in *K. pneumoniae* was observed for meropenem (48.4%), amikacin (55.2%), and cefoperazone-sulbactam (44.9%), while ceftazidime-avibactam showed 53.6% susceptibility.

• Susceptibility to most antibiotics was higher in OPD isolates compared with ward and ICU isolates, whereas ICU isolates demonstrated the lowest susceptibility rates across most antibiotic classes.

Clinical relevance

• Among Enterobacterales, *E. coli* was the predominant pathogen isolated from urine samples, indicating its major role in urinary tract infections.

• High susceptibility to fosfomycin and good activity of nitrofurantoin support their continued use as first-line agents for uncomplicated cystitis.

• Amikacin and carbapenems may be considered for complicated urinary tract infections and severe systemic infections, particularly where multidrug-resistant Enterobacterales are suspected.

• The low susceptibility to third-generation cephalosporins and fluoroquinolones among both *E. coli* and *K. pneumonia* suggests these agents should be used cautiously for empirical therapy.

• Reduced carbapenem susceptibility in *K. pneumoniae*, particularly among hospital and ICU isolates, highlights the emerging concern of carbapenem-resistant Enterobacterales (CRE) and underscores the need for continuous AMR surveillance and antimicrobial stewardship interventions.

2. Non-fermenting Gram-negative bacteria

Highlights of AMR trends

• Out of 7,722 culture-positive isolates, 1,243 (16.1%) were identified as non-fermenting Gram-negative bacilli (NFGNB). The predominant organisms were *Acinetobacter baumannii* (635; 51%) and *Pseudomonas aeruginosa* (597; 48%), while *Stenotrophomonas maltophilia* accounted for 1% of isolates.

• The majority of NFGNB isolates were recovered from superficial infection samples (35.1%) and lower respiratory tract specimens (34.2%), followed by urine (18.8%) and blood (8%).

• *P. aeruginosa* demonstrated good susceptibility to piperacillin-tazobactam (66.5%) and tobramycin (68.9%), with comparatively high activity also observed with amikacin (67.3%). Ceftazidime-avibactam showed high susceptibility (81.2%), indicating better activity compared to other β-lactams.

• Carbapenem susceptibility in *P. aeruginosa* was variable, with meropenem showing 54.6% susceptibility, whereas imipenem demonstrated lower activity (18.6%).

• Fluoroquinolones such as ciprofloxacin and levofloxacin showed intermediate susceptibility, with overall susceptibility rates of 59.5% and 48.8% respectively, though lower rates were observed in ICU isolates.

• *Acinetobacter baumannii* isolates demonstrated high levels of resistance to most tested antibiotics. The highest susceptibility was observed with minocycline (43.2%), followed by amikacin (31.8%), levofloxacin (29.5%), and piperacillin-tazobactam (26.1%).

• Carbapenem susceptibility in *A. baumannii* was particularly low, with imipenem susceptibility of 8.2% and meropenem susceptibility of 23%, indicating a high prevalence of carbapenem resistance.

• Susceptibility to most antibiotics was higher among OPD isolates, while ICU isolates showed the lowest susceptibility across nearly all antimicrobial agents, reflecting a greater burden of antimicrobial resistance in critical care settings.

Clinical relevance

• Non-fermenting Gram-negative bacilli, particularly *P. aeruginosa* and *A. baumannii*, are important causes of hospital-acquired infections, especially in respiratory, wound, and urinary infections.

• For *P. aeruginosa* infections, antibiotics such as piperacillin-tazobactam, tobramycin, amikacin, and ceftazidime-avibactam demonstrated comparatively better activity and may be considered in appropriate clinical settings based on susceptibility results.

• Carbapenem showed variable activity against *P. aeruginosa* with meropenem demonstrating better effectiveness than imipenem, suggesting the need for susceptibility-guided therapy.

• In *A. baumannii* infections, treatment options are limited due to high resistance to most antibiotics, with minocycline showing relatively better activity compared to other agents.

• The markedly lower susceptibility among ICU isolates highlights the importance of strict infection control practices and antimicrobial stewardship to limit the emergence and spread of multidrug-resistant non-fermenting Gram-negative bacteria.

3. Gram-positive cocci

Highlights of AMR trends

• The proportion of methicillin resistance (based on cefoxitin susceptibility) showed fluctuation over the surveillance period. Susceptibility declined from 31.5% in 2020 to 22.9% in 2021, increased to 42.8% in 2023, and again dropped to 23.4% in 2025, indicating a persistently high burden of MRSA across the years.

• Anti-MRSA agents such as vancomycin and teicoplanin demonstrated excellent in-vitro activity, with nearly 100% susceptibility among MRSA isolates.

• Linezolid susceptibility remained above 98% until 2023, followed by a decline to 80.3% in 2025, which may warrant closer monitoring; moreover, as linezolid is also an important anti-tuberculosis drug; its routine use for *Staphylococcus aureus* infections is discouraged.

• Coagulase-negative Staphylococci (CoNS), often dismissed as mere colonizers, are increasingly recognized as opportunistic pathogens, especially in bloodstream infections, prosthetic device infections, and immunocompromised patients.

• Coagulase-negative Staphylococci (CoNS) showed generally high susceptibility to most antibiotics. Resistance to glycopeptides (vancomycin, teicoplanin) and linezolid was negligible, indicating these remain highly effective treatment options.

• *Enterococcus* spp. without species level identification were the most commonly isolated species (44.6%), followed by *E. faecalis* (29.2%) and *E. faecium* (26.2%). This emphasizes the importance of identifying Enterococcus beyond faecalis and faecium, as some of these species are intrinsically resistant to glycopeptides.

• Vancomycin and linezolid remained highly effective against Enterococcus isolates. Other antibiotics such as tetracycline, tigecycline, and trimethoprim-sulfamethoxazole showed variable activity, highlighting the need for species-level identification and susceptibility testing.

Clinical relevance

• Vancomycin continues to be a reliable empirical therapy for serious MRSA and Enterococcus infections.

• Linezolid remains effective but should be used cautiously due to its importance in tuberculosis treatment.

• Knowledge of species distribution, especially non-faecalis/non-faecium Enterococcus, is important to guide appropriate therapy.

4. Enteric Fever Pathogens

Highlights of AMR trends

• *Salmonella typhi* isolates from blood showed very good susceptibility to ceftriaxone and azithromycin, based on disk diffusion zones.

• Most isolates were highly resistant to fluoroquinolones (ciprofloxacin, nalidixic acid, norfloxacin), indicating limited effectiveness of these drugs.

• Ampicillin and co-trimoxazole showed variable susceptibility among isolates.

• One blood isolate of *S. Typhi* had ceftriaxone resistance, highlighting rare but significant resistance. This is clinically important because ceftriaxone is the first-line intravenous therapy for hospitalized enteric fever cases as resistance in even a single isolate highlights the potential emergence of treatment failure and underscores the need for continued surveillance and susceptibility testing before therapy.

Clinical relevance

• Trimethoprim-sulfamethoxazole and azithromycin remain reliable oral options for enteric fever.

• IV ceftriaxone is appropriate for hospitalized cases.

• Routine use of carbapenems is not warranted for enteric fever treatment.

5. Diarrheal Pathogens (Faecal Isolates)

Highlights of AMR trends

• Only 181 (2.34%) of the total isolates were from stool samples, indicating poor representation of the true burden of bacterial diarrhoea. Other causes, such as viruses, Entamoeba, and parasites, were not included in this report.

• The predominant organisms isolated from stool samples included *Salmonella spp., Shigella spp. (S. sonnei, S. flexneri, S. dysenteriae), and diarrheagenic Escherichia coli.*

Clinical relevance

• Among faecal isolates, AST results demonstrate high resistance to fluoroquinolones (like norfloxacin and ofloxacin) and cephalosporins (like cefixime), indicating that empirical use of these drugs should be avoided.

• Shigella spp. isolates demonstrated good susceptibility to tetracycline (or doxycycline) and azithromycin.

5. INTERPRETATION OF CULTURE AND SUSCEPTIBILITY REPORTS

Introduction: Culture and susceptibility testing is the cornerstone of a successful antimicrobial stewardship program. Unlike biochemical or haematological assays, the processing, interpretation of the growth and reporting rely on the judgement of the microbiologist. The microbiologist in turn relies on the information provided in the test request form and the quality of the specimen to determine the significance of any growth and make a decision on whether to proceed with susceptibility testing.

Interpretation of culture growth

When an obvious pathogen e.g. *Brucella sp.* or *Salmonella sp.* is isolated in culture, their significance is undisputed. However, problem arises as to the significance of a growth when an organism constituting the normal flora (commensal) or a common environmental contaminant is isolated. The type of specimen also determines the significance of a growth, with growth from a normal sterile site like CSF or other body fluids likely to be significant. Interpretation of blood culture, respiratory specimen and urine culture is discussed below as these specimens are more liable to interpretative errors.

Interpretation of a positive blood culture

Organisms whose growth in blood culture represent true blood stream infection include *Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae,* members of the order Enterobacterals, *Pseudomonas aeruginosa* and *Candida sp.*[1] In contrast, growth of viridans group of Streptococcus, Coagulase negative Staphylococci and Enterococcus sp. represents true bacteremia only in 38%, 15% and 78% respectively.[2,3] The non-fermenting Gram negative bacteria including *Acinetobacter sp.* and *Burkholderia sp.* (other than *Burkholderia pseudomallei*) are another group of organisms where the significance of the growth can be hard to predict especially in a hospitalised patient as they are found as common environmental contaminants in the hospital setting. Single culture positive for these organisms usually represent contamination from the skin or the environment. Multiple separate cultures growing the same organism identified to the species level or showing the same susceptibility pattern, are more likely to indicate clinically significant bacteraemia. Growth from a sample collected from a central line may indicate central line colonization alone and should always be paired with a sample drawn from a peripheral venepuncture. When agents associated with bacterial endocarditis is grown, it should be correlated with compatible clinical features.

Interpretation of growth from upper respiratory specimen

Culture of external nares are conducted for the purpose of detection of nasal carriage of methicillin resistant *Staphylococcus aureus* and as such the growth of any other organism including methicillin susceptible strains of *Staphylococcus aureus* is not reported. Group A, C and G beta-haemolytic *Streptococcus, Arcanobacterium haemolyticum, Corynebacterium diphtheriae* and *Neisseria gonorrhoea* are agents implicated in pharyngitis.[3] The growth of *Haemophilus influenzae, Streptococcus pneumoniae* and *Neisseria meningitidis* from a throat

swab indicate a carrier state or colonization and need not be treated except in a patient with epiglottitis.

Interpretation of growth from lower respiratory specimen

Lower respiratory specimens, sputum samples in particular, are liable to contamination with oropharyngeal secretions. Detection of possible pathogen in sputum samples grossly contaminated with saliva may merely reflect oropharyngeal flora. A simple examination of the specimen for presence of < 10 squamous epithelial cells per low power field and presence of inflammatory cells and compatible bacterial morphology in Gram-stained smear indicate the isolate to be clinically significant.[1,3] Another strategy to determine the significance of the growth is to get a simultaneous blood culture drawn. Bacteraemia is observed in 15% of patients with ventilator associated pneumonia (VAP) and blood culture is recommended for all patients suspected of VAP. Growth of same organism in blood and from respiratory specimen confirm the respiratory tract as the source of infection. Semi-quantitative culture of endotracheal aspirates and quantitative culture of broncho-alveolar lavage (BAL) or protected brush specimen (PBS) is recommended for the diagnosis of VAP.[4] It is recommended to withhold antimicrobial for quantitative growth below the threshold level (BAL < 10^4CFU/ml or PBS < 10^3 CFU/ml). Initiation of antimicrobial therapy should be based on clinical criteria alone in a suspected case of VAP, and de-escalated on availability of culture reports.

Interpretation of urine culture

The distal urethra is colonized with different organisms which result in contamination of 5% to as high as 40% of voided urine specimens.[3] The interpretation of urine culture also depends on the type of specimen collected – mid-stream clean catch, catheter, supra-pubic aspirate etc. While the presence of even a single CFU/ml in suprapubic aspirate sample is significant, presence of > 10^5 CFU/ml of possible pathogen is likely to be significant in a mid-stream clean catch specimen. While growth of <10^3 CFU/ml usually indicate contamination, growth with 10^3-10^5 CFU/ml of possible pathogen has to be correlated with clinical findings to determine the significance of the growth. Foley's catheter tip is not acceptable for culture as they are always contaminated with uretheral flora.[1] Screening for asymptomatic bacteriuria is reserved only in pregnant women and prior to urological procedure, asymptomatic bacteriuria otherwise is not an indication for treatment.

Interpretation of susceptibility report

Antimicrobial panel for testing and reporting is prepared according to the specimen site, the organism isolated and local susceptibility pattern according to Clinical and Laboratory Standards Institute (CLSI) Guidelines.[5] The objective of susceptibility testing is to predict the outcome of treatment with the tested antimicrobials. Interpretative categories are determined by comparing against breakpoints recommended by standard institutions like the CLSI or EUCAST (European Committee on Antimicrobial Susceptibility Testing). A '**susceptible**' category indicates inhibition of the organism at an achievable level of the drug at the site of infection. The infection is likely to respond to treatment with the recommended dose and regimen. A '**resistant**' category indicates the organism is not inhibited at achievable

level of the drug and treatment with the agent will likely lead to failure. The '**intermediate**' category indicates a buffer zone for inherent variability in test method. Extreme caution has to be taken in the use of the agent for body compartment infection where drug penetration is restricted even in presence of inflammation e.g., meningitis. A '**susceptible-dose-dependent (SDD)**' category indicates necessity of giving a higher dose and dosing regimen which will provide higher drug exposure. SDD category is available for the agents cefepime and piperacillin-tazobactam used against infection by organisms belonging to Enterobacterals, and for ceftaroline against *Staphylococcus aureus*. Table 47 give the standard dose for susceptible strains and dose modification for SDD strains for applicable agents according to CLSI guideline.

Table 47: Standard dose for susceptible strains and dose modification for susceptible dose-dependent strains according to CLSI guidelines

Antimicrobial agent	Susceptible		Susceptible Dose Dependent	
	MIC	Standard dose	MIC	SDD dose
Cefepime	≤ 2µg/ml	1 g every 12 hours	4 µg/ml	1 g every 8 hourly or 2 g every 12 hourly
			8 µg/ml or zone 19-24 mm*	2 g every 8 hourly
Piperacillin-Tazobactam	≤ 8/4 µg/ml	3.375 – 4 g every 6 hour as 30 min infusion	16/4 µg/ml	4.5 g every 6 hour as a 3-hour infusion or, 4.5 g every 8 hour as a 4-hour infusion
Ceftaroline	≤ 1 µg/ml	600 mg every 12 hours	2-4 µg/ml	600 mg every 8 hours administered over 2 hours

*Zone diameter cannot be exactly correlated with MIC value. An isolate with zone diameter in SDD zone should be treated as if it might be MIC 8 µg/ml.

Testing of an agent can predict results of closely related agents in the same class as cross-resistance and cross-susceptibility is nearly complete. Laboratories may report results of only one drug in this case. Table 48 give a list of equivalent agents according to CLSI guidelines.

Table 48: List of equivalent antimicrobial agents for susceptibility testing according to CLSI guidelines

Antimicrobial agents	Organism
Cefotaxime or Ceftriaxone	Enterobacterals
Colistin or Polymyxin B	Enterobacterals, *Pseudomonas aeruginaosa, Acinetobacter baumannii* complex
Azithromycin or Clarithromycin or Erythromycin	*Staphylococcus sp.*
The result of Ampicillin susceptibility is used to predict activity of Amoxicillin	*Haemophilus sp.* and Anaerobes

Repeat testing for resistance detection

Repeat testing of subsequent isolates from the same anatomical site is done to detect development of resistance on treatment. The risk of resistance development is higher with longer period of follow-up and some bug-drug combinations are more prone to development of resistance than others. Development of resistance within 3 to 4 days of treatment has been most notably detected in *Enterobacter sp., Klebsiella aerogenes, Citrobacter* and *Serratia sp.* with third generation cephalosporins, *Pseudomonas aeruginosa* with most antimicrobials and *Staphylococcus sp.* with fluoroquinolones.[6] Prolonged treatment of *Staphylococcus aureus* infection with vancomycin can lead to development of intermediate resistance against vancomycin. Clinical exposure to ceftazidime-avibactam and meropenem-varbobactam for treatment of carbapenem resistant Enterobacterals result in resistance development in approximately 10-20% and 3% of patients respectively.[7] Decision to repeat testing should be determined by clinical judgement and testing is indicated if clinical response is lower than expected under treatment. Susceptibility testing for patients on newer beta-lactams should be repeated if the patient present with sepsis-like picture suggestive of new or relapsed infection.

Indications for change of therapy

Empiric therapy may need to be changed based on availability of susceptibility testing result. For a patient with uncomplicated cystitis on treatment, if clinical improvement occurs, there is no need to change the antibiotic regimen even when the agent the patient is on shows resistance on testing. However, for all other infections, if the organism is resistant to the empiric antimicrobial agent used, treatment should be changed to another agent showing susceptibility and a full treatment course should be given counting from the day the active agent is started. Considerations on safety, cost and availability should be given when choosing an agent when the organism is equally susceptible to more than one antimicrobial agents.[7] De-escalation to oral therapy can be considered when the following criteria are met:

1. Susceptibility to an oral agent is demonstrated
2. The patient is haemodynamically stable
3. Reasonable source control measures have occurred and
4. Concerns about insufficient intestinal absorption are not present

Use of MIC (minimum inhibitory concentration) data for therapy

In recent years, efforts have been made to incorporate MIC data in choosing appropriate antimicrobial agent especially for treating infections in critical care patients. The aim is to choose the agent with the most favourable pharmacodynamic effect. Breakpoint to MIC quotient (BMQ) is a recent parameter which has come in vogue to determine this effect.[8] BMQ is calculated as the ratio of the susceptibility breakpoint of the drug for the organism group divided by the MIC of the isolate. The BMQ is inversely correlated with the minimum bactericidal concentration, with higher BMQ correlating with more bactericidal effect. The application of this parameter is limited in practice because of the restricted range of drug concentration which is usually tested to give a categorical interpretation.

Role of diagnostic stewardship

The correct interpretation of a culture and susceptibility report, while critical, represents only one of many decision points within the broader framework of diagnostic stewardship. Diagnostic stewardship serves as a vital complement to antimicrobial stewardship, fundamentally ensuring that the right test is ordered for the right patient at the right time.[9] To achieve this, diagnostic tests should be tailored to the pre-test probability of disease. The implementation of diagnostic stewardship enhances diagnostic accuracy and ensures that results are clinically relevant for guiding treatment. Following an appropriate test choice, optimal specimen collection is paramount; samples that are unfit for purpose - such as Foley catheter tip cultures for diagnosing urinary tract infections - should be rejected to prevent misleading results. Furthermore, diagnostic stewardship leverages the microbiologist's expertise to refine *what* is reported and *when*. This is often operationalized through selective and cascade reporting, a strategy where the laboratory effectively "nudges" prescribers toward narrower, targeted therapy by prioritizing the reporting of susceptible narrow-spectrum agents over broader alternatives.

Very importantly, for an effective antimicrobial management of a patient and by extension, for a successful stewardship program, the importance of communication and co-operation between the treating physician and the clinical microbiologist cannot be emphasised enough. This process should start right from deciding appropriate tests to uncompromised sample collection and continue beyond the despatch of the culture and susceptibility report.

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6. MANAGEMENT OF SEPSIS AND SEPTIC SHOCK

Introduction and definition: Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection. Timely identification of sepsis is the single most important step in reducing mortality. Delays in recognition are associated with a 7–10% increase in mortality for each hour of delay in antibiotic administration in septic shock.

The Third International Consensus Definitions (Sepsis - 3, 2016) gives clinical criteria to aid clinicians in distinguishing sepsis and septic shock from uncomplicated infection without any organ dysfunction. The presence of septic shock increases in-hospital mortality by > 40% .[1]

Table 49. Sepsis-3 Definitions of infection, sepsis and septic shock (Singer et al., JAMA 2016)

Term	Definition/Criteria
Infection	Suspected or documented invasion of normally sterile tissues by microorganisms
Sepsis	Life-threatening organ dysfunction (SOFA score increase ≥ 2 points) due to a dysregulated host response to infection
Septic Shock	Sepsis with: (a) Vasopressor requirement to maintain MAP ≥ 65 mmHg, and (b) Serum lactate > 2 mmol/L despite adequate fluid resuscitation

Screening Tools for identification of sepsis/septic shock

The quick Sequential Organ Failure Assessment (qSOFA) provides a rapid bedside screen. However, it has low sensitivity and the full SOFA score and clinical gestalt remain paramount.

Table 50. qSOFA and SOFA scoring systems for screening and assessment of sepsis

qSOFA Score (1 point each)	SOFA Score – Organ Systems Assessed
Altered mentation (GCS < 15) Respiratory rate ≥ 22 breaths/min Systolic BP ≤ 100 mmHg	Respiratory (PaO2/FiO2 ratio) ≤ 300 GCS < 15 SBP ≤ 100 mmHg Platelets ≤ 150 k/µL Bilirubin ≥ 1.2 mg/dL Serum creatinine ≥ 1.2 Mechanical ventilation Vasopressors (present/absent) Vasopressors (more than one)
Score ≥ 2 suggests sepsis with high mortality risk; escalate care	SOFA score of ≥ 2 = organ dysfunction = Sepsis

Red Flag Features Warranting Immediate ICU Assessment

- Lactate ≥ 2 mmol/L (tissue hypoperfusion)
- Systolic BP < 90 mmHg or MAP < 65 mmHg not responsive to initial fluid bolus
- Acute altered mental status or new onset confusion

- Respiratory rate > 30/min or SpO2 < 90% on room air
- Urine output < 0.5 mL/kg/hour for > 2 hours
- Creatinine > 2 mg/dL or bilirubin > 2 mg/dL (acute rise)
- Platelet count < 100,000/mm3 (acute)

Immediate evaluation for management of Sepsis

Securing the airway and obtaining venous access are immediate priorities in managing patients with sepsis and septic shock, as they allow for the prompt delivery of fluids and antibiotics. At the same time, a focused clinical history and examination should be performed, along with necessary laboratory, microbiological and imaging studies (ideally within 45 minutes of presentation).

Table 51. Immediate Laboratory Investigations in suspected sepsis and their clinical priorities

Test	Purpose in Sepsis	Priority
Blood cultures (×2)	Identify causative organism and sensitivity	STAT - before antibiotics
Serum lactate	Tissue hypoperfusion marker; prognostic; bundle trigger	STAT
Procalcitonin (PCT)	Bacterial infection marker; antibiotic stewardship	STAT (if available)
CRP	Inflammatory marker; less specific than PCT	Urgent
Complete blood count with differential	Leucocytosis/leucopenia, thrombocytopenia	STAT
Renal function (BUN, Creatinine)	Acute kidney injury (AKI) assessment; antibiotic dose adjustment	STAT
Liver function tests	Hepatic dysfunction; cholestatic sepsis	Urgent
Coagulation (PT, aPTT, D-dimer)	DIC screening	Urgent
ABG (arterial blood gas)	Acid-base, oxygenation, ventilation	STAT
Blood glucose	Hypoglycaemia / hyperglycaemia	STAT
Urine C&S, urinalysis	Urosepsis identification	STAT
Chest X-ray / CT (as indicated)	Pneumonia, effusion, source identification	Urgent
Malaria RDT / smear	High priority in Manipur (malaria-endemic area)	STAT in febrile patients
Scrub typhus / leptospira serology	Relevant to NE India endemic pathogens	Urgent

Role of blood cultures in sepsis management

Blood cultures remain the gold standard for identifying the causative pathogen and directing targeted therapy. A minimum of two sets of blood cultures (aerobic and anaerobic) from two separate venepuncture sites is advised before antibiotic initiation when logistically feasible without causing a delay of more than 45 minutes. Each set should contain 10 mL of blood per bottle to maximise sensitivity.[2] Always obtain cultures from indwelling catheters and peripheral sites separately if catheter-related bloodstream infection is suspected.

At RIMS, Imphal, blood culture positivity rate is approximately 18–25% in clinical sepsis cases based on departmental audit data, with Gram-negative organisms predominating (~ 65%), followed by Gram-positive organisms (~ 25%) and Candida spp. (~10%).

Contaminant organisms (Coagulase-negative Staphylococci, Bacillus spp.) should be interpreted in context. Blood cultures should be repeated in 48-72 hours if patient is clinically deteriorating despite antibiotic therapy or if initial cultures are negative.

Initial resuscitation measures for Sepsis and Septic Shock

1. Fluid Resuscitation

Rapid administration of intravenous (IV) fluids is a key component in the management of sepsis. IV fluids are given to correct hypovolemia and restore tissue perfusion, thereby improving the delivery of oxygen to cells.

Choice of fluid:

- SSC 2021 recommends balanced crystalloids (such as Ringer's Lactate or Plasma-Lyte) over 0.9% normal saline for large-volume resuscitation, given evidence of reduced hyperchloraemic acidosis and acute kidney injury. Administer IV crystalloid at 30 mL/kg within the first 3 hours for hypotension or lactate $\geq$ 4 mmol/L. Reassessment should be done response after each 250–500 mL fluid bolus using clinical indicators such as resolution of tachycardia, improvement in MAP, urine output, and lactate clearance.
- Avoid fluid administration beyond initial resuscitation in patients without haemodynamic instability. Positive fluid balance >4-6 litres at 24 hours is independently associated with increased mortality.
- SSC 2021 recommends against colloids (particularly HES/starches) and gelatin for fluid resuscitation in sepsis due to potential harm.
- Albumin (4–5%) may be considered in patients who have received large volumes of crystalloid (> 3 litres).

2. Haemodynamic Goals of Resuscitation

The primary resuscitation goal is restoration of adequate tissue perfusion, as evidenced by MAP $\geq$ 65 mmHg, lactate clearance, and resolution of clinical signs of hypoperfusion. The ANDROMEDA-SHOCK trial supports targeting capillary refill time as a complement to lactate-guided resuscitation, potentially reducing fluid overload.[2,3,4]

3. Antimicrobial Therapy in Adults with sepsis/septic shock

Sepsis can arise from both community-acquired and hospital-acquired infections. Thus the choice of empirical antibiotics depends on the suspected site of infection, location of infection onset (community or hospital acquired), patients medical history and local microbial susceptibility pattern. Empirical antibiotic therapy must begin within 1 hour of recognition of septic shock. For sepsis without shock, therapy should begin within 3 hours.

Table 52. RIMS Antibiogram 2025: Estimated resistance patterns and preferred empirical agents in sepsis pathogens[5]

Organism	Common Source	Key Resistance Pattern*	Effective Agents*
E. coli	BSI, UTI, IAI	ESBL ~ 60%; FQ ~55%	Meropenem, Piperacillin-Tazobactam (if non-ESBL)
K. pneumoniae	BSI, HAP, IAI	ESBL ~55%; CR ~30%	Meropenem (if non-CR); Polymyxin-B + Meropenem (if CR)
A. baumannii	HAP, VAP, BSI	CRAB ~ 65–70%	Polymyxin-B + Carbapenem; Tigecycline (limited BSI use)
P. aeruginosa	HAP, VAP, BSI	Pip-Taz R ~ 40%; CR ~35%	Piperacillin-Tazobactam (if sensitive); Meropenem
S. aureus (MRSA)	BSI, SSTI, pneumonia	Methicillin R ~ 35%	Vancomycin; Teicoplanin; Linezolid (oral)
Enterococcus spp.	BSI, UTI, IAI	Ampicillin R ~ 30%; VRE ~ 5%	Vancomycin (VSE); Linezolid/Daptomycin (VRE)
Candida spp.	BSI (catheter-related, post-surgical)	C. krusei/glabrata: azole R	Echinocandin (Micafungin/Anidulafungin); Fluconazole (if non-resistant)

RIMS Antibiogram 2025 - Estimated Resistance Rates among Blood-Culture Isolates
**Approximate percentages based on departmental microbiology audit and published RIMS data. BSI – Bloodstream infection; HAP – Hospital-acquired pneumonia; VAP – Ventilator-associated pneumonia; IAI – Intra-abdominal infection; UTI – Urinary tract infection; SSTI = Skin & soft tissue infection; ESBL = Extended-spectrum beta-lactamase; FQ = Fluoroquinolone; CR = Carbapenem resistant; CRAB = Carbapenem-resistant Acinetobacter baumannii; VRE = Vancomycin-resistant Enterococcus.*

Table 53.Empirical Antimicrobial Regimens for Sepsis of Unclear Source (Normal Renal Function) based on ICMR 2025 guideline[6]

Patient Category	First-Line Regimen	Alternative (MDR Risk / Allergy)	Comments
Community-acquired sepsis, no risk for MDR	Piperacillin-Tazobactam 4.5 g IV q6h + Amikacin 15 mg/kg/day (single daily dose)	Ceftriaxone 2 g IV OD + Metronidazole 500 mg IV q8h (if intra-abdominal source)	ICMR 2025 & RIMS antibiogram: ESBL prevalence ~55–60% makes 3rd-gen cephalosporins unreliable for empirical monotherapy

Hospital-acquired / ICU sepsis, MDR risk factors*	Meropenem 1 g IV q8h + Amikacin 15 mg/kg/day	Imipenem-Cilastatin 500 mg IV q6h + Amikacin	Reserve carbapenems for confirmed ESBL or risk for MDR-GN; avoid routine empirical carbapenem for community sepsis to conserve the drug class
Suspected MRSA (e.g. SSTI, catheter-related)	Add Vancomycin 25–30 mg/kg/day IV (divided q12h; target trough 15–20 mcg/mL OR AUC/MIC 400–600)	Teicoplanin 400 mg IV q12h × 3 doses, then 400 mg/day; or Linezolid 600 mg IV/PO q12h	Do not use Vancomycin routinely unless MRSA risk factors present; nephrotoxicity monitoring essential
CRAB suspected (VAP, prolonged ICU stay, prior carbapenem)	Polymyxin-B 1.5–2.5 mg/kg/day IV (divided q12h) + Meropenem 2 g IV q8h (extended infusion 3–4h)	Polymyxin-B + Tigecycline 100 mg loading then 50 mg q12h (not for BSI as primary indication)	Polymyxin nephrotoxicity and neurotoxicity monitoring essential. Daily renal function monitoring. Tigecycline inferior in BSI - use only in combination
Suspected candida sepsis (risk factors†)	Micafungin 100 mg IV OD Or Anidulafungin 200 mg loading then 100 mg OD	Fluconazole 800 mg loading then 400 mg OD if haemodynamically stable and no prior azole exposure	Risk factors†: prolonged ICU, TPN, broad-spectrum antibiotics, renal replacement therapy, abdomen surgery, prior Candida colonisation. Confirm with blood culture, beta-D-glucan, fungal susceptibility

*Empirical Antimicrobial Therapy for Sepsis of Unclear Source for Adults with Normal Renal Function *MDR risk factors: hospitalisation >5 days, prior antibiotics in last 90 days, ICU admission, immunosuppression, indwelling devices. Doses are for adults with normal renal function (eGFR >60 mL/min/1.73m²). Dose adjust if renal impairment. All regimens are empirical; de-escalate as per culture/sensitivity results.*

Infection Control, Respiratory Support and General Supportive Care

1. The following steps outline the role of infection control measures in the management of sepsis and septic shock.

- Strict hand hygiene – 5 moments WHO compliance; alcohol-based hand rub at every patient encounter.
- Contact and droplet precautions for MRSA, CRAB, CRKP and VRE.
- Dedicated nursing assignments for MDR patients; patient cohorting during outbreaks.

- Bundle care for central venous catheters (CVCB): maximal sterile barrier, chlorhexidine skin antisepsis, subclavian preference, daily review of catheter necessity.
- Ventilator-associated event (VAE) bundle: head-of-bed elevation 30–45°, daily sedation vacation, oral care with chlorhexidine, subglottic secretion drainage.
- Source control: Drain abscesses, remove infected foreign material (catheters, prostheses) within 6-12 hours of identification. This is a critical and often under-emphasised component of sepsis management.
- Antimicrobial stewardship programme (AMSP): Mandatory review of all patients receiving carbapenems, polymyxins and vancomycin at 48-72 hours with the clinical microbiologist is emphasized.

2. Respiratory Support

Respiratory failure is the most frequent organ dysfunction in sepsis, and management is guided by the severity of hypoxaemia:

Table 54. Respiratory support strategies in sepsis-induced hypoxaemia respiratory failure

Severity	SpO2 / PaO2 Criterion	Intervention
Mild hypoxaemia	SpO2 88–94% on room air	Nasal cannula O2 (2–6 L/min) or face mask
Moderate hypoxaemia	SpO2 < 90% on low-flow O2	High-Flow Nasal Oxygen (HFNO) - SSC 2021 preferred over NIV for hypoxaemic respiratory failure
Severe ARDS	PaO2/FiO2 < 150 mmHg	Invasive mechanical ventilation: low tidal volume (6 mL/kg IBW), PEEP titration, prone positioning if P/F <150
Refractory ARDS	PaO2/FiO2 < 80 mmHg on FiO2 1.0	VV-ECMO if available in experienced centre (SSC 2021- weak recommendation)

3. General supportive care is recommended as follows:

- Thromboprophylaxis: LMWH (Enoxaparin 40 mg SC OD) preferred over UFH; mechanical compression devices if anticoagulation is contraindicated.
- Stress ulcer prophylaxis: Pantoprazole 40 mg IV OD for mechanically ventilated patients; avoid routine PPI in non-ventilated patients.
- Blood glucose control: Target 140–180 mg/dL using insulin infusion. Avoid hypoglycaemia.
- Sedation and analgesia: Analgesia-first approach (fentanyl or morphine). Minimise sedation; daily sedation holidays. Prefer dexmedetomidine or propofol over benzodiazepines for sedation.
- Renal replacement therapy (RRT): For severe AKI with refractory fluid overload, refractory acidaemia, or hyperkalaemia. Continuous RRT preferred in haemodynamically unstable patients.
- Delirium: CAM-ICU assessment twice daily; minimise benzodiazepines; early physiotherapy; maintain sleep - wake cycle.

4. Nutrition:

Early enteral nutrition (within 24–48 hours of ICU admission) is generally recommended, provided hemodynamic are stabilised. Avoid parenteral nutrition in the first 7 days if enteral route is feasible. Ensure selenium and thiamine supplementation (the latter particularly relevant given the high alcohol use disorder burden in the North-East region).

Management of patients who failed initial therapy

1. Role of vasopressors

Vasopressors should be started when mean arterial pressure (MAP) remains below 65 mmHg despite adequate fluid resuscitation (30 mL/kg crystalloid along with dynamic assessment). To avoid delays while obtaining central access, vasopressors may be initiated through a peripheral line. However, peripheral administration should be restricted to no more than 6 hours and delivered via a large, proximal vein.[2]

Table 55. Vasopressor selection and recommended dosing in septic shock (SSC 2021 Recommendations)

Agent	Starting Dose	Role	Notes (SSC 2021)
Nor-epinephrine	0.01- 0.05 mcg/kg/min; titrate to MAP ≥ 65 mmHg	First line	Strong recommendation. Drug of choice in septic shock.
Vasopressin	0.03 units/min IV fixed dose	Second-line add-on	Add when NE ≥ 0.25 mcg/kg/min. Catecholamine-sparing effect. Reduces NE dose requirements.
Epinephrine	0.01- 0.05 mcg/kg/min	Third-line/ alternative	Alternative if NE unavailable. Risk of tachycardia and lactic acidosis. Use with caution.
Dopamine	5-20 mcg/kg/min	Alternative if NE unavailable	Higher risk of arrhythmias. SSC 2021: avoid unless NE unavailable. High-dose only for vasopressor effect.
Angiotensin II	20 ng/kg/min; titrate	Adjunct in refractory shock	SSC 2021: very low quality evidence. Not routinely recommended. Limited availability in India.

2. Glucocorticoids (Corticosteroids)

For adults with septic shock who continue to require vasopressors (particularly at doses ≥ 0.25 mcg/kg/min for ≥ 4 hours), IV glucocorticoids is suggested. The recommended regimen is hydrocortisone 200 mg/day IV (given as 50 mg every 6 hours OR as a continuous infusion of 200 mg over 24 hours). This accelerates resolution of shock by approximately 1.5 days and reduces vasopressor requirement. Mortality benefit remains unclear from individual RCTs, though meta-analyses suggest a modest benefit in early shock resolution.[7]

3. Inotropic Therapy (Dobutamine)

Dobutamine (2.5-20 mcg/kg/min) as an adjunct to NE (Nor Epinephrine) is indicated when there is evidence of cardiac dysfunction (low cardiac output state) despite adequate MAP and fluid resuscitation.

4. Red Blood Cell (RBC)

Transfusion may be advised when haemoglobin falls below 7 g/dL. A higher threshold of 8-9 g/dL may be appropriate in patients with active myocardial ischaemia or severe hypoxaemia. Platelet transfusion is advised if < 10,000/mm3 (regardless of bleeding) or <20,000/mm³ with significant bleeding risk. For invasive procedures, maintain platelets >50,000/mm³.

5. Intravenous Immunoglobulin (IVIG)

The available RCT data do not demonstrate consistent mortality benefit, however IVIG may be considered on a case-by-case basis for specific indications e.g., confirmed streptococcal toxic shock syndrome or necrotising fasciitis.

Supportive ICU Care

Patients with confirmed or suspected septic shock, SOFA ≥2, or failure to respond to initial resuscitation within 2 hours should mandatorily be managed in the ICU.

Echocardiography (bedside POCUS) for cardiac function and fluid responsiveness assessment is recommended for patients who fail initial resuscitation.

Monitoring Treatment Response in Sepsis and Septic Shock

Serial monitoring of clinical, hemodynamic, and laboratory parameters is essential to evaluate the trajectory of response and guide therapeutic adjustments for treatment.

Table 56. Monitoring parameters and treatment response assessment in sepsis and septic shock

Parameter	Frequency	Interpretation / Action
Serum Lactate	Every 2 hours until < 2 mmol/L	Lactate clearance ≥ 10% per 2 hours = adequate resuscitation; failure = reassess fluids, vasopressors, cardiac output
MAP	Continuous (arterial line) or q30 min	Target ≥ 65 mmHg; escalate vasopressor if below target
Urine Output	Hourly	Target ≥ 0.5 mL/kg/h; persistent oliguria despite MAP ≥ 65 = AKI, consider RRT
Procalcitonin (PCT)	Every 48 hours	Falling PCT = response to treatment; plateau/rise = treatment failure, consider resistant organism, consider source control failure

Blood Cultures	Baseline; repeat at 48-72h if no improvement	Identify causative pathogen; direct targeted therapy
SOFA Score	Daily	Improving SOFA = treatment response; rising SOFA = organ failure progression = reassess all management
Capillary Refill Time	Every 2 hours (initial resuscitation)	Target ≤ 2 seconds; adjunct to lactate monitoring (SSC 2021)
Vasopressor requirement	Continuous	Weaning vasopressors signals improvement; escalation suggests refractory shock
Clinical examination	4-6 hourly	Assess consciousness (GCS), skin perfusion, abdominal exam for occult source

De-escalation of treatment in Septic Shock

De-escalation should be assessed at 48-72 hours after initiation of empirical therapy. When culture results identify a specific organism and susceptibility pattern, narrow the antibiotic spectrum to the most targeted effective agent. Duration of antibiotic therapy is usually 7 days but should ideally be individualized. If blood cultures are negative at 48-72 hours and the patient is clinically improving, discontinue broad-spectrum agents and reassess antimicrobial necessity. Consider converting IV to oral antibiotics in clinically stable patients with a functioning GI tract, no concerns about absorption, and an oral equivalent available.[8]

Procalcitonin-guided cessation (PCT < 0.25 ng/mL or > 80% fall from peak) can safely shorten antibiotic duration although supporting evidence is limited (ICMR 2025, SSC 2021). Avoid prolonged courses without specific indications (e.g., endocarditis, osteomyelitis).[9,10]

Recent Advances in the Management of Sepsis and Septic Shock

1. Biomarker-Guided Therapy

Soluble triggering receptor expressed on myeloid cells-1 (sTREM-1), presepsin, midregional pro-adrenomedullin (MR-proADM), and cell-free DNA are under active investigation. Of these, MR-proADM shows particular promise for predicting 28-day mortality and guiding disposition decisions.

2. Artificial Intelligence and Sepsis Prediction Algorithms

Machine learning models (e.g., the Sepsis Immunology in the ICU - MERCS score; Hospital-acquired Sepsis Alert systems) can predict sepsis onset 6-12 hours before clinical recognition with sensitivities of 75-85% and specificities of 80-90%. SSC 2021 acknowledges machine learning as the most accurate current method for sepsis identification, superior to qSOFA and SIRS criteria alone. Electronic alert systems integrated with electronic health records (EHRs) are recommended.

3. Source Control Innovations

The principle of aggressive source control remains central to sepsis management. Minimally invasive techniques are increasingly preferred over open surgery as they reduce the physiological insult in an already compromised patient.

4. Immunotherapy in Sepsis

Sepsis is characterised by a paradoxical combination of initial hyper-inflammation and subsequent immunosuppression (the 'immunoparalysis' phase). Phase II and III trials are ongoing for immunostimulatory agents such as IL-7, anti-PD1 antibodies (pembrolizumab, nivolumab), and GM-CSF in the immunosuppressed phase. No current recommendation for clinical use exists outside of clinical trials.

5. Novel Antimicrobials and Combination Strategies

Ceftazidime-Avibactam (Caz-Avi) represents a major advance for treating carbapenem-resistant Enterobacterales (CRE) producing KPC or OXA-48 enzymes. While limited data exist for metallo-beta-lactamase (MBL/NDM) - producing organisms (which are prevalent in India), Aztreonam-Avibactam (in combination with Caz-Avi) shows promise. Cefiderocol, a siderophore cephalosporin, is active against most MDR-Gram-negatives including CRAB and provides an emerging option for pan-resistant organisms. These agents should be reserved for confirmed MDR/XDR infections in consultation with a clinical microbiologist, given their high cost and the need to preserve activity.

6. Post-Sepsis Syndrome and Long-Term Recovery

Sepsis survivors face significant long-term morbidity - post-intensive care syndrome (PICS) encompasses physical debilitation, cognitive impairment, and psychological sequelae including PTSD and depression. SSC 2021 introduced 12 new recommendations addressing these long-term outcomes.

Conclusion: Sepsis and septic shock remain among the most challenging and time-sensitive emergencies encountered in the wards and ICUs of Regional Institute of Medical Sciences, Imphal (RIMS). The RIMS Antibiogram 2025 reveals a high weightage of ESBL-producing Enterobacterales and carbapenem-resistant organisms, which necessitates not only an empirical carbapenem use for hospital-acquired sepsis but also a combination approach for suspected CRAB infections. These guidelines aim to provide a clear, actionable and locally-contextualised recommendations that serve as a living document to be updated annually as resistances patterns evolve.

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7 A. INFECTIONS IN GENERAL MEDICINE

1. Tropical Infections: Tropical infections are predominantly vector-borne or viral, hence antibiotics are not routinely indicated (e.g., dengue). Empirical therapy should be syndrome-based, targeting likely pathogens such as Salmonella.[1] Based on regional antibiogram trends, there is increasing fluoroquinolone resistance in enteric fever, with preserved sensitivity to ceftriaxone and azithromycin, while carbapenems are reserved for XDR strains.[2,3] Judicious use of macrolides is essential to prevent emerging resistance.[3]

a. Dengue (viral illness)

As dengue is caused by a virus, antibiotics are not indicated and management is entirely supportive.

b. Scrub typhus (Orientia tsutsugamushi)[3]

- First-line therapy is doxycycline 100 mg twice daily for 7-14 days, which leads to rapid defervescence.
- In pregnancy, azithromycin 500 mg once daily for 3-5 days is preferred due to safety.

c. Typhoid fever (Salmonella typhi/paratyphi)[3,4]

Uncomplicated cases

- Cefixime 200 mg twice daily for 10-14 days
- Cotrimoxazole 160/800 mg twice daily for 10-14 days
- Azithromycin 500 mg once daily for 5-7 days

Multidrug-resistant (MDR)

- Ceftriaxone 2 g IV once daily for 10–14 days

Extensively drug-resistant (XDR)[3]

Resistant to chloramphenicol, ampicillin, co-trimoxazole, fluoroquinolones & third-generation cephalosporins (defining feature), leaving very limited options.

- Azithromycin is currently the drug of choice for uncomplicated XDR typhoid in India
- Dose: 10-20 mg/kg/day (max 1 g/day) orally for 7 days

For Severe/Complicated XDR Typhoid[3]

- Meropenem (carbapenem) is the treatment of choice when oral therapy not feasible or patient is toxic
- Dose: 20 mg/kg/dose IV every 8 hours (60 mg/kg/day) for 10-14 days

Although Azithromycin is effective in typhoid fever, it should be prudently used to preserve its efficacy against extensive drug resistant strains.[1,2]

d. Tuberculosis

Treatment based on Central TB Division. National Tuberculosis Elimination Programme: Technical and Operational Guidelines. New Delhi: Ministry of Health and Family Welfare, Government of India; 2022 (updated 2025).

2. Infections of the Gastrointestinal System: Most acute diarrheal illnesses are self-limiting and viral, and indiscriminate antibiotic use should be avoided.[1] Antibiotics are reserved for specific indications such as dysentery, cholera or immune-compromised states.[2] Institutional antibiogram data support third-generation cephalosporins for SBP, while metronidazole remains effective for anaerobic and protozoal infections.[5] Rising resistance among enteric Gram-negative organisms necessitates culture-guided therapy whenever feasible.

a. Acute watery diarrhea (mostly viral)

- Typically self-limiting; antibiotics are not required unless high-risk features are present.

Clostridioides difficile infection

- Oral vancomycin 125 mg four times daily for 10 days is the treatment of choice.

b. Acute bloody diarrhea (invasive bacterial)

Empirical therapy includes:

- Ciprofloxacin 500 mg twice daily for 3 days, or
- Azithromycin 500 mg once daily for 3 days, or
- Cefixime 200 mg twice daily for 5 days
- Antibiotics must be avoided in shiga toxin- producing E. coli due to risk of HUS.

c. Amoebic dysentery (Entamoeba histolytica)

- Metronidazole 400 mg three times daily for 7-10 days, or
- Tinidazole 2 g once daily for 3 days

d. Spontaneous bacterial peritonitis[6]

Common pathogens include gut bacteria such as E. coli, Klebsiella spp. and Streptococcus spp. Third-generation cephalosporins (e.g., cefotaxime 2 g IV thrice daily or ceftriaxone 2 g IV once daily) are the standard first-line agents duration of 10 to 14 days course. A repeat peritoneal fluid analysis is recommended to verify declining PMN counts and sterilization of the ascitic fluid.

e. Helicobacter pylori infection[7]

For treatment-naive patients with H. pylori infection, bismuth quadruple therapy (BQT) for 14 days is the preferred regimen when antibiotic susceptibility is unknown. BQT consists of a proton-pump inhibitor (PPI), bismuth, a nitroimidazole and tetracycline.

Key change from Prior Guidelines: The 2024 ACG guideline reinforces the importance of using non-clarithromycin-based regimens for both initial and salvage treatment of H. pylori infection, due to increasing resistance to clarithromycin and levofloxacin which have lowered the effectiveness of standard treatments. It also recommends the use of potassium-competitive acid blockers (PCABs) in dual or triple therapy regimens as first-line treatment options. Treatment-Experienced Patients (Salvage Therapy) optimized BQT is conditionally suggested in those who have not yet tried this regimen. If patients have a prior history of optimized BQT, rifabutin triple therapy is then suggested.

3. Infections of the Genitourinary System: UTIs are among the most common bacterial infections, predominantly caused by Enterobacteriaceae.[5] Local antibiogram trends show high resistance to fluoroquinolones and cotrimoxazole, making nitrofurantoin and fosfomycin preferred for uncomplicated cystitis.[4,8] For complicated infections or pyelonephritis, aminoglycosides or carbapenems may be required depending on severity. Therapy should always consider renal function, prior antibiotic exposure and local resistance patterns.

a. Acute uncomplicated cystitis

Preferred narrow-spectrum therapy:

- Fosfomycin 3 g single dose, or
- Nitrofurantoin 100 mg twice daily for 5 days
- These agents are favored due to low resistance and minimal collateral damage

b. Acute pyelonephritis

Requires systemic therapy:

- Amikacin 1 g once daily for 7 days, or
- Meropenem 1 g IV every 8 hours for 10-14 days
- Choice depends on severity and resistance profile.[6]

4. Infections of the Central Nervous System: CNS infections require urgent empirical therapy due to high morbidity and mortality.[1] Empirical regimens are designed to ensure adequate CSF penetration and broad pathogen coverage, typically combining third-generation cephalosporins with vancomycin. De-escalation should follow microbiological results.[9] In TB-endemic settings, early initiation of anti-tubercular therapy is critical in suspected TB meningitis. Antimicrobial choice must balance efficacy with neurotoxicity risks.

a. Acute bacterial meningitis

Empirical therapy should be initiated urgently:

- Ceftriaxone 2 g IV every 12 hours for 10-14 days, or
- Cefotaxime 2 g IV every 6-8 hours + Vancomycin 15-20 mg/kg every 8 hours
- Duration may extend to 21 days for resistant or gram-negative infections

b. Herpes simplex encephalitis

- Acyclovir 10 mg/kg IV every 8 hours for 14-21 days
- Early initiation is critical to reduce mortality

c. Brain abscess

Broad-spectrum therapy:

- Ceftriaxone 2 g IV every 12 hours or Cefotaxime 2 g IV every 6 hours, plus
- Metronidazole 500 mg IV every 8 hours, or
- Meropenem 1 g IV every 8 hours
- Duration: 3-12 weeks, depending on response and imaging[1,9]

5. Infections of the Cardiovascular System: Infective endocarditis and related infections require prolonged, bactericidal and often combination therapy.[10] Treatment is guided by organism identification and susceptibility patterns, but empiric therapy should cover streptococci, staphylococci and enterococci. Local antibiogram data indicates persistent MRSA prevalence, necessitating vancomycin or equivalent agents when risk factors are present.[11] Strict adherence to guideline-directed therapy is essential to prevent complications and relapse.

a. Infective endocarditis (native valve)

Prolonged bactericidal therapy is required:

- Ceftriaxone 2 g IV every 12 hours for 6 weeks, or
- Ampicillin 2 g IV every 4 hours + Gentamicin 3 mg/kg once daily for 2-6 weeks

b. Purulent pericarditis

Requires aggressive broad-spectrum therapy:

- Vancomycin 15-20 mg/kg every 8-12 hours + Ceftriaxone 2 g once daily, or
- Meropenem 1 g every 8 hours, or
- Piperacillin-tazobactam 4.5 g every 8 hours
- Duration: 2-6 weeks, along with drainage when required.[10,11]

6. Infections of the Respiratory System: Respiratory infections range from self-limiting viral URTIs to severe bacterial pneumonia. Antibiotics should not be used in uncomplicated viral infections.[12] For CAP, empirical therapy is guided by common pathogens and local resistance patterns with increasing beta-lactam + macrolide combinations.[13] Hospital-acquired infections show higher prevalence of multidrug-resistant organisms (MDROs) on the antibiogram, necessitating antipseudomonal and carbapenem-based regimens, with escalation reserved for ICU settings.[4]

a. Community-acquired pneumonia

- Amoxicillin-clavulanate 1.2 g IV every 8 hours + Azithromycin 500 mg once daily
- Duration: 5-7 days

b. Severe Community-acquired pneumonia

- Ceftriaxone 2 g once daily + Azithromycin 500 mg once daily
- Alternatives: Amikacin/Cefoperazone-sulbactam/Meropenem
- Duration: 7-14 days, with MRSA coverage if indicated

c. Hospital-acquired pneumonia

- Piperacillin-tazobactam 4.5 g every 8 hours or Meropenem 1 g every 8 hours
- Duration: 7-12 days

d. Ventilator-associated pneumonia[13]

- Piperacillin-tazobactam + Aminoglycoside, or
- Meropenem/Colistin-based therapy
- Duration: 10-14 days

e. Aspiration pneumonia[13]

- Amoxicillin-clavulanate or Piperacillin-tazobactam
- Duration: 7-10 days

f. Lung abscess[13]

- Beta-lactam with anaerobic coverage
- Duration: 2-4 weeks

g. Upper respiratory tract infections

- Usually viral; no antibiotics required
- Streptococcal infection: Amoxicillin 500 mg twice daily for 10 days[13]

7. Skin and Soft Tissue Infections: Skin and Soft Tissue Infections commonly involve Staphylococcus aureus and streptococci, but diabetic foot and severe infections are often polymicrobial.[6] Institutional antibiogram trends highlight significant MRSA and Gram-negative resistance, supporting the use of broad-spectrum agents like piperacillin-tazobactam or carbapenems in severe cases. Early source control (e.g., debridement) is crucial and antibiotic therapy should be tailored based on culture results.[4,14]

a. Cellulitis[4,14]

- Mild to moderate - Amikacin or Minocycline (200 mg loading → 100 mg BD)
- Severe - Meropenem 1gm every 8 hours
- Duration: 7-14 days

b. Diabetic foot infection[4,14]

- Broad-spectrum therapy required:
- Piperacillin-tazobactam 4.5 g every 8 hours or Meropenem 1 g every 8 hours

For MRSA coverage:

- Vancomycin 15-20 mg/kg every 8-12 hours
- Duration: 10-14 days (up to 3 weeks in severe cases)

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7 B. INFECTIONS IN GENERAL SURGERY

Introduction: The World Health Organization (WHO), through its global patient safety initiatives, has emphasized the importance of safe surgical practices, including infection prevention strategies, to improve outcomes in patients undergoing operative procedures.[1] Despite advances in a sepsis, surgical site infection (SSI) remains a significant problem, constituting the third most common cause of nosocomial infections and affecting approximately 14–16% of hospitalized patients.[2] Among surgical patients, SSI is the most frequent healthcare-associated infection and is responsible for nearly 77% of postoperative mortality related to infections.[3]

The introduction of antibiotics for prophylaxis and treatment, along with improvements in anesthesia and critical care, has transformed surgical practice. Conditions such as fecal peritonitis, once associated with near-universal mortality, can now be managed effectively with timely surgical intervention and appropriate antimicrobial therapy.[4] However, inappropriate antibiotic use-including incorrect timing, selection, and duration-remains a major contributor to antimicrobial resistance (AMR).[5]

Surgical site infections (SSIs) continue to pose a significant challenge in modern surgical practice, despite advances in operative techniques, sterilization protocols, and perioperative care. They remain among the most common healthcare-associated infections and are associated with increased morbidity, prolonged hospitalization, higher treatment costs, and, in severe cases, mortality.[1,2] In surgical patients, post operative wound infections constitute the most frequent complication and contribute substantially to adverse clinical outcomes.[3]

The development of SSI is multi-factorial, involving host factors, microbial burden, surgical technique, and perioperative management. Among these, antimicrobial therapy plays a crucial role both in prophylaxis and treatment. Timely administration of appropriate antibiotics has enabled safer performance of procedures even in contaminated surgical fields such as fecal peritonitis.[4]

However, inappropriate use of antibiotics-including incorrect selection, delayed administration, suboptimal dosing, and unnecessarily prolonged duration has contributed to the rapid emergence of antimicrobial resistance (AMR), which now represents a major threat to effective surgical care.[5,6] It is estimated that a substantial proportion of SSIs are preventable through adherence to standardized protocols, yet compliance remains suboptimal in routine clinical practice.[7]

In this context, institution specific antibiotic guidelines based on local microbiological data assume critical importance. The present recommendations are formulated using local antibiogram data, supported by national and international evidence, to promote rational antibiotic use, improve patient outcomes, and limit the emergence of resistance.

Microbiological Profile and Local Epidemiology

The institutional antibiogram for the period July 2024 to June 2025 revealed a total of 7,722 culture-positive isolates, with an overall culture positivity rate of 42%.[8] Gram-negative organisms predominated, accounting for approximately 54.5% of isolates, highlighting their dominant role in surgical infections.[8]

The most frequently isolated organisms were:

- Escherichia coli - 26.3%
- Klebsiella pneumoniae - 19.5%
- Staphylococcus aureus - 9.5%
- Acinetobacter baumannii - 8.2%
- Pseudomonas aeruginosa - 7.7%

Superficial and surgical wound infections were predominantly caused by Staphylococcus aureus, with additional contributions from Gram-negative bacilli such as E. coli and Klebsiella pneumoniae. In intensive care settings, multidrug-resistant organisms, particularly Acinetobacter baumannii and Pseudomonas aeruginosa, were more frequently encountered.[8]

Antimicrobial Resistance Trends

The antibiogram demonstrates the following key patterns:

Reduced susceptibility to:

- Third-generation cephalosporins (cefotaxime, ceftazidime)
- Fluoroquinolones (ciprofloxacin, levofloxacin)

Relatively preserved susceptibility to:

- Amikacin (~ 80% sensitivity in E. coli)
- Carbapenems (moderate but declining sensitivity)
- Fosfomycin (> 90% sensitivity in E. coli)

Klebsiella pneumoniae shows reduced susceptibility to multiple drug classes, including beta-lactam-beta-lactamase inhibitor combinations and carbapenems, suggesting emerging multidrug resistance.[8] High prevalence of methicillin-resistant Staphylococcus aureus (MRSA), with excellent susceptibility to vancomycin and good susceptibility to linezolid.[8] These findings underscore the need to avoid indiscriminate empirical use of cephalosporins and fluoroquinolones and to base therapy on local susceptibility patterns.

Principles of Antibiotic Use in Surgery

Antibiotic therapy in surgical practice must be guided by antimicrobial stewardship principles:[9,10]

- Antibiotics should be used only when clearly indicated
- The chosen agent should cover the most likely pathogens
- Adequate tissue concentration must be ensured at the time of incision
- Duration of therapy should be minimized to the shortest effective period

Failure to adhere to these principles contributes to increased SSI rates, antimicrobial resistance, and healthcare burden.

Preoperative Antibiotic Prophylaxis

Timing:

Antibiotics should be administered within 60 minutes prior to surgical incision to ensure adequate tissue levels during the critical period of bacterial contamination.[11] For agents requiring prolonged infusion, administration should begin within 120 minutes.

Selection, Dosing, and Redosing:

Selection should be guided by the expected microbial flora and local antibiogram. Weight-based dosing may be necessary in obese patients.

Redosing is indicated when:

- Procedure duration exceeds two half-lives of the drug
- Significant intraoperative blood loss occurs[12]

Duration:

A single preoperative dose is sufficient in most procedures. Prophylaxis should not exceed 24 hours, and continuation due to drains or catheters is not recommended.[13]

PROCEDURE SPECIFIC ANTIBIOTIC RECOMMENDATIONS

1. Biliary tract procedures

Biliary tract procedures, including cholecystectomy and common bile duct exploration, are generally categorized as clean-contaminated surgeries. The risk of SSI varies depending on patient-related factors such as age, diabetes, biliary obstruction, and intraoperative bile spillage.[1,11]

Organisms:

The most common pathogens implicated include:

- Escherichia coli
- Klebsiella pneumoniae
- Enterococcus species

Local antibiogram data confirms E. coli and Klebsiella as dominant Gram-negative pathogens, with reduced susceptibility to cephalosporins and fluoroquinolones and better sensitivity to amikacin.[8,12]

Recommendations:

Single-dose prophylaxis:

- Cefazolin or Ceftriaxone

or

- Amikacin (preferred in high resistance settings)

Avoid empirical fluoroquinolones due to poor susceptibility.[8] High-risk patients (elderly, diabetes, anticipated spillage) should receive prophylaxis routinely.

2. Appendicectomy

Appendicitis represents one of the most common emergency surgical conditions. The risk of SSI is significantly higher in complicated appendicitis (perforation, gangrene) compared to uncomplicated cases.[11]

Organisms:

- Aerobic: E. coli (most common)
- Anaerobic: Bacteroides fragilis

Local data confirms predominance of enteric Gram-negative organisms with good sensitivity to amikacin and poor response to fluoroquinolones.[8]

Recommendations:

a) Uncomplicated appendicitis:

Cefazolin + Metronidazole
or
Amikacin + Metronidazole

b) Complicated appendicitis:

Piperacillin–tazobactam
or
Carbapenem (in severe sepsis or MDR risk) [14]

Early source control remains the cornerstone.[14] De-escalation based on culture within 48-72 hours.[15]

3. Small Intestinal Procedures

Small bowel surgeries include resection, anastomosis, and bypass procedures. The risk of infection increases in the presence of obstruction, ischemia, or perforation.[1]

Organisms:

a) Predominantly enteric Gram-negative bacilli:

- E. coli
- Klebsiella

b) Occasional Gram-positive cocci

Local antibiogram supports high prevalence of Gram-negative organisms with reduced cephalosporin sensitivity.[8]

Recommendations:

a) Without obstruction:

Cefazolin
or
Amikacin

b) With obstruction/perforation:

Cefazolin + Metronidazole
or
Amikacin + Metronidazole

Broader coverage (Piperacillin-Tazobactum/Carbapenem) in septic patients.

4. Hernia Repair Procedures (Hernioplasty/Herniorrhaphy)

Hernia repair is generally a clean procedure; however, the use of prosthetic mesh increases the risk of SSI and prosthesis-related infections.[11] Routine prophylaxis is recommended for mesh repair.

Organisms:

- Staphylococcus aureus (including MRSA)
- Streptococci
- Enterococcus

Local data shows high MRSA prevalence with preserved susceptibility to vancomycin.[8]

Recommendations:

- Single-dose prophylaxis: Cefazolin

- Add Vancomycin if,

  - Known MRSA colonization
  - High-risk patients
  - Avoid prolonged antibiotic use

5. Colorectal Procedures

Colorectal surgery carries one of the highest risks of SSI due to high bacterial load within the bowel lumen.[11]

Organisms:

- Anaerobes: Bacteroides fragilis
- Aerobes: E. coli

These organisms account for the majority of postoperative infections.

Recommendations:

- Cefazolin + Metronidazole
  or
- Cefoxitin

- Combined mechanical bowel preparation + oral antibiotics recommended.
- Cephalosporin monotherapy is not recommended due to inadequate anaerobic coverage.

ADDITIONAL SURGICAL INFECTION SCENARIOS

1. Diabetic Foot Ulcer

Organisms:

Polymicrobial:

- Staphylococcus aureus
- Gram-negative bacilli (E. coli, Klebsiella)
- Anaerobes

Recommendations:

- Mild: Amoxicillin-clavulanate
- Moderate - Severe: Piperacillin-tazobactam ± Vancomycin
  - Consider MDR organisms based on antibiogram
  - Early debridement essential

2. Fournier's Gangrene

Organisms:

Polymicrobial:

- Gram-positive cocci
- Gram-negative bacilli
- Anaerobes

Recommendations:

Emergency broad-spectrum therapy:

- Piperacillin-tazobactam
  or
- Carbapenem ± Vancomycin

- Urgent surgical debridement mandatory

3. Infected Traumatic Wounds

Organisms:

- Staphylococcus aureus
- Gram-negative bacilli
- Environmental organisms

Recommendations:

a) Early prophylaxis:
- Cefazolin

b) Contaminated wounds:
- Ceftriaxone ± Metronidazole
- Tailor therapy based on culture

4. Burns

Organisms:

a) Early: Staphylococcus aureus
b) Late: Pseudomonas aeruginosa, Acinetobacter baumannii

Recommendations:

- Avoid routine systemic prophylaxis
- Use systemic antibiotics only in sepsis
- Silver sulfadiazine 1% cream is recommended for second- and third-degree burn wounds. It provides broad-spectrum bactericidal coverage against Gram-positive and

Gram-negative organism and should be used as an adjunct to standard wound care, including debridement and appropriate dressing.

Prefer:

- Piperacillin-tazobactam
- Carbapenems (severe cases)

TOPICAL ADMINISTRATION OF IRRIGATION, PASTES AND WASHES:

The use of topical antimicrobial agents such as wound irrigation solutions, antibiotic pastes, and washes has been explored as an adjunct to systemic antibiotic prophylaxis. However, available evidence suggests that topical administration alone is inferior to systemic therapy and does not significantly enhance outcomes when used in combination with intravenous antibiotics.[11] Routine use of topical antibiotics for SSI prevention is therefore not recommended. Their use may be considered selectively in contaminated wounds, but further evidence is required to establish clear benefit.

Management of Surgical Site Infection:

Empirical Therapy:

Severity	**Recommended Therapy**
Mild	Amoxicillin-clavulanate
Moderate	Piperacillin-tazobactam ± Vancomycin
Severe	Carbapenem ± Vancomycin ± Amikacin

Targeted Therapy:

Appropriate microbiological samples should be obtained prior to antibiotic administration whenever feasible. Therapy should be reviewed and de-escalated within 48-72 hours based on culture and sensitivity reports.

Duration of Therapy:

- Superficial SSI: 5-7 days
- Deep SSI: 7-14 days
- Intra-abdominal infections: 4-7 days following adequate source control.[15]

Special Considerations:

ICU Infections:

Higher prevalence of multidrug-resistant organisms necessitates the use of -

- Piperacillin- tazobactam
- Carbapenems

- Empirical use of cephalosporins should be avoided in critically ill patients.
- Non-Fermenting Gram-Negative Bacilli
- Pseudomonas aeruginosa: relatively sensitive to piperacillin-tazobactam and aminoglycosides
- Acinetobacter baumannii: highly resistant; minocycline shows relatively better activity.[8]
- MRSA: Vancomycin remains the drug of choice. Linezolid may be used selectively but should be reserved.

Antimicrobial Stewardship Recommendations:

- Avoid empirical overuse of broad-spectrum antibiotics
- Restrict third-generation cephalosporins and fluoroquinolones
- Promote culture-guided therapy
- Ensure early de-escalation
- Implement antibiotic audit and feedback
- Adhere strictly to single-dose prophylaxis protocols

Conclusion: Surgical infections remain a major challenge, particularly in the context of rising antimicrobial resistance. The current institutional antibiogram highlights a predominance of Gram-negative organisms with declining susceptibility to commonly used antibiotics such as cephalosporins and fluoroquinolones.[8]

A rational, evidence-based approach guided by local antibiogram data, adherence to antimicrobial stewardship principles and timely surgical intervention is essential to optimize surgical outcomes. Appropriate antibiotic selection, correct timing, minimal effective duration, and early de-escalation based on culture reports are critical components of effective infection control. Continuous surveillance and periodic updating of antibiotic policies are critical to combat the evolving threat of antimicrobial resistance and ensure safe surgical care.

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7 C. INFECTIONS IN OBSTETRICS & GYNAECOLOGY

Introduction: Vaginal flora of a normal, asymptomatic reproductive-aged woman includes multiple aerobic, facultative anaerobic and obligate anaerobic species. These bacteria exist with the host in a symbiotic relationship, which is alterable depending on the microenvironment.

Certain bacterial species normally found in vaginal flora have access to the upper reproductive tract. The female upper reproductive tract is not sterile and the presence of these bacteria does not indicate active infection. Together, these findings illustrate the potential for infection following gynecologic surgery and the need for antimicrobial prophylaxis.[1,2]

Clean contaminated wounds are those in which the genital tract is entered under controlled conditions and without unusual bacterial contamination. This group encompasses many gynecologic procedures including total hysterectomy, cervical conization and dilatation and curettage (D & C). Of these, hysterectomy is the gynecological procedure most frequently followed by surgical site infection. These problems are usually elective, hysterectomy and obstetric D & C require antimicrobial prophylaxis to reduce postoperative infection.

Gynecological surgery patients undergoing an operative procedure will develop SSI in approximately 8-10% of cases. Rates vary according to pre-morbid condition of the patient, as well as surgical and environmental factors.[3]

In a retrospective study by Fanning et al., less than 10% of the gynecologic patients who developed a postoperative fever had an attributable infectious etiology. [4]

Risk of SSI has been independently correlated with depth of subcutaneous wound, in a meta-analysis by Chelmow et al. (2004), subcutaneous tissue closure decreased SSI risk by 34% for women with subcutaneous tissue depth greater than 2 cm.[5]

Prophylactic antibiotics should be given approximately 30-60 minutes before skin incision to allow for adequate tissue concentration.[6]

a) Inj. Ceftriaxone + Sulbactam (1.5 g IV), single dose to be administered.

b) Additional dose of antibiotic is required for prolonged surgery (>3 hours), Massive haemorrhage (>1.5 L blood loss).

c) In complicated cases or infected cases, Inj. Amikacin is added or changed to Piperacillin–Tazobactam and sometimes Meropenem.

Our institute has its antibiogram. Prophylactic single-dose antibiotics should be encouraged. For infected cases, therapeutic antimicrobial therapy for 5-7 days has to be given depending on the response of the patients.

Systematic review of SSI cases on both, a departmental and an institutional level is an important component of quality improvement. Having an active SSI monitoring system facilitates problem identification and change implementation.

Bacterial vaginosis is a common complex clinical syndrome reflecting vaginal flora, in which anaerobic species are over represented. It is associated with a significant reduction in normal Lactobacillus species.

Recommended treatment regimens:

a) Metronidazole 500 mg orally twice daily for 7 days, or

b) Metronidazole (0.75%) gel, 5 g (one full applicator) intra-vaginally once daily for 5 days, or

c) Clindamycin cream 2%, 5 g (one full applicator) intra-vaginally at bedtime for 7 days.

Outpatient treatment of PID:

a) Doxycycline 100 mg orally twice daily for 14 days.

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7 D. INFECTIONS IN OPHTHALMOLOGY

Introduction: Antibiotics are fundamental in Ophthalmology for both therapeutic and prophylactic purposes given that ocular infections can rapidly threaten vision if not managed appropriately. The selection of an antibiotic depends on the clinical findings, the most likely causative organism, the laboratory confirmation and the pharmacokinetics of the drug.

Table 57. Antibiotics of choice for common ocular pathogens and ophthalmic infections

Ophthalmic infections	Likely organisms	First line/ Suggested regimen	Alternate regimen	Remarks
1. Eyelid infections[1] • External Hordeolum (stye) • Internal Hordeolum	S. aureus	Warm compression Topical and oral antibiotics In some cases, incision and drainage of the stye	Amoxicillin-clavulanate 625 mg BD for 5 days	Eye drop Moxifloxacin 0.5%/ Gatifloxacin 0.3% QID for 1 week
• Blepharitis	MSSA / S. epidermidis	Topical Azithromycin/ Chloramphenicol to lid margin after lid hygiene. Tetracycline (250 mg) QID for 1 month, Or Doxycycline (50-100 mg) OD or BD for 1 month	Lid margin care with baby shampoo and warm compresses 24 hourly Artificial tears (if associated with dry eye)	
	MRSA	Oral Trimethoprim-sulphamethoxazole (960 mg BD), Or Linezolid (600 mg BD)	Lid margin care with baby shampoo and warm compresses 24 hourly Artificial tears (if associated with dry eye)	
2. Conjunctival Infections[2] • Viral conjunctivitis		Primarily supportive No antibiotics required to treat for symptoms		Highly contagious. If pain and photophobia, suggestive of keratitis
• Bacterial conjunctivitis	S. aureus S. pneumoniae H. influenzae	Eye drop: Gatifloxacin 0.3% Levofloxacin 0.5% Moxifloxacin 0.5%		Uncommon causes: Chlamydia trachomatis

		1-2 drops q2h while awake during first 2 days, then q4-8h up to 7 days		N.gonorrhoeae (Culture of conjunctiva is indicated in suspected neonatal conjunctivitis)
3. Corneal Infections[2] • Herpes simplex keratitis	H. simplex type 1 & 2	Topical Ganciclovir 0.13% or Aciclovir (3%) 5 times daily for 2 weeks, gradually tapering to maintenance dose of 1-2 times/day In active infections, oral aciclovir (400 mg) 5 times/day for 7-10 days	1% Trifluridine ophthalmic solution 1 drop 2 hourly upto 9 times/day until re-epithialised Then, 1 drop 4 hourly upto 5 times/day for total duration of 21 days	
• Varicella zoster ophthalmicus	Varicella zoster virus	Oral Famciclovir 500 mg BD or TID Or, Valacyclovir 1gm TID for 10 days	Aciclovir 800 mg 5 times/ day for 10 days	
• Acute bacterial keratitis (no morbidities)	S. aureus S. pneumonia S. pyogenes Haemophilus spp	Broad spectrum fourth generation Fluoroquinolones Or, A combination of fortified antibiotics such as fortified Cephazoline (50 mg/ml) and fortified Gentamicin (15 mg/ml) 1 drop 1 hourly for first 48 hours, then reduce as per response	Eye drop Moxifloxacin 0.5% 1 drop 1 hourly for first 48 hours, then reduce as per response	For MRSA, Vancomycin (50 mg/ml)
• Acute bacterial keratitis (contact lens users)	P. aeruginosa	Cefazoline (50 mg/ml) 5%, Gentamicin (15 mg/ml) 1.5 % + Piperacillin or ticarcillin e/d (6-12 mg/ml) q15-60 min	Eye drop Moxifloxacin 0.5%	
• Fungal keratitis	Aspergillus Fusarium	Natamycin 5% 1 drop 1-2 hourly for	Amphotericin B (0.15%)	Empirical therapy is not

	Candida and others	several days, then 3-4 hourly for several days depending on response Voriconazole 400 mg Itraconazole 200 mg Fluconazole 200 mg	Voriconazole 1% Fluconazole 2% Econazole 1% Clotrimazole 1%	recommended
• Protozoan keratitis (soft contact lens)	Acanthamoeba spp.	Optimal regimen uncertain Suggested: (Chlorhexidine 0.02% or Polyhexamethylene biguanide 0.02%) + (Propamidine isethionate 0.1% or Hexamidine 0.1%) eye drops 1 drop every 1 hourly during daytime, taper according to clinical response Supplemented with oral ketoconazole 200 mg BD or Itraconazole 100 mg OD, taper over several weeks to months depending on the response		
4. Orbital infections • Orbital cellulitis[3]	S. pneumoniae H. influenzae S. aureus Anaerobes Group A Streptococcus Occasionally, gram negative *Bacilli* Post-trauma	Cloxacillin 2 gm IV q4h + Ceftriaxone 2gm IV q24 hourly + Metronidazole 1gm IV 12h	Vancomycin 1gm IV q12h+ Metronidazole 1gm IV 12h + Levofloxacin 750 mg IVOD	
• Endophthalmitis[4] - Post ocular surgery	S. epidermidis S. aureus Streptococci Enterococci Gram-bacilli	Immediate ophthalmic consultation. Intravitreal inj. Vancomycin (1mg in 0.1ml) + Ceftazidine (2.25mg in 0.1ml)	Inj. Vancomycin+ inj. Amikacin 400 mg in 0.1ml	

		Topical: Gatifloxacin/ Moxifloxacin 1 hourly, Fortified Cephazoline + Tobramycin 1 hourly	Topical vancomycin 5% (50mg/ml) Ceftazidime 5%	
- Hematogenous	S. pneumoniae S. aureus Streptococcus K. pneumoniae N. meningitidis	Intravitreal Inj. Vancomycin (1mg in 0.1ml) + Ceftazidime (2.25 mg in 0.1ml) + Systemic antibiotics Inj. Meropenem 1gm IV q8h/Inj. Ceftriaxone 2 gm IV q24h + Inj. Vancomycin 1gm IV q12h		
- Endophthalmitis Mycotic (Fungal)	Aspergillus Candida Fusarium	Intravitreal Amphotericin B (0.005-0.01mg in 0.1ml) Systemic therapy: Amphotericin B (0.7-1mg/kg) + Flucytosine (25 mg/kg) QID	Liposomal amphotericin B 3-5mg/kg Or, Voriconazole 50-100 micrograms	Duration of treatment is 4-6 weeks or longer depending upon clinical responses

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7 E. INFECTIONS IN ENT

Table 58. Recommended antibiotic therapy for common ENT infections

S. no.	Clinical condition	Antibiotic choice	Dose	Frequency	Route	Duration
1	SINUSITIS PHARYNGITIS LARYNGITIS TONSILLITIS CSOM	Amoxycillin clavulanate[1]	625 mg	BD	Oral	7-14 days
		Clarithromycin[1]	500 mg	BD	Oral	7-14 days
		Levofloxacin[1]	500 mg	OD	Oral	10 days
		Moxifloxacin[1]	300 mg	OD	Oral	10 days
		Clindamycin[1]	300 mg	BD	Oral	10 days
		Cefuroxime[1]	500 mg	BD	Oral	10 days
		Co-trimoxaxole[1]	960 mg	BD	Oral	10 days
		Inj. Ceftriaxone or any 3rd Generation Cephalosporin[1]	1 gm	12 hrly	IV (AST)	5-7 days
		Inj. Amoxycillin clavulanate[1]	1.2 gm	8 hrly	IV (AST)	5-7 days
2	CSOM with complications DEEP NECK SPACE INFECTION (Ludwig's Angina, Parapharyngeal abscess, Retropharyngeal abscess, Peritonsillar abscess, etc) FACIAL/ ORBITAL CELLULITIS	Inj. Ceftriaxone or any 3rd Generation Cephalosporin[2]	1gm	12 hrly	IV (AST)	5 -7 days
		Inj. Amoxycillin clavulanate[1]	1.2 gm	8 hrly	IV (AST)	5-7 days
		Inj. Piperacillin + Tazobactam[2]	4.5 gm	8 hrly	IV (AST)	5-7 days
		Inj. Amikacin[2]	250/500 mg	12 hrly	IV	5 days
		Inj. Ciprofloxacin[1]	500 mg	12 hrly	IV	5 days
		Inj. Clindamycin[2]	300 mg	12 hrly	IV	5 days
		Inj. Metronidazole[1]	500 mg	8 hrly	IV	5 days
		Inj. Meropenem[1]	1 gm	12 hrly	IV	5 days

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7 F. INFECTIONS IN ORTHOPAEDICS

Introduction: This policy provides evidence-based guidelines for rational antimicrobial use in orthopaedic surgery to prevent surgical site infections (SSIs), minimize antimicrobial resistance, and optimize patient outcomes. The policy has been updated to incorporate the 2024-2025 hospital antibiogram data, reflecting local pathogen prevalence and antimicrobial susceptibility patterns.[1,2]

Scope: Applies to all orthopaedic procedures including elective surgeries, trauma management, and treatment of bone and joint infections at RIMS, Imphal.

Guiding Principles

a) Prophylaxis to prevent SSIs, not treat existing infections
b) Shortest effective duration ($\leq$ 24 hours for most procedures)
c) Culture-guided de-escalation for infections
d) Local adaptation based on institutional antibiogram
e) Compliance with national (NCDC/ICMR) guidelines adapted to regional needs.[3]

Local Antibiogram Summary (2024-2025)

Key Findings from RIMS Antibiogram-

Total culture-positive isolates- 7,722 from 18,381 samples (42% positivity rate)

Predominant organisms-

a) Escherichia coli 26.3% (2,029 isolates)
b) Klebsiella pneumoniae 19.5% (1,508 isolates)
c) Staphylococcus aureus 9.5% (736 isolates)
d) Acinetobacter baumannii 8.2% (634 isolates)
e) Pseudomonas aeruginosa 7.7% (597 isolates)
f) Enterococcus spp. 5.7% (438 isolates)

Specimen distribution relevant to orthopaedics-

a) Superficial infections: 26.4% of positive cultures
b) Blood cultures: 5.4%
c) Other sites (deep tissue, bone, joint fluid): 2.9%

Key susceptibility patterns-

a) Gram-positives- Vancomycin 100%, linezolid 80-99%, clindamycin 55-78%
b) Gram-negatives- Amikacin 53-68%, tobramycin 74-88%, meropenem 48%, imipenem 17% (declining)
c) Enterobacterales- Piperacillin-tazobactam 60%, cefoperazone-sulbactam 56%, fosfomycin 80%

Clinical implications-

a) High prevalence of Gram-negative pathogens in superficial infections
b) Excellent staphylococcal coverage with vancomycin and linezolid
c) Declining carbapenem activity requires judicious use
d) Aminoglycosides remain reliable for Gram-negative coverage[1]

SURGICAL ANTIBIOTIC PROPHYLAXIS (SAP)

General Principles

1. Indications for Prophylaxis

a) All clean-contaminated and contaminated orthopaedic procedures
b) Clean procedures involving implants (prostheses, internal fixation devices)
c) Open fractures (all grades)
d) High-risk patients (diabetes, immunosuppression, malnutrition, obesity)

2. Timing of Administration

Critical Success Factor: Preoperative dose must achieve bactericidal tissue concentrations at time of incision.[4]

a) Standard antibiotics (cefazolin): 30-60 minutes before incision
b) Before tourniquet inflation: 10 minutes prior ensures limb tissue concentration
c) Vancomycin/fluoroquinolones: Begin 60-120 minutes before incision (requires longer infusion)

3. Choice of Prophylactic Agent

First-line agent: Cefazolin 2g IV (3g if ≥120 kg) [5]

Rationale for cefazolin as first-line:

a) Excellent bone and soft tissue penetration
b) Covers common skin flora: *S. aureus*, *S. epidermidis*
c) Proven efficacy in orthopaedic surgery per AAOS/ASHP guidelines
d) Local antibiogram supports continued use for staphylococcal coverage [2,6]

Alternative considerations based on local antibiogram:

a) Cefuroxime not tested in institutional antibiogram; cefazolin preferred
b) Add coverage for Gram-negative pathogens when indicated

Table 59. Recommended surgical antibiotic prophylaxis in patients with β-lactam Allergy

Allergy Type	Symptoms	Management
Non-severe	Rash, nausea	Consider cefazolin (cross-reactivity < 3%)

Severe (Ig E-mediated)	Anaphylaxis, angioedema, urticaria	Vancomycin 15 mg/kg IV + Gentamicin 5 mg/kg IV single dose

Table 60. Antibiotic selection for special circumstances in surgical prophylaxis

Scenario	Regimen
Known MRSA colonization	Add Vancomycin 15-20 mg/kg IV to cefazolin
High institutional Enterococcus rate (5.7%)	Consider vancomycin for high-risk implant surgery
Gram-negative risk (UTI, open fracture)	Add gentamicin 5 mg/kg IV or amikacin 15 mg/kg IV (local susceptibility 53-88%)
Polymicrobial contamination (Grade III open)	Cefazolin + gentamicin + metronidazole 500 mg IV

Redosing During Surgery:

Maintain therapeutic levels throughout procedure by redosing at intervals based on drug half-life.[5,7]

Table 61. Intraoperative antibiotic redosing guidelines during surgery

Antibiotic	Half-life	Redosing interval
Cefazolin	1.2-2.2 hours	Every 4 hours
Vancomycin	4-8 hours	Not needed for most cases
Gentamicin/Amikacin	2-3 hours	Not needed (single dose)

Redose if:

a) Surgery duration > 2 half-lives of antibiotic (> 4 hours for cefazolin)
b) Blood loss >1500 mL
c) Extensive irrigation/fluid loss

Duration of Prophylaxis

Evidence-Based Standard: Maximum 24 hours postoperatively.[8,9]

a) Single preoperative dose sufficient for most clean procedures
b) Closed fractures: Postoperative IV dosing for 24-48 hours
c) Presence of surgical drains does NOT justify extended prophylaxis
d) No additional doses after wound closure for clean procedures with implants

Procedure-Specific Prophylaxis Protocols

Clean Procedures without Implants

Examples: Soft tissue procedures, hand surgery, diagnostic arthroscopy, simple excisions

Recommendation: No routine prophylaxis (Strength of Evidence: C)

Exceptions (give single preoperative dose):

a) Diabetes mellitus
b) Immunosuppression
c) Malnourishment (albumin <3.0 g/dL)
d) Obesity (BMI ≥35)
e) Prolonged surgery (>2 hours)

Table 62.Surgical antibiotic prophylaxis protocol for clean procedures without implants

Timing	Regimen
Preoperative	Nil, or Cefazolin 2g IV if risk factors present
Postoperative	Nil

Closed Fractures with Internal Fixation

Examples: Femur, tibia, humerus, forearm fractures requiring ORIF with plates/screws/nails

Pathogen coverage: Skin flora (*S. aureus*, *S. epidermidis*)

Table 63.Surgical antibiotic prophylaxis protocol for closed fractures with internal fixation

Timing	Regimen
Preoperative	Cefazolin 2g IV (3g if≥120 kg), 30 - 60 min before incision
Intraoperative	Redose if surgery > 4 hours
Postoperative	Cefazolin 2g IV every 8 hours × 24 - 48 hours
Total Duration	24 - 48 hours

Open Fractures (Gustilo-Anderson Classification)

Updated based on local antibiogram: High Gram-negative prevalence (*E. coli* 26.3%, *Klebsiella* 19.5%, *Pseudomonas* 7.7%) requires appropriate coverage.[1]

Grade I: Clean wound < 1 cm

Table 64.Surgical antibiotic prophylaxis for Gustilo-Anderson Grade I open fractures

Timing	Regimen
Preoperative	Cefazolin 2g IV
Postoperative	Cefazolin 2g IV every 8 hours × 24-48 hours
Total Duration	24-48 hours

Grade II: Wound 1-10 cm, moderate contamination

Table 65.Surgical antibiotic prophylaxis for Gustilo-Anderson Grade II open fractures

Timing	**Regimen**
Preoperative	Cefazolin 2g IV + Gentamicin 5 mg/kg IV (or Amikacin 15 mg/kg IV)
Postoperative	Cefazolin 2g IV every 8 hours × 48-72 hours Gentamicin 5 mg/kg IV once daily × 3 days
Total Duration	3-5 days

Local data: Aminoglycosides show stable activity (amikacin 53-68%, tobramycin 74-88%)

Grade III: Extensive soft tissue damage, severe contamination

Table 66.Surgical antibiotic prophylaxis for Gustilo-Anderson Grade III open fractures

Timing	**Regimen**
Preoperative	Cefazolin 2g IV + Gentamicin 5 mg/kg IV + Metronidazole 500 mg IV (if soil/fecal contamination)
Postoperative	Cefazolin 2g IV every 8 hours × 3-5 days Gentamicin 5 mg/kg IV once daily × 3-5 days Metronidazole 500 mg IV TID × 3-5 days (if indicated) Culture-guided modification after debridement
Total Duration	5-7 days, then culture-directed therapy

Key Principles for Open Fractures:

a) Emergency surgical debridement within 6-8 hours
b) Obtain deep tissue cultures before antibiotics if feasible
c) Repeated debridement may require extended duration
d) De-escalate based on culture/sensitivity results
e) Consider *Pseudomonas* coverage for Grade III (local prevalence 7.7%) [1,10]

Total Joint Arthroplasty (THA/TKA/Shoulder)

High-stakes procedure: Infection rate 0.5-2%; devastating consequences

Preoperative Optimization:

a) Screen and treat remote infections (UTI, dental, skin)
b) Nasal swab for MRSA colonization if resources available
c) If MRSA positive: Mupirocin nasal ointment BD × 5 days preoperatively

Table 67.Surgical antibiotic prophylaxis protocol for Total Joint Arthroplasty

Timing	Regimen
Preoperative	Cefazolin 2g IV (3g if ≥120 kg), 30-60 min before incision **If MRSA colonized: ADD Vancomycin 15-20 mg/kg IV**
Intraoperative	Redose cefazolin if > 4 hours
Postoperative	Cefazolin 2g IV every 8 hours × 24 hours
Total Duration	24 hours
Drain Management	Remove closed suction drain at 24-48 hours **NO extended antibiotics for drain presence**

Special Considerations:

Antibiotic-loaded bone cement (ALBC): Gentamicin 1g per 40g cement may be used; consider fosfomycin synergy (local activity 80%) [1]

ALBC is **adjunct**, NOT replacement for systemic prophylaxis

Maintain normothermia (36-37°C) and glycemic control (< 200 mg/dL) [11]

Spine Surgery (With or Without Instrumentation)

Examples: Discectomy, laminectomy, spinal fusion, deformity correction

Table 68.Surgical antibiotic prophylaxis protocol for Spine Surgery

Timing	Regimen
Preoperative	Cefazolin 2g IV
Intraoperative	Redose if >4 hours (common in multilevel fusion)
Postoperative	Cefazolin 2g IV every 8 hours × 24 hours Instrumented cases: Add 24 hours oral
Total Duration	24-48 hours depending on complexity

Paediatric Orthopaedic Surgery

Table 69.Weight-based antibiotic dosing guidelines for Paediatric Orthopaedic Surgery

Antibiotic	Paediatric Dose
Cefazolin	30 mg/kg IV (max 2g per dose)
Vancomycin	15 mg/kg IV BD

Gentamicin	2.5 mg/kg IV OD
Amikacin	15 mg/kg IV OD

Duration: Same principles as adults (≤ 24 hours for clean; extended for open fractures)

Limb Salvage and Tumour Surgery

Complex procedures with prolonged operative time, high infection risk

Table 70.Surgical antibiotic prophylaxis protocol for Limb Salvage and Tumour Surgery

Timing	**Regimen**
Preoperative	Cefazolin 2g IV
Intraoperative	Redose every 4 hours
Postoperative	Cefazolin 2g IV every 8 hours × 24-48 hours
Total Duration	24-48 hours

TREATMENT OF ESTABLISHED INFECTIONS

This section covers TREATMENT, not prophylaxis - longer duration, culture-guided therapy.

1. Acute Osteomyelitis (Non-Diabetic)

Most Common Pathogen: *S. aureus* (60-70%); local prevalence 9.5%.[1]

Initial Empiric Therapy (before culture results).

Table 71. Empiric antimicrobial therapy for Acute Osteomyelitis

Component	**Recommendation**
Drug of Choice	Cefazolin 2g IV every 8 hours
If MRSA suspected	Vancomycin 15-20 mg/kg IV every 12 hours (100% susceptibility locally) OR Teicoplanin 400 mg IV OD
If Gram-negative risk	ADD Amikacin 15 mg/kg IV OD (68% local activity) OR Ceftazidime-avibactam if available
Duration	4-6 weeks total (IV followed by PO switch)
Investigations	Blood culture, bone biopsy culture before antibiotics
Surgical Management	Debridement of necrotic bone, abscess drainage

Culture-Guided Therapy:

a) MSSA: Continue Cefazolin or switch to Cloxacillin/Cephalexin PO
b) MRSA: Vancomycin IV → Linezolid 600 mg PO BD after 2-3 weeks
c) Gram-negative: Per sensitivity; consider Piperacillin-tazobactam (60% activity) or ciprofloxacin if susceptible[1]
d) Switch to PO: At 2-3 weeks if clinically improving, CRP/ESR declining[12]

2. Chronic Osteomyelitis

Characteristics: Polymicrobial, often with resistant organisms (*Acinetobacter* 8.2%, *Pseudomonas* 7.7%) and biofilm formation.[1]

Management Strategy:

a) Radical surgical debridement (remove all dead bone/sequestra)
b) Deep tissue cultures (≥ 3 samples from affected bone)
c) IV antibiotics for 2-3 weeks, then PO for 3-6 months total
d) Consider antibiotic-impregnated PMMA beads for local delivery

Empiric Therapy:

Table 72.Empiric therapy for Chronic Osteomyelitis based on local susceptibility patterns

Component	Recommendation
Broad-spectrum IV	Piperacillin-tazobactam 4.5g IV every 6 hours (60% local activity) OR Cefoperazone-Sulbactam 3g IV every 8 hours (56% activity) Avoid imipenem monotherapy (17% local susceptibility)
Add if MRSA risk	Vancomycin 15-20 mg/kg IV every 12 hours
Pseudomonas coverage	Ceftazidime 2g IV every 8 hours + Tobramycin 5 mg/kg IV OD (88% activity)
De-escalation	Based on culture/sensitivity at 48-72 hours
Total Duration	Minimum 12 weeks (individualized)

Local Antibiogram Implications:

a) Declining carbapenem activity: Use piperacillin-tazobactam or cefoperazone-sulbactam first-line
b) Aminoglycosides (tobramycin 74-88%) remain reliable for *Pseudomonas*
c) Meropenem (48%) reserved for MDR cases after culture confirmation[1]

3. Septic Arthritis (Native Joint)

Most Common Pathogens: *S. aureus* (40-50%), Streptococci (20-30%)

Diagnostic Criteria:

a) Joint aspiration with synovial fluid WBC > 50,000/mm³, PMN > 90%
b) Gram stain and culture of synovial fluid mandatory

Table 73.Initial empiric antibiotic therapy for Septic Arthritis

Patient Group	**Regimen**
Adults (non-gonococcal)	Cefazolin 2g IV every 8 hours + Vancomycin 15-20 mg/kg IV every 12 hours
Children	Cefotaxime 50 mg/kg IV every 8 hours + Vancomycin 15 mg/kg IV every 6 hours
Duration	3-4 weeks IV (or 2 weeks IV then 2 weeks PO acceptable)
Surgical Management	Urgent arthroscopic/open drainage

Culture-Directed Therapy:

a) MSSA: Cefazolin or Cloxacillin
b) MRSA: Vancomycin or Teicoplanin
c) Streptococci: Ceftriaxone 2g IV OD
d) Gram-negative: Per sensitivity (consider *E. coli* 26.3%, *Klebsiella* 19.5% prevalence)[1]
e) Gonococcal: Ceftriaxone 1g IV/IM OD × 7 days [13]

Prosthetic Joint Infection (PJI)

Definitions:

a) Early (< 3 months): *S. aureus*, *S. epidermidis*; acute onset
b) Delayed (3-24 months): *S. epidermidis*, CNS; indolent
c) Late (> 24 months): Hematogenous seeding; any organism

Diagnostic Workup:

a) Joint aspiration (hold antibiotics if possible)
b) Synovial fluid culture (aerobic, anaerobic, fungi, mycobacteria)
c) ESR, CRP (elevated)
d) ≥3 intraoperative tissue cultures at surgery

Treatment Strategy: Individualized

Debridement, Antibiotics, Implant Retention (DAIR)

Indications: Early infection (< 3 weeks symptoms), stable implant, no sinus tract

Table 74.DAIR strategy for early prosthetic joint infection

Component	Regimen
Surgical	Thorough debridement, polyethylene exchange
Empiric antibiotics	Vancomycin 15-20 mg/kg IV every 12 hours + Piperacillin-tazobactam 4.5g IV every 6 hours (Local data: 60% activity against GNB)
Targeted Therapy	Based on cultures (see organism-specific table below)
Duration	2 weeks IV, then 10 weeks PO (12 weeks total)

Two-Stage Exchange

Indications: Most chronic PJI, sinus tract, loose implant

Table 75.Two-Stage Exchange protocol for chronic prosthetic joint infection

Stage	Management
Stage 1	Implant removal, spacer insertion, cultures Antibiotics: IV 2 weeks, then PO 4-6 weeks
Antibiotic holiday	2-4 weeks off antibiotics before reimplantation
Stage 2	Reimplantation after infection control confirmed Post-reimplantation: IV 2 weeks, then PO 2-3 months

Organism-Specific PJI Treatment (Updated with Local Data):

Table 76.Organism-Specific antimicrobial therapy for PJI adapted to local antibiogram

Organism	IV Phase (2 weeks)	PO Phase (10 weeks)
MSSA/MSSE	Cefazolin 2g every 8h	Cephalexin 500 mg QID + Rifampicin 600 mg OD
MRSA/MRSE	Vancomycin 15-20 mg/kg every 12h (100% local activity)	Linezolid 600 mg BD + Rifampicin 600 mg OD
Streptococci	Ceftriaxone 2g IV OD	Amoxicillin 1g TID
Enterococcus (5.7%)	Ampicillin 2g every 4h + Gentamicin 1 mg/kg every 8h	Amoxicillin 1g TID
Gram-negative (53%)	Per sensitivity; Piperacillin-tazobactam 4.5g every 6h OR Ceftriaxone/Meropenem if susceptible	Ciprofloxacin 750 mg BD if susceptible; TMP-SMX (50-60% activity) alternative

Role of Rifampicin:

a) Excellent biofilm penetration
b) **ONLY use with implant retained** or after reimplantation (Stage 2)
c) NOT for spacer period (risk of resistance)
d) Always combine with second agent (never monotherapy)[14]

Diabetic Foot Osteomyelitis

Characteristics: Polymicrobial (aerobic + anaerobic), often with MRSA and *Pseudomonas*

Assessment:

a) Probe-to-bone test (positive if bone palpable)
b) MRI for extent
c) Deep bone culture after debridement (not superficial swab)

Empiric Therapy (Broad-Spectrum):

Table 77.Empiric broad-spectrum antibiotic therapy for Diabetic Foot Osteomyelitis

Severity	**Regimen**
Moderate Infection	Piperacillin-Tazobactam 4.5g IV every 6 hours (60% local activity) OR Ceftriaxone 2g IV OD + Metronidazole 500 mg IV every 8 hours
Severe/Limb-Threatening	Meropenem 1g IV every 8 hours (48% activity) + Vancomycin 15-20 mg/kg IV every 12 hours
After Culture	De-escalate to narrow-spectrum targeted therapy
Duration	Minimum 6 weeks; up to 12 weeks if residual bone
Surgical Management	Debridement of all necrotic/infected bone (essential)

PO Switch Options (after 2-3 weeks IV):

a) MSSA: Cephalexin 500 mg QID or Cloxacillin 500 mg QID
b) MRSA: Linezolid 600 mg BD or Cotrimoxazole DS BD (50-60% local activity)[1]
c) Gram-negative: Ciprofloxacin 750 mg BD if susceptible
d) Mixed: Amoxicillin-Clavulanate 625 mg TID + Ciprofloxacin[15]

ANTIMICROBIAL STEWARDSHIP

Core Interventions

a) Prospective audit with feedback: Weekly review by Orthopaedics-Microbiology team.
b) Automatic stop orders: Surgical prophylaxis auto-discontinues at 24 hours unless justified.

c) Culture stewardship: Obtain appropriate cultures before starting antibiotics for infections.
d) IV to PO switch: Transition when clinically stable, afebrile × 48 hours, improving biomarkers.
e) Antimicrobial timeout: Reassess indication, spectrum, duration at 48-72 hours.

Monitoring and Audit

Process Measures:

a) Prophylaxis timing within 60 min of incision (Target: ≥ 95%)
b) Appropriate agent selection (Target: ≥ 90%)
c) Discontinuation ≤ 24 hours (Target: ≥ 85%)

Outcome Measures:

a) SSI rates by procedure (NHSN definitions)
b) Antimicrobial consumption (DDD per 100 patient-days)
c) *C. difficile* infection incidence

Quarterly Department Review:

a) Antibiotic usage patterns
b) SSI surveillance data
c) Resistance trends from local antibiograms
d) Update policy based on evidence and local data

Local Antibiogram Integration

Annual review: Request updated antibiogram from Microbiology Department

Key monitoring parameters:

a) MRSA prevalence trends
b) Carbapenem resistance rates (currently imipenem 17%, meropenem 48%)
c) Enterococcus prevalence (currently 5.7%)
d) *E. coli/Klebsiella* ESBL rates
e) Aminoglycoside susceptibility patterns

Action thresholds:

a) If MRSA > 20%: Consider routine vancomycin for implant surgery
b) If carbapenem resistance > 30%: Restrict use to culture-proven indications
c) If fluoroquinolone resistance > 30%: Avoid empiric use for Gram-negatives[1]

Education

a) Mandatory training for all residents annually
b) Pocket cards with quick reference protocols

c) Online module access for nursing staff
d) Grand rounds presentations on antimicrobial stewardship

SPECIAL SITUATIONS

1. *Penicillin/Cephalosporin Allergy*

Table 78.Special situations in surgical antimicrobial prophylaxis- Penicillin/Cephalosporin Allergy management

Allergy Type	Symptoms	Management
Non-severe	Rash, nausea	Consider cefazolin (cross-reactivity <3%)
Severe/IgE-mediated	Anaphylaxis, angioedema, urticaria	Vancomycin 15-20 mg/kg IV + Gentamicin 5 mg/kg IV

2. *Renal Impairment*

Table 79.Dose adjustment prophylactic antibiotics in renal impairment (CrCl < 50 mL/min)

Antibiotic	Dose Adjustment
Cefazolin	CrCl 10-30: 1g IV every 12h; <10: 1g IV every 24h
Vancomycin	Load 25-30 mg/kg, then per levels (target trough 15-20 mg/L)
Gentamicin/Amikacin	Extend interval every 24h or every 36-48h; monitor levels

Note: Single preoperative prophylactic dose usually does NOT require adjustment.

3. *Obesity (BMI ≥ 35)*

Table 80.Antibiotic dosing adjustment in obese patients (BMI ≥ 35) for adequate tissue levels:

Antibiotic	Dosing Adjustment
Cefazolin	3g IV instead of 2g if weight ≥120 kg
Vancomycin	15-20 mg/kg IV; use actual body weight
Gentamicin/Amikacin	Use adjusted body weight: IBW + 0.4 (ABW - IBW)

4. *Immunosuppression*

Patients on Corticosteroids, Biologics, Chemotherapy:

a) Continue immunosuppressive therapy perioperatively (newer guidelines)[16]
b) DO NOT extend prophylaxis duration beyond 24 hours (no evidence of benefit)
c) Lower threshold for workup if postoperative fever/wound issues
d) Consider MRSA prophylaxis if colonized

5. Local Antimicrobial Delivery

Antibiotic-Loaded Bone Cement (ALBC):

a) Consider for THA/TKA, revision arthroplasty
b) Standard: Gentamicin 1g per 40g cement
c) Alternative: Vancomycin 1g per 40g cement if MRSA risk
d) Local data consideration: Fosfomycin (80% activity) shows promise for synergistic combinations[1]
e) ALBC is ADJUNCT, not replacement for systemic prophylaxis

Antibiotic-Impregnated PMMA Beads:

a) For chronic osteomyelitis, open fractures with bone loss
b) Gentamicin 4.8g mixed with 40g PMMA
c) Remove at 2-6 weeks (not permanent implant)

MICROBIOLOGY CONSIDERATIONS

1. Common orthopaedic pathogens at RIMS (2024-2025 Data)

Table 81.Common orthopaedic pathogens at RIMS (2024-2025 Data) and their clinical associations

Organism	Frequency (%)	Clinical Association
E. coli	26.3	UTI, open fractures, superficial infections
K. pneumoniae	19.5	Hospital-acquired, respiratory, wounds
S. aureus	9.5	SSI, osteomyelitis, septic arthritis
A. baumannii	8.2	Hospital-acquired, chronic wounds
P. aeruginosa	7.7	Grade III open fractures, chronic OM
Enterococcus spp.	5.7	PJI polymicrobial, UTI
S. epidermidis/CNS	(Not separately listed)	PJI, biofilm producer

Pathogen distribution from RIMS antibiogram (Total: 7,722 isolates)

2. Key Susceptibility Patterns

Table 82.Key susceptibility patterns of gram-positive organisms: *S. aureus* & Enterococcus susceptibility profile

Antibiotic	Susceptibility (%)
Vancomycin	100
Linezolid	80-99
Teicoplanin	High (specific data pending)
Clindamycin	55-78
Ciprofloxacin	27-49
TMP-SMX	58-77

Table 83.Gram-Negative Bacilli (GNB) susceptibility patterns in orthopaedic infection: Enterobacterales, Pseudomonas and Acinetobacter

Antibiotic	Susceptibility (%)	Clinical Note
Amikacin	53-68	Stable activity; first-line aminoglycoside
Tobramycin	74-88	Excellent *Pseudomonas* coverage
Piperacillin-tazobactam	60	Improved from prior years
Cefoperazone-sulbactam	56	Alternative beta-lactam option
Meropenem	48	Declining; reserve for MDR
Imipenem	17	Avoid as empiric choice
Fosfomycin	80	High UTI activity
Ceftazidime-avibactam	64-70	Consider for ESBL/carbapenem-resistant
Ciprofloxacin	24-30	Limited empiric utility
TMP-SMX	50-60	Oral switch option if susceptible

3. Clinical Implications

Key Takeaways for Orthopaedic Practice:

a) Staphylococcal infections: Vancomycin/linezolid remain highly effective (100%/80-99%)
b) Gram-negative predominance: *E. coli* and *Klebsiella* account for 45.8% of isolates; ensure adequate coverage in open fractures
c) Carbapenem crisis: Imipenem activity severely compromised (17%); meropenem declining (48%) - use judiciously
d) Aminoglycoside reliability: Amikacin and tobramycin maintain stable activity; preferred for GNB coverage
e) Beta-lactam/BLI options: Piperacillin-tazobactam (60%) and cefoperazone-sulbactam (56%) are viable alternatives to carbapenems
f) Enterococcus awareness: 5.7% prevalence requires consideration in polymicrobial infections (PJI, diabetic foot)
g) *Pseudomonas prevalence:* 7.7% of isolates; critical in Grade III open fractures and chronic osteomyelitis

4. Culture Techniques to Maximize Diagnostic Yield

a) Hold antibiotics before sampling if clinically safe
b) Obtain ≥3 tissue specimens (not swabs) for chronic infections
c) Request aerobic, anaerobic, fungal, mycobacterial cultures for chronic OM
d) Sonication of explanted prostheses increases PJI detection
e) Synovial fluid: Send for cell count, Gram stain, culture simultaneously

INFECTION PREVENTION BUNDLE

1. Preoperative Measures

Patient Optimization:

a) Control diabetes: HbA1c < 7.5%, blood glucose < 200 mg/dL[17]
b) Smoking cessation ≥ 4 weeks before elective surgery
c) Nutritional support: Albumin ≥ 3.5 g/dL if possible
d) Treat remote infections (UTI, dental abscess, skin infections)

MRSA Screening (High-Risk Cases):

a) Nasal swab for arthroplasty, spine instrumentation
b) If positive: Mupirocin 2% nasal ointment BD × 5 days + chlorhexidine body wash

Skin Preparation:

a) Chlorhexidine-alcohol 2% preferred over povidone-iodine
b) Full-body bath with antiseptic soap night before surgery
c) No hair removal unless necessary; if needed, use clippers (not razors)

2. Intraoperative Measures

a) Maintain normothermia (core temperature 36-37°C)
b) Supplemental oxygen (FiO_2 0.8) during and 2 hours post-op if feasible
c) Minimize operating room traffic
d) Laminar airflow for arthroplasty if available
e) Double gloving; frequent glove changes (every 90 min or if punctured)
f) Impervious gowns for implant surgery
g) Wound irrigation: Saline ≥ 3 liters for joint arthroplasty

3. Postoperative Measures

a) Sterile dressing for 24-48 hours, then exposure if dry/intact
b) **Early drain removal** (24-48 hours) - drains NOT indication for prolonged antibiotics
c) Glycemic control < 180 mg/dL for 48 hours postoperatively
d) Early mobilization (VTE prophylaxis, muscle pump activation)
e) Prompt recognition of SSI signs (fever, wound erythema, purulent drainage)

DOCUMENTATION REQUIREMENTS

1. Prophylaxis Documentation

Mandatory (Anaesthesia record or nursing checklist):
a) Antibiotic name and dose

b) Time of administration relative to incision
c) Intra-operative redosing if applicable
d) Allergy status checked
e) Stop order placed for postoperative discontinuation

2. Infection Treatment Documentation

Progress notes must include:

a) Indication for antibiotic (diagnosis)
b) Empiric regimen with rationale
c) Culture results and sensitivity
d) Plan for de-escalation or IV to PO switch
e) Planned total duration
f) Response assessment (clinical, biomarkers)

RESPONSIBILITIES

1. Orthopaedic Surgeon

a) Prescribe appropriate prophylaxis per protocol
b) Optimize patient preoperatively
c) Minimize operative time and tissue trauma
d) Obtain cultures for infections before antibiotics
e) Consult Microbiology for complex/resistant infections

2. Anaesthesiologist

a) Administer prophylactic dose at correct timing
b) Redose during prolonged procedures
c) Maintain normothermia and hemodynamic stability

3. Nursing Staff

a) Verify antibiotic order and allergy status
b) Prepare and administer dose within 60 minutes of incision
c) Document administration time accurately
d) Monitor for immediate adverse reactions

4. Microbiology Department

a) Provide timely culture results (preliminary at 48 hours, final at 5-7 days)
b) Annual antibiogram for orthopaedic isolates
c) Consultation for antimicrobial selection and duration

5. Hospital Infection Control Committee

a) SSI surveillance using NHSN definitions
b) Feedback to department on infection rates

c) Coordinate antimicrobial stewardship rounds
d) Audit compliance with prophylaxis protocol

APPENDIX A: Quick Reference Dosing Chart

Table 84.Quick reference dosing chart for surgical antimicrobial prophylaxis in adults and pardiatric patients

Antibiotic	Adult Dose	Paediatric Dose	Redose Interval
Cefazolin	2g IV (3g if ≥120 kg)	30 mg/kg IV	4 hours
Vancomycin	15-20 mg/kg IV	15 mg/kg IV	Not needed
Gentamicin	5 mg/kg IV	2.5 mg/kg IV	Not needed
Amikacin	15 mg/kg IV	15 mg/kg IV	Not needed
Metronidazole	500 mg IV	15 mg/kg IV	Not needed
Clindamycin	900 mg IV	10 mg/kg IV	6 hours

APPENDIX B: Surgical Site Infection Surveillance Definitions (NHSN)

Superficial Incisional SSI:

a) Infection occurs within 30 days after procedure
b) Involves only skin and subcutaneous tissue
c) At least one: purulent drainage, positive culture, pain/tenderness/swelling with deliberate opening, or surgeon diagnosis

Deep Incisional SSI:

a) Infection occurs within 30-90 days (90 days if implant present)
b) Involves deep soft tissue (fascia, muscle)
c) At least one: purulent drainage from deep incision, dehiscence/opened by surgeon with fever/pain, abscess, or surgeon diagnosis

Organ/Space SSI (e.g., septic arthritis after arthroscopy):

a) Infection occurs within 30-90 days
b) Involves any anatomic area (other than incision) opened/manipulated during procedure
c) Positive culture, abscess, or surgeon diagnosis

APPENDIX C: Local Antibiogram Summary Table

Table 85. Local antibiogram summary for Orthopaedic Practice at RIMS (2024-2025): Most Relevant Antibiotics and recommendations

Antibiotic	Gram-Positive (%)	Gram-Negative (%)	Recommendation
Vancomycin	100	N/A	First-line for MRSA, Enterococcus
Linezolid	80-99	N/A	PJI, chronic OM (PO option)

Cefazolin	High (inferred)	Low-Moderate	Prophylaxis standard
Amikacin	N/A	53-68	Reliable GNB coverage
Tobramycin	N/A	74-88	Preferred for *Pseudomonas*
Piperacillin-Tazobactam	N/A	60	Broad-spectrum empiric
Meropenem	N/A	48	Reserve for culture-proven MDR
Imipenem	N/A	17	Avoid empirically
Ceftazidime-Avibactam	N/A	64-70	ESBL/carbapenem-resistant
TMP-SMX	58-77	50-60	Oral switch option
Fosfomycin	Limited data	80	UTI, synergy potential

This policy is based on current best evidence and institutional antibiogram data. It will be updated periodically to reflect new research, evolving resistance patterns, and local surveillance data. All practitioners are expected to familiarize themselves with these guidelines and implement them in clinical practice.

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7 G. INFECTIONS IN RESPIRATORY TRACT

Lower Respiratory Tract Infections

LRTI includes acute uncomplicated bronchitis/tracheobronchitis, acute exacerbation of COPD and bronchiectasis, community acquired pneumonia, hospital acquired pneumonia, ventilator associated pneumonia, lung abscess and empyema.

Acute uncomplicated bronchitis / Tracheobronchitis

Acute uncomplicated bronchitis is defined as a self-limited inflammation of the large air ways with a cough (may be dry or productive) lasting up to 6 weeks (without evidence of pneumonia). It is often accompanied by mild constitutional symptoms. Approximately 5% of adults develop acute bronchitis in a given year, resulting in approximately 100 million ambulatory care visits in the United States. Acute bronchitis leads to more inappropriate antibiotic prescribing than any other LRTI syndrome in adults.[1]

Clinicians should not perform testing or initiate antibiotic therapy in patients with bronchitis unless pneumonia is suspected.

Pneumonia

Pneumonia is defined as an infection of the pulmonary parenchyma from the level of the respiratory bronchioles to alveoli. Clinically, pneumonia can be recognized by the presence of a new lung infiltrate coupled with any of the following: new or increased cough, dyspnea, pleuritic chest pain, purulent sputum, confusion, fever, hypoxemia, rales, leukocytosis or leukopenia.[2]

Pneumonia that occurs in community-dwelling individuals is termed as community-acquired pneumonia (CAP). Hospital acquired pneumonia (HAP) is defined as pneumonia that occurs 48 hrs or more after hospital admission, while ventilator-associated-pneumonia (VAP) is defined as pneumonia occurring 48 hrs or more after endotracheal intubation.[2,3]

Table 86. Etiological classification of pneumonia: Bacterial and non-bacterial pathogens[3]

Bacterial pneumonia	**Non-bacterial pneumonia**
Typical Pneumonia: • Gram positive - S. pneumonia - S. aureus - Group A Streptococcus	Viral pneumonia - Influenza Respiratory syncytial virus, Para influenza virus, Corona viruses, Coxsackie virus, Rhino viruses etc.
• Gram-negative enteric pneumonia: - Klebsiella spp. - Pseudomonas aeruginosa - Escherichia coli - Enterobacter spp. - Serratia spp. - Haemophilus influenzae	Bacteria-like and rickettsia-like pneumonia

Atypical pneumonia: • Legionella spp.(legionnaires') • Mycoplasma pneumonia • Chlamydia spp. • Coxiella burnetii (Q fever)	Fungal and actinomycotic pneumonia
Anaerobic pneumonia (mixed flora)	
• Bacteroides spp. • Fusobacterium spp. • Peptococcus spp. • Peptostreptococus spp.	
Pathogens associated with VAP in hospital ICUs	
Staphylococcus aureus, Selected Klebsiella species, Pseudomonas aeruginosa, Enterobacter species, Haemophilus influenza All, Streptococcus species, Escherichia coli, Serratia species, Stenotrophomonas maltophilia, Acinetobacter species, Proteus species, Burkholderia cepacia and Others.	

Lung abscess [2,3]

A lung abscess is a localized area of destruction of lung parenchyma in which infection by pyogenic organism's results in tissue necrosis and suppuration. Lung abscesses may be single or multiple and they frequently contain air-fluid levels. When multiple and small (< 2 cm in diameter) they are sometimes referred to as necrotizing or suppurative pneumonia, but they are an expression of the same pathological process and the distinction is an arbitrary one.

Causes include anaerobic and aerobic organisms, tuberculosis, non-bacterial organisms including fungi and protozoa, other pathologies such as necrosis in a lung tumour or infection within a lung cyst.

Empyema [4]

Empyema refers to a purulent collection in any body site. It is commonly used to indicate a pleural space infection. It is typically associated with underlying pulmonary parenchymal infection but may also be associated with blood-borne infection, thoracic surgery, trauma, abdominal infection, or neoplasm.

Acute exacerbation of COPD

It is characterized by worsening cough, dyspnoea and sputum production beyond normal day-to-day variation. These exacerbations are associated with acute deterioration of lung function during the exacerbation and may also accelerate lung function decline. Increasing dyspnoea accompanied by a change in the quantity or colour of phlegm is usually an indication of bacterial infection and should prompt initiation of antibiotic.

Table 87. Common causes of exacerbation of COPD

Respiratory viral infections	Bacterial infections or super infections	Severe air pollution
Rhinovirus, respiratory syncytial virus, influenza, adenovirus and metapneumo virus	Haemophilus influenzae, Moraxella catarrhalis and Streptococcus pneumoniae; gram-negative bacteria	Particulates, sulphur dioxide, ozone and nitrogen dioxide

Acute exacerbation of bronchiectasis [5,6]

It is an acute clinical deterioration, requiring a change in therapy, manifesting with at least three of the following symptoms over ≥ 48 hours:

a) Cough
b) Sputum volume and/or consistency
c) Sputum purulence
d) Breathlessness and/or exercise intolerance
e) Fatigue and/or malaise
f) Hemoptysis

Antimicrobial therapy is the mainstay of treatment for exacerbations of bronchiectasis. The bacteriology of bronchiectasis is quite complex. *Pseudomonas aeruginosa* and *Haemophilus influenzae* are the most common pathogens (cultured in 35% of patients with bronchiectasis). Others include *Staphylococcus aureus, Moraxella catarrhalis* and *Streptococcus pneumoniae*.

Management guidelines [7,8,9,10]

All patients with CAP should be risk stratified.

The scoring system CURB-65 is preferred for its simplicity as it contains only five variables (confusion, blood urea nitrogen > 20 mg/dL, respiratory rate ≥ 30 breaths per minute, systolic blood pressure < 90 mm Hg or diastolic blood pressure ≤ 60 mm Hg, and age ≥ 65 years of age).

Patients with a score of 0 to 2 are classified as low-risk and have 30-day mortality rates less than or equal to 2.1%. The British Thoracic Society recommends CURB-65 due to ease of use.

CURB-65 divides patients into 3 groups:

Score	Mortality risk	Managed as
0 – 1	Low risk of 30 day mortality	Out-patient
2	Intermediate risk and	In-patient/Genaral ward
3 – 5	High risk of 30 day mortality	ICU

The Infectious Diseases Society of America/American Thoracic Society and the British Thoracic Society guidelines suggest that patients with CURB-65 scores of 0-1 are at low risk of death and thus may be managed as outpatients.

For admission in ICU, the 2007 IDSA–ATS major and minor criteria for severe CAP are recommended for use in IDSA–ATS guidelines. [8,11]

Table 88. IDSA-ATS 2007 guidelines for ICU admission

Minor criteria	**Major criteria**
Respiratory rate ≥ 30 breaths/min	Need for invasive mechanical ventilation
PaO2/FiO2 ≤ 250	Septic shock with need for vasopressors
Multilobar infiltrates	
Confusion/disorientation	
Uraemia (BUN ≥ 20 mg/dL)	
[a]Leukopenia (WBC count < 4,000cells/mm3	
Thrombocytopenia (platelet count < 100,000 cells/mm3)	
Hypothermia (core temperature < 36°C)	
Hypotension requiring aggressive fluid resuscitation	

- ICU admission is warranted for the patient who fulfilled either one of the major criteria or three of the minor criteria.
- Other minor criteria to consider include hypoglycaemia (in nondiabetic patients), acute alcoholism/alcohol withdrawal, hyponatremia, unexplained metabolic acidosis or elevated lactate level, cirrhosis and asplenia.
- A need for non-invasive ventilation can substitute for a respiratory rate >30 breaths/min or PaO2/FiO2 ≤ 250.
- [a]Leukopenia: as a result of infection alone.

Severe pneumonia is defined as the presence of at least one major or three or more minor criteria. (BUN - blood urea nitrogen; PaO2/FiO2 - arterial oxygen pressure/fraction of inspired oxygen).

Table 89. Empiric antibiotic therapy regimens for Community Acquired Pneumonia[7,8,9,10]

Group	**Antibiotic regimens**
Healthy outpatients without risk factors for MRSA or Pseudomonas aeruginosa	Monotherapy with Amoxicillin: Tab. Amoxicillin 1gm TDS for 5 to 7 days (or) Macrolide: Tab. Azithromycin 500 mg OD for 5 days (or) Tab. Clarithromycin 500 mg BD for 5 days (or) Doxycycline: Tab. Doxycycline 100 mg BID for 5 to 7 days
[a](Risk factors include: prior respiratory isolation of methicillin-	Combination therapy: Amoxicillin-clavulanate or cephalosporin

resistant Staphylococcus aureus or Pseudomonas aeruginosa, Recent hospitalization with receipt of parenteral antibiotics during the previous ninety days)	+ Macrolide or doxycycline
Outpatients with co-morbidities (Notable co-morbidities include chronic heart, lung, liver, or renal disease, diabetes mellitus, alcohol use disorder, malignancy, or asplenia)	Tab. Amoxicillin-clavulanate 625 mg TDS (or) 1gm TDS for 5 to 7 days (or) Tab. Cefuroxime-clavulanate 625 mg 1 tab BID for 5 days (or) Tab. Cefpodoxime CV 325 1 tab BID for 5 days + Tab. Azithromycin 500 mg OD for 5 days (or), Tab. Clarithromycin 500 mg BD for 5 days (or), Tab. Doxycycline 100 mg BID for 5 to7 days (or) • Monotherapy with a respiratory fluroquinolone Tab. Levofloxacin 500 mg (or) 750 mg 1 tab OD for 5-7 days (or), Tab. Moxifloxacin 400 mg 1 tab OD for 5-7 days
In patients with non-severe CAP without risk factors for MRSA or P. aeruginosa[a]	Combination therapy: β-lactam + macrolide [Inj. Amoxicillin-clavulanate 1.2g I.V. TDS (or), Inj. Ceftriaxone-sulbactum 1.5g I.V. BID (or) Inj. Cefoperazone-sulbactum 1.5g I.V. BID + Tab. Azithromycin 500 mg OD for 5 days (or), Tab. Clarithromycin 500 mg BD for 5 days (or), Tab. Doxycycline 100 mg BID for 5 to7 days] Mono therapy with Respiratory fluroquinolone (not practised): Combination therapy with β-lactam + doxycycline can be considered if contraindications to both macrolides and fluroquinolones
Severe CAP	Combination therapy with β-lactam/penem + macrolide [Inj. Piperacillin-tazobactam 4.5g I.V. TDS (or), Inj. Meropenem 1g I.V. TDS + Tab. Azithromycin 500 mg OD for 5 days (or), Tab. Clarithromycin 500 mg BD for 5 days] (or) β-lactam/penem + respiratory fluoroquinolone

	[Inj. Piperacillin-tazobactam 4.5 g I.V. TDS (or), Inj. Meropenem 1 g I.V. TDS + Inj. Levofloxacin 100 mL or moxifloxacin 100 ml I.V. OD]
Empiric treatment for MRSA	Vancomycin or linezolid
Empiric treatment for P. aeruginosa	Piperacillin-tazobactam, cefepime, ceftazidime, aztreonam, meropenem, or imipenem

Anaerobic Coverage [7,8]

IDSA–ATS guidelines now explicitly recommend against the addition of anaerobic coverage for patients with aspiration pneumonia in the absence of lung abscess or empyema (conditional recommendation, very low quality of evidence).

This recommendation is driven by the changing microbiology of aspiration pneumonia. While historic studies describe high rates of infection with anaerobic pathogens, confirmation of an anaerobic infection is now increasingly uncommon. But, in cases with suspicion of aspiration pneumonia (according to clinical history) and cases of lung abscess/empyema, Inj. Metronidazole 400 mg 100 mL i.v. TDS/ inj. Ornidazole 100 mL i.v. BID.

Table 90.Dosage regimens of higher antibiotics used based on culture and sensitivity reports in severe respiratory infections

Imipenem - Cilastatin	I.V. 500 mg QID
Colistin	I.V. Loading dose = 300 mg CBA Followed by150 mg CBA BID Begin maintenance dose12 hours after the loading dose [Colistin base activity 1 mg (CBA) is equivalent to 30,000 units Colistimethate sodium] Nebulisation 150 mg CBA TDS delivered over 60minutes
Tigecycline	I.V. • Initial dose = 50 mg 2 vials as a single dose • Maintenance dose: = 50 mg 1 vial BID • Infuse over 30 to 60 minutes
Teicoplanin	I.V. • Initial dose = 6mg/kg 12 hrly for 3 doses • Maintenance dose = 6mg/kg OD • Give as infusion over 30 minutes or bolus over 3-5 mins
Tobramycin	Nebulisation: 300 mg every 12 hours

Table 91.Empiric antibiotic regimens for lung abscess and empyema [4,7,8]

Lung abscess/Empyema	Inj. Piperacillin-tazobactam 4.5 g I.V. TDS (or), Inj. Meropenem1g I.V. TDS + Inj. Levofloxacin100 mL or moxifloxacin 100 mL I.V. OD + Inj. Metronidazole 400 mg I.V. TDS (or), Inj. Ornidazole 500 mg I.V. BID

Antibiotic treatment of COPD exacerbations

First line

- Amoxicillin/Clavulanate 625 mg PO TID for 5 days (or)
- Doxycycline 100 mg PO BID for 5 days (or)
- Azithromycin 500 mg PO OD for 5 days

Alternatives

- Amoxicillin/clavulanate 875 mg PO BID (or)
- Clarithromycin 500 mg PO BID (or)
- Second-generation cephalosporins

Previous antibiotics or known gram-negative pathogens

- Levofloxacin 500-750 mg PO OD for 7 days (or)
- Ciprofloxacin 500 mg PO BID for 7 days

Prevention of Pulmonary Exacerbations in Non-Cystic Fibrosis Bronchiectasis cases

(3 or more exacerbations requiring antibiotic therapy per year)

Azithromycin oral

500 mg 3 times weekly for 6 months

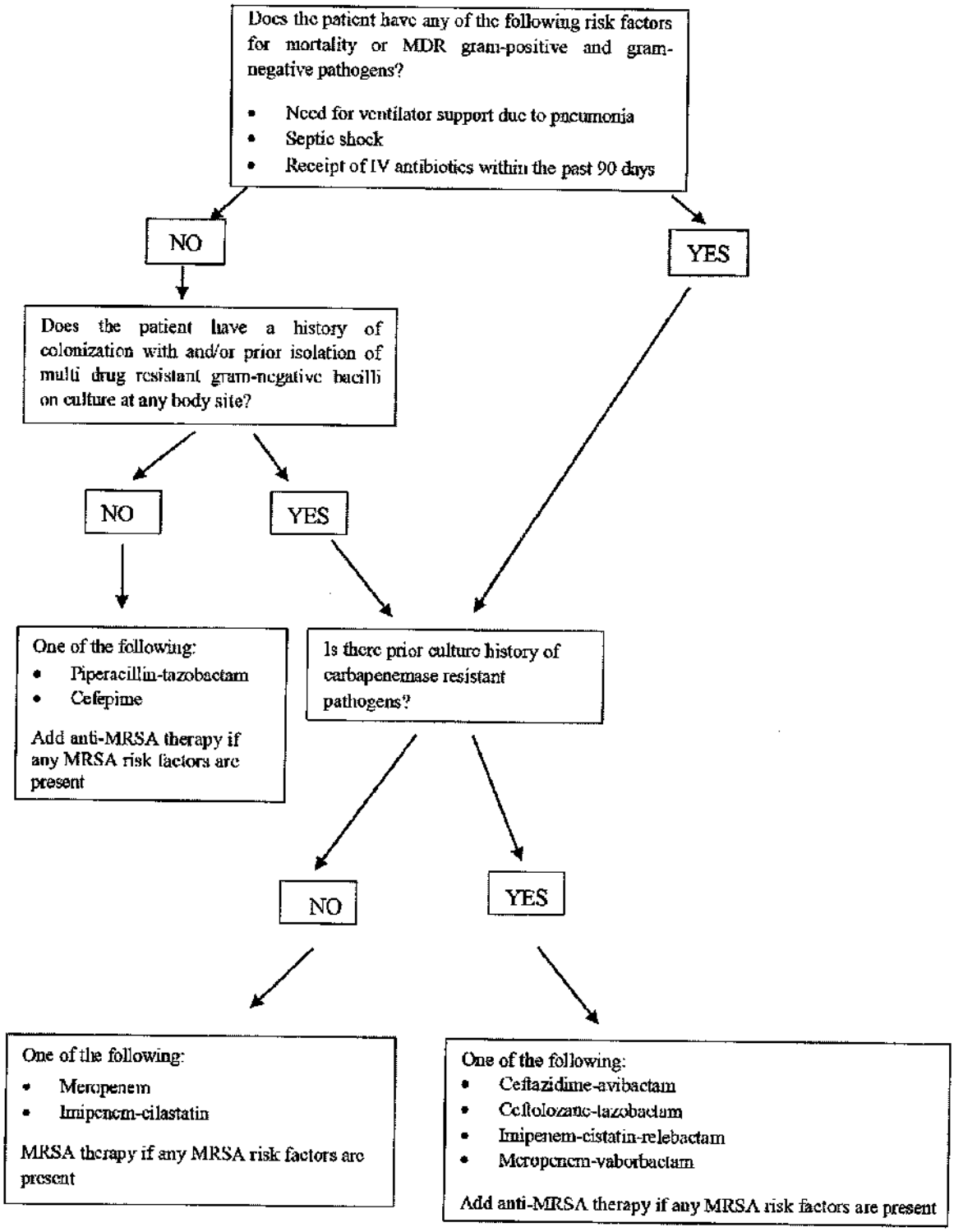
Pulmonary Exacerbations in Non-Cystic Fibrosis Bronchiectasis cases

(3 or more exacerbations requiring antibiotic therapy per year) [5,6]

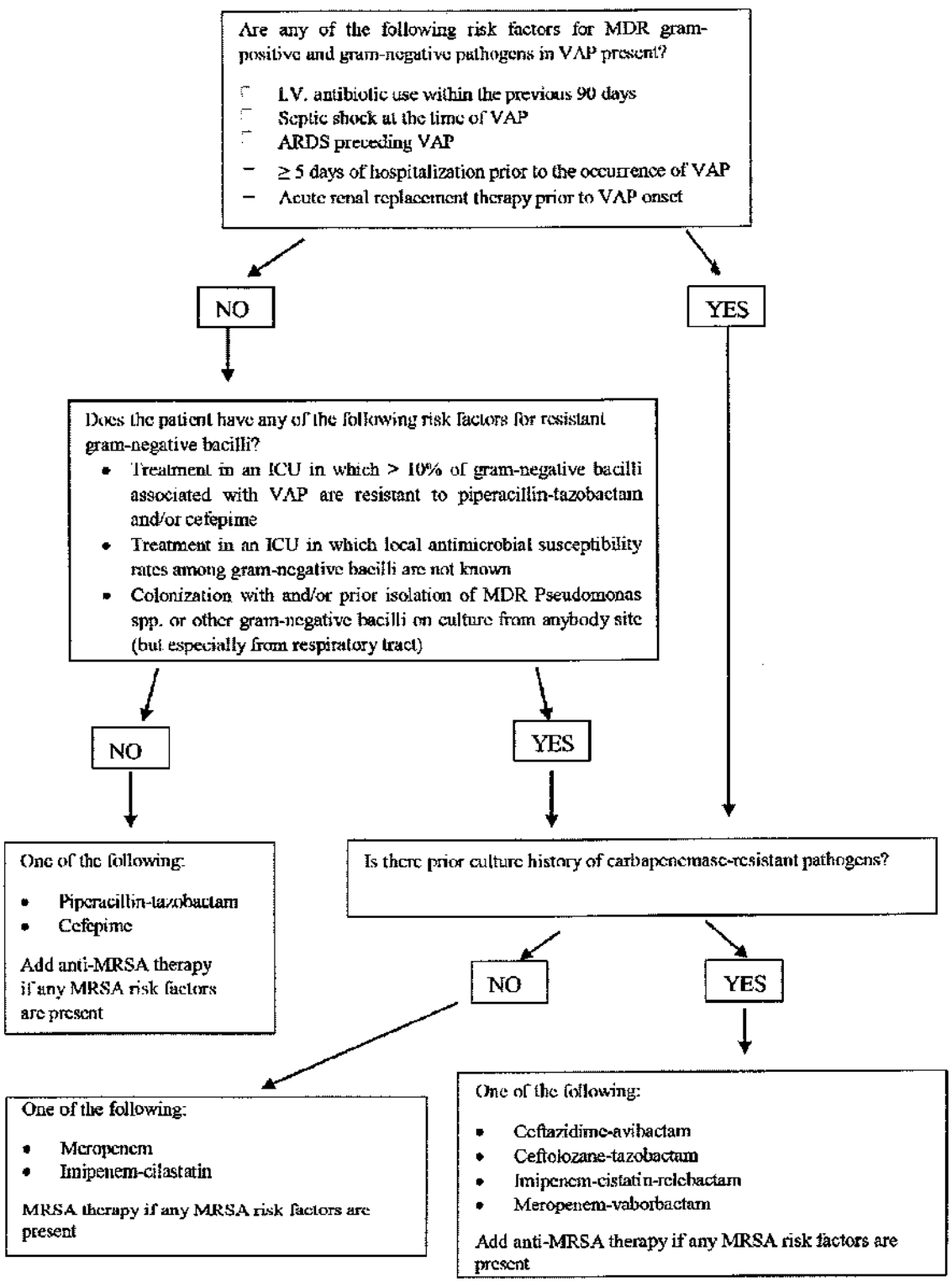
For acute exacerbations:

Beta-lactam (if there is no previous positive microbiology) or anti-pseudomonal cephalosporin
+
Aminoglycoside i.e. Inj. Amoxicillin-clavulanate 1.2 g I.V. TDS (or),
Inj. Cefoperazone-sulbactum 1.5 g I.V. BID
+
Nebulisation with tobramycin 300 mg BID
(Doxycycline for those with penicillin allergy)

Flow chart 1.Empiric treatment algorithm for non-ventilator hospital-associated pneumonia in adults with normal renal function



Flow chart 2. Empiric antibiotic selection pathway for ventilator-associated pneumonia (VAP) in adults with normal renal function



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7 H. INFECTIONS IN DERMATOLOGY

Introduction: The use of antibiotics in dermatology is restricted mainly to acne and skin and soft tissue infections (SSTI). While antibiotic stewardship has helped to tackle the problem to quite some extent, a lot more needs to be done as many dermatological prescriptions come from non dermatologists and other physicians. So a multi-disciplinary approach and awareness is also essential for a successful implementation of any antibiotic guidelines.

The concern over antimicrobial resistance has shaped many international guidelines for the treatment of acne. Misuse of topical and oral antibiotics is the primary driver of this resistance. The frequency of resistant Cutibacterium acnes *(C. acnes)* to any antibiotic rose from 34.5% in 1991 to 55.5% in 2000. While a study in 52 *C. acnes* strains isolated from 80 patients in India reported 100% resistance to azithromycin. Though some resistance is developing, doxycycline remains highly effective for moderate-to-severe acne. Overall, there are higher rates of clindamycin and erythromycin resistance and lower rates of doxycycline resistance of *C. acnes*. The present recommendation for systemic antibiotics for acne, to doxycycline and lymecycline, is to limit the treatment period to 3 months. The use of systemic antibiotics, other than the tetracyclines and macrolides, is discouraged because there are limited data for their use in acne. There should be a restriction for the use of oral azithromycin for acne due the increased resistance seen due to unrestricted use. To reduce the occurrence of resistance, treatments should be combined with bezoyl peroxide (BPO) or retinoids and use treatment other than antibiotics. Antimicrobial resistance should be suspected if there is no improvement after 6 weeks of treatment. BPO is a topical treatment that clinically improves acne, does not induce bacterial resistance and shows a well-established antibacterial non-antibiotic action. In addition, BPO has been shown to reduce antibiotic-resistant *C. acnes* strains. Also topical antibiotic should preferably be avoided as monotherapy. Use of non antibiotics formulation for acne is advisable to combat the menace of antibiotic resistance. Antibiotics should be used only when required. Table 1 highlights the recommended antibiotics for acne.[1,2]

Table 92. Recommendation of oral antibiotics in acne

Oral tetracyclines	Doxycycline, lymecyclence, minocycline, serecycline
Oral macrolides	Azithromycin, Erythromycin (in pregnancy and< 8 years)
Trimethoprim-sulphamethoxazole	Only in severe acne cases
Cephalosporin (1st generation)	Use not encouraged
Clindamycin	Use in severe and resistant acne cases

Bacterial skin infections are common in children and frequently do not require systemic antibiotic therapy, particularly for superficial forms. Skin infections are most often caused by two intermittent hosts of the skin, which themselves possess a wide range of virulence factors: Staphylococcus aureus and Streptococcus pyogenes or Group A Streptococcus (GAS).

Those infections which are localized (skin surface < 2%) and few (< 5 lesion sites), washing (with soap and water) and careful rinsing of the lesion are the key points of treatment. Washing with a detergent (soap) not only removes scales and crusts, but also destroys the lipids making up the bacterial wall. Similarly, in abscessed lesions, it is the drainage of pus, whether spontaneous or surgical, that will enable healing, rather than antibiotic therapy, which will diffuse very poorly within the pus. However, special care must be taken in immunocompromised children and in cases of particular localization, particularly in the perineal region, where other bacteria may be involved, such as enterobacterales, anaerobes or Pseudomonas.[3] Antibiotic should target both SA and GAS as they are frequently associated unless specific organism is involved.[3,4] Table 93 shows the management of SA infections.[4]

Table 93. Management of skin infections caused by Staphylococcus aureus

Infections	Treatment	Adult dosing	Pediatric dosing	Duration
Impetigo (localized and simple)	Mupirocin 2 % ointment Ratapamulin 1% Fusidic acid 1% Oxenoxacin 2%	Twice a day Twice a day	Twice a day Twice a day	5-7 days
Impetigo, ecthyma, folliculitis (methicillin sensitive SA)	Dicloxacillin	250-500 mg po 4 times daily	Not typically used in children	7 days recommended depending on clinical response
	Cephalexin	500 mg po 4 times daily	50-100 mg/kg/day (3-4 divided dose)	
	Erythromycin	200-500 mg po 4 times daily	30-50 mg/kg/day (3-4 divided dose)	
	Amoxicillin/ clavulanic acid	875/125 mg po twice daily	25 mg/kg/day (3 divided dose)	
	Clindamycin	300-450 mg po 3-4 times daily	20-30 mg/kg/day (3-4 divided dose)	
Impetigo, ecthyma, folliculitis (methicillin resistant SA)	Clindamycin	300-450 mg po 3-4 times daily	20-30 mg/kg/day (3-4 divided dose)	7 days recommended depending on clinical response
	TMP-SMX	1 DS twice a day	8-12 mg/kg/day (TMP dose) (divided twice daily)	
	Doxycycline	100 mg po twice daily	Not in children < 8 years	
	Minocycline	200x1+ 100 mg po twice daily	Not in children < 8 years	
Furuncle, carbuncle, abscesses (simple)	Incision and drainage	Not applicable	Not applicable	7-14 days course recommended depending on clinical course
Furuncle, carbuncle,	Incision and drainage			7-14 days course

abscesses that are not drainable and are associated with cellulitis	Clindamycin	300-450 mg po 3-4 times daily	20-30 mg/kg/day (3-4 divided dose)	recommended depending on clinical course
	TMP-SMX	1 DS twice a day	8-12 mg/kg/day (TMP dose) (divided twice daily)	
	Doxycycline	100 mg po twice daily	Not in children < 8 years	
	Minocycline	200 x 1+ 100 mg po twice daily	Not in children < 8 years	
	Linezolid	600 mg po twice daily	10 mg/kg/dose po thrice daily (maximum 600mg /dose)	
Complicated MRSA and SSTIs	Vancomycin	15-20 mg/kg IV q 8-12 h	40 mg/kg/day IV (4 divided dose)	7-14 days course recommended depending on clinical course
	Linezolid	600 mg po twice IV daily	10 mg/kg/dose po thrice IV daily (maximum 600 mg /dose)	
	Daptomycin	4 mg/kg IV daily	Not determined	
	Ceftaroline	600 mg IV q 12h	8-12 mg/kg/dose po or IV 8h	
	Clindamycin	600 mg po or IV thrice daily	10-13 mg/kg/dose po or IV q 6-8 h (maximum 40 mg/kg/day)	
	Telavancin	10 mg/kg IV daily	Not determined	
	Quinupristin-dalfopristin	7.5 mg/kg IV q8-12h	Not determined	
Nares and skin colonization	Mupirocin 2% ointment	Twice daily x 5-10 days		Can be repeated monthly for 3 months
	Chlorhexidine soaps	Daily x 5-14 days		
	Bleach bath	Twice weekly x 3 months		
		300 mg twice daily + other oral antibiotics x 7-14 days		

In contrast to SA, the antibiotic treatment of superficial pyodermas caused by GAS is penicillin and treatment should be continued for 10 days to ensure eradication of the infections. Those allergic to penicillin, erythromycin or clindamycin can be given. For acute GAS lymphangitis, children older than 3 years or adults without co-morbidities and non toxemic can be treated in OPD settings. Those with systemic signs and symptoms should be admitted treated with IV antibiotics. Table 94 is a tabular form for treatment of skin infections caused by GAS.[4]

For simple furuncles, carbuncles and abscesses, incision and drainage is alone performed, and its likely to be adequate. But additional antibiotic coverage has better cure. If infection is severe, multiple sites, surrounding cellulitis, signs of systemic infections and patients who are immunosuppressed, very old or young patients, systemic antibiotic must be added.[4] The choice of antibiotic should be changed according to the sensitivity pattern. Children with recurrent abscess should be evaluated for neutrophilic disorders and primary immune-deficiencies. Hidradenitis suppurativa, pilonidal sinus or foreign body should be ruled out if recurrent furuncle or abscess happens at the same sites.[3,4] So to sum up for a successful management of SSTI, a correct diagnosis, antibiotics according to sensitivity, simple washing with soap and water, incision and drainage are some of the points to be taken care of. Not to forget, taking care of the recurrent factors and co-morbidities are additional requirement for long term and proper management of the patients. Also the occurrence of multidrug resistance should be kept in mind as it is an emerging problem that has to be managed subsequently.[1,3]

Table 94. Management of Skin Infections Caused by Group A Streptococcus

Infection	Treatment	Adult Dosing	Pediatric Dosing	Duration
Impetigo (Localized and simple	Mupirocin 2% ointment	Twice daily	Twice daily	5 to 7 days course
	Retapamulin 1% ointment	Twice daily	Twice daily	
	Fusidic acid 1% cream (not available in U.S)	2 - 4 times daily	2 - 4 times daily	
Impetigo Ecthyma (Group A) Streptococcus GAS)	Penicillin VK	250 –500 mg po 4 times daily	25-45mg/kg/day (2-3 divide doses)	10 days course recommended, depending on clinical response
	Amoxicillin – clavulanic acid	875/125 mg po twice daily	25-45 mg/kg/day (amoxicillin dose twice daily	
	Benzathine penicillin G	1.2 million units IM x1 dose	600,000 units IM x 1 dose	
	Cephalexin	500 mg po 4 times daily	50-100 mg/kg/day (3-4 divided doses)	
	Erythromycin	200 -500 mg po 4 times daily	30 – 50 mg/kg/day (3-4 divided doses)	
	Clindamycin	300 - 450 mg po thrice daily	20-30 mg/kg/day (3-4 divided doses)	

Lymphangitis (GAS)	Penicillin	2-4 million units IV q4-6h	60.000-100.000 units/kg/dose IV q6h	10 to 14 days course recommended, depending on clinical/ response
	Clindamycin	600 -900 mg IV q8h	10-13 mg/kg/dose IV q8h	
	Nafcillin	1 2g IV q4-6h	50 mg/kg/dose IV q6h	
	Cefazolin	1 g IV q8h	33 mg/kg/dose IV q8h	
	Vancomycin	15 -20 mg/kg IV q8 -12h	40 mg/kg/day IV (4 divided doses q6h)	
	Linezolid	600 mg po or IV twice daily	10 mg/kg/dose po or IV thrice daily (maximum : 600 mg/dose)	
	Daptomycin	4 mg/kg IV daily	Not determined	
	Telavancin	10 mg/kg IV daily	Not determined	
Recurrent GAS Infection	Clindamycin	350 - 450 mg po thrice daily	20 - 30 mg/kg/day (3 - 4 divided doses)	10 – days course recommended depending on clinical response
	Amoxicillin – Clavulanic acid	875/125 mg po twice daily	25 - 45 mg /kg/day (amoxicillin dose) twice daily.	

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7 I. INFECTIONS IN RADIATION ONCOLOGY

Introduction: Patients who undergo cytotoxic chemotherapy and those receiving radiation therapy to high volume of functioning bone marrow are at increased risk of neutropenia due to myelosuppression. Moreover, radiation therapy and chemotherapy induced mucositis increases the risk of invasive infection due to seeding of blood stream from endogenous flora in gastrointestinal tract. Patients with underlying malignancy also has increased risk of infection in biliary tract, bronchial, gastrointestinal tract or urinary system because of tumour induced obstruction. The risk is particularly high during the period of neutropenia. Prevention and appropriate management of febrile neutropenia (FN) is important because the rate of major complications (eg, hypotension, acute renal, respiratory, or heart failure) in the context of FN is approximately 25% to 30% and mortality up to 11%. In the setting of severe sepsis or septic shock, the hospital mortality rate may be as high as 50%. Antimicrobial prophylaxis can decrease the risk of infection. However because of drug related adverse effect as well as concern about antimicrobial resistance and cost calls for proper weighing of benefit and harm.[1]

Antimicrobial prophylaxis

1) American Society of Clinical Oncology/Infectious Disease Society (IDSA) recommendation:

- Risk of febrile neutropenia should be systematically assessed, with consideration of patient-related, cancer-related, and treatment-related factors.[1]
- Antibiotic prophylaxis is not routinely recommended for patients with solid tumors.[1]
- Prophylaxis (e.g. with trimethoprim-sulfamethoxazole [TMP-SMX]) is recommended for patients receiving chemotherapy regimens associated with 3.5% risk for Pneumocystis jirovecii pneumonia (e.g. those with ≥ 20 mg prednisone equivalents daily for ≥ 1 month or those receiving purine analogs).[1]
- Treatment with a nucleoside reverse transcription inhibitor (e.g. Entecavir or tenofovir) is recommended for patients who are at high risk of hepatitis B virus reactivation.[1]
- Yearly influenza vaccination with inactivated vaccine is recommended for all patients receiving chemotherapy for malignancy and all family and household contacts and health care providers.[1]

Risk stratification

Risk stratification is required to determine the management of patients with fever and neutropenia, including the route of antibiotic therapy (oral vs. IV), its duration, and the choice of inpatient or outpatient care. Widely accepted indications of high risk include either or both of the following:

- Chemotherapy-related neutropenia that is expected to be prolonged (duration 7 days) and profound (absolute neutrophil count [ANC] < 100 cells/Ml.[2]

- Significant medical co-morbid conditions (e.g. hypotension, pneumonia, new-onset abdominal pain, neurologic changes).[2]

2) NCCN recommendation[2]

Initial Empiric Antibiotic Therapy

Empiric antibiotics are necessary in patients with fever and neutropenia, because currently available diagnostic tests are not sufficiently rapid, sensitive, or specific to identify or exclude microbial causes of fever from other noninfectious causes.[3]

Selection of initial therapy should consider the following:

- The infection risk assessment of patients.
- The antimicrobial susceptibilities of pathogens isolated locally.
- The most common potentially infecting organisms, including antibiotic resistant pathogens, such as extended spectrum beta-lactamase producing gram-negative rods, vancomycin-resistant enterococcus (VRE) and colonization with or previous infection with MRSA.
- The potential sites of infection.
- The importance of a broad-spectrum bactericidal antibiotic regimen that includes antipseudomonal coverage.[4-6]
- Clinical instability (e.g. hypotension, organ dysfunction)
- Drug allergy
- Recent antibiotic use (including prophylaxis) and
- Bactericidal nature of the antibiotic.

Recommended Approaches

Low risk of infection with fever and neutropenia -

- One approach is IV antibiotic monotherapy with imipenem/cilastatin, meropenem, piperacillin/tazobactam, or an extended-spectrum antipseudomonal cephalosporin.[7-10]
- Local institutional bacterial susceptibilities should be considered when selecting empiric antibiotic therapy.

Another approach for initial empiric therapy for patients at low risk for infections with fever and neutropenia is oral antibiotic therapy-[11]

- Ciprofloxacin plus amoxicillin/clavulanate.[11]
- Ciprofloxacin plus clindamycin for patients allergic to penicillin.
- Moxifloxacin
- Levofloxacin[11]

- Fluoroquinolone regimens should not be administered in patients receiving antimicrobial prophylaxis with a fluoroquinolone.[12]

IV antibiotic monotherapy is the preferred treatment option for patients at intermediate or high risk with fever and neutropenia. However, IV antibiotic combination therapy, though not routinely recommended, may be considered in higher risk or antimicrobial resistant cases. In such situations, an aminoglycoside combined with an antipseudomonal agent can be considered. Use of vancomycin, linezolid, daptomycin, or tedizolid is not routinely recommended.

For patients at high risk for *Pseudomonas* infections (e.g. history of previous *Pseudomonas* infections, presence of ecthyma gangrenosum), initial combination therapy with the most active antipseudomonal agents available in the local setting should be considered.[13,14] Vancomycin should be reserved for specific indications and should not be considered as a routine component of initial therapy for fever and neutropenia.[15]

Empiric addition of Vancomycin

Because of the increased risk for vancomycin-resistant organisms, empiric vancomycin use should be considered only in patients at high risk for serious gram-positive infection, and should not be considered as a routine component of initial therapy for fever and neutropenia.[16]

Vancomycin should be considered in the following clinical situations:[17-20]

- Clinically apparent, serious IV catheter-related infection (to cover coagulase-negative staphylococcal isolates, which are usually beta-lactam antibiotic-resistant and MRSA)
- Blood cultures positive for gram-positive bacteria before final identification and susceptibility testing
- Known colonization with penicillin/cephalosporin-resistant pneumococci or MRSA
- Clinical instability (e.g. hypotension or shock), pending the results of cultures and
- Soft tissue infection (particularly in regions where MRSA infection is common)

If empiric vancomycin (or other agents for gram-positive resistant infection) is initiated in any of these situations, its use should be reassessed within 2 to 3 days of initiation. If a resistant gram-positive pathogen (e.g. MRSA) is not identified, the Panel recommends discontinuing the agent. For management of complicated cases of *C. difficile* infections, oral vancomycin can be considered.[21]

In patients with neutropenic fever and severe mucositis who are receiving imipenem /cilastatin, meropenem, or piperacillin/tazobactam (i.e. antibiotic with activity against oral flora), it does not appear that the addition of vancomycin is advantageous. Thus, the NCCN Guidelines Panel strongly recommends that vancomycin should not be routinely added to an empiric regimen solely based on persistent neutropenic fever of unknown etiology.[22-23]

Agents with Broad-Spectrum Activity against Gram-Positive Pathogens

If decreased susceptibility is found on minimum inhibitory concentration assessment, other treatment options for resistant gram-positive infections should be considered. Linezolid, daptomycin, and tedizolid are active against the majority of gram-positive organisms, including beta-lactam resistant and vancomycin-resistant pathogens.[24]

Vancomycin or linezolid should be used for the treatment of MRSA pneumonia in patients who are ventilated. Linezolid is not approved by FDA for treatment of catheter related infections, catheter-site infections, or gram-negative infections. The use of linezolid, daptomycin, and tedizolid is limited to specific situations involving infections caused by documented vancomycin-resistant organisms, or for patients in whom vancomycin is not an option.[25,26]

Initial Empiric Therapy for Patients who are Clinically Unstable

Sepsis is suggested by signs of clinical instability including hypotension, tachypnea, new or worsening tachycardia, mental status changes, decreased urine output and organ dysfunction. Initial therapy for sepsis should broadly cover pathogens that are likely to cause sepsis while minimizing the potential for inadequate treatment. The antibiotic regimen should be modified, if necessary, after culture results and susceptibility are known. The initial empiric regimen for neutropenia with clinical instability may include a broad-spectrum beta-lactam (eg, imipenem/ cilastatin, meropenem, piperacillin-tazobactam) plus an aminoglycoside and vancomycin. Addition of fluconazole or an echinocandin should be strongly considered in patients not receiving antifungal prophylaxis.[27-29] Local susceptibility patterns and recent antibiotic use should be taken into account when devising the antibiotic regimen. Patients who have a history of *P. aeruginosa* colonization or of invasive disease should receive combination therapy with an antipseudomonal beta-lactam plus an aminoglycoside or ciprofloxacin.[30]

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7 J. INFECTIONS IN CARDIOLOGY

Introduction: Antibiotics in the cardiology department are primarily used of perioperative prophylaxis in cardiac surgery (e.g, CABG), prevention of infective endocarditis (IE) in high-risk patients and treatment of cardiac device infections. Standard practice favors 1st generation cephalosporins (like cefazolin) for surgery, while in some regions, dual therapy (e.g., Amikacin-co-amoxiclav) is common in pediatric cardiology.[1]

Key uses of Antibiotics in Cardiology

- *Cardiac surgery Prophylaxis:* First-generation cephalosporins (cefazolin) are the standard choice to prevent post-sternotomy infections, usually administered before skin incision and continued for 24-48 hours.
- *Infective Endocarditis (IE) prevention:* AHA/ESC guidelines recommend antibiotics prophylaxis (e.g amoxicillin) for high-risk dental procedures in patients with prosthetic heart valves, prior IE or unrepaired cyanotic congenital heart disease.
- *Cardiac Implantable Electronic devices (CIED):* Prophylactic antibiotics are used during pacemaker or defibrillator implantation to prevent infection, typically with beta-lactamase stable penicillin or cephalosporin.
- *Pediatric Cardiology:* Studies show frequent, often dual, antibiotic therapy for inpatients with coexisting infections, particularly for conditions like ventricular septal defect or rheumatic heart disease.
- *Endocarditis treatment*: High–dose IV antibiotics are the main stay for treating active infections, with 40-50% of cases requiring surgery.
- *Rheumatic fever & Myocarditis.*
- *Bacterial Pericarditis:* A rare, life threatening infection causing purulent pericarditis, urgent treatment requires intravenous antibiotics and surgical drainage.

Important consideration and risk

- **Antibiotic Resistance:** Over use of prophylactic antibiotics is linked to increased resistance, prompting calls for strict adherence to 24-48 hour, short-duration guidelines.[2]
- **Cardiac Risks:** While some studies suggested potential, yet unproven, benefits for reducing inflammation in coronary artery disease (e.g using macrolides), evidence does not support routine, long term use due to potential arrhythmia risks (QT prolongation) and increased mortality in some studies.[3]

Antibiotic Prophylaxis in Cardiac Surgery

The primary prophylactic antibiotic for adult cardiac surgery is recommended to be a first – generation cephalosporin, which is usually cefazolin. The most frequent organism cultured in cardiac SSI (surgical site infection) is Staphylococcus and colonization is considered the major factor in wound contamination. For this reason, until rapid screening test for S. aureus colonization are widely available, mupirocin is recommended as a routine prophylactic measure. In patient considered at high risk for a staphylococcal infection,

vancomycin (one pre operative with or without one additional dose) may be reasonable as an adjuvant agent to the cephalosporin. For patients who are considered β-lactam or penicillin allergic, vancomycin is recommended as the primary prophylactic antibiotic with additional gram-negative coverage. Topical antibiotics may be useful.[4]

Post- cardiovascular Surgery Infections [5]

Table 95. Choice of Antibiotic during CABG

S. no.	Surgery	Antibiotic prophylaxis			Comments
		1st line	2nd line	Special Antibiotic/ Combination	
1	CABG	Cefazolin	Cefuroxime		*Vancomycin/Teicoplanin to be used in case of high prevalence of MRSA infections only* Using only Vancomycin/Teicoplanin is NOT recommended due to lack of coverage of GNB Vancomycin infusion to be given over 1 hour & to be started 2 hrs before the surgical incision Teicoplanin dosing to start with 800 mg × 3 doses and then 6 mg/kg to complete prophylaxis Duration of prophylaxis: Continued till 48 hours after the surgery

Table 96. Empirical treatment after appropriate cultures have been collected

S. no.	Infection/ Syndrome	Likely Causative agents	Antibiotics			Comments
			1st line	2nd line	Special Antibiotic/ Combination	
1	Sternotomy site infection	Not known	BL-BLI (Piperacillin-tazobactam, Cefoperazone-sulbactam, Cefepime-tazobactam) with or without amikacin. With Vancomycin/ Teicoplanin	Daptomycin/ Linezolid with carbapenem	Consider de-escalation to TMP/SMX, doxy/ minocycline, cloxacillin, cefazolin, If these are sensitive	Removal of the foreign body (steel wires) should be considered

2	Infection of vascular catheters	Not known	BL-BL1 (Piperacillin-tazobactam, Cefoperazone-sulbactam, Cefepime-tazobactam) with or without amikacin. With Vancomycin/ teicoplanin	Carbapenem (Empirical anti-MRSA drug if the incidence of MRSA CRBSI is high)		Consider de-escalation as per the isolate, susceptibility, MICs, adverse effects, drug allergy
3	Pneumonia	Not known	BL-BL1 (Piperacillin-tazobactam, Cefoperazone-sulbactam) with or without amikacin	Carbapenem		Consider de-escalation as per the isolate, susceptibility, MICs, adverse effects, drug allergy
4	Mediastini-tis	Not known	BL-BL1 (Piperacillin-tazobactam, Cefoperazone-sulbactam) with or without amikacin with Vancomycin/ teicoplanin	Carbapenem with or without Amikacin		Consider de-escalation as per the isolate, susceptibility, MICs, adverse effects, drug allergy
5	Urinary tract infection	Not known	BL-BL1 (Piperacillin-tazobactam, Cefoperazone-sulbactam) with or without amikacin	Carbapenem with or without Amikacin		Consider de-escalation as per the isolate, susceptibility, MICs, adverse effects, drug allergy

Table 97. Definitive treatment after appropriate culture have been collected

S. no.	Infection/ Syndrome	Likely Causative agents	Antibiotics			Comments
			1st line	2nd line	Special Antibiotic/ Combination	
1	Stemotomy site infection	Coagulase Negative Staphylo-cocci	Vancomycin/ Teicoplanin	Daptomycin, Linezolid	Consider de-escalation to Cotrimoxazole or Cloxacillin or Cefazolin	1) Consider MICs, risk of nephrotoxicity, bone penetration for choosing the antibiotic

		MRSA	Vancomycin/ Teicoplanin	Daptomycin, Linezolid	Consider de-escalation to TMP/SMX or doxy/minocycline if these are sensitive	2) Removal of the foreign body (steel wires) should be considered
		Enterococcus	Vancomycin/ Teicoplanin		Consider de-escalation to Ampicillin/ Ampi-sulbactam	3) Longer duration of duration – 6-12 months may be required
		GNB (Enterobacteriacae, Pseudomonas acinetobacter)	BL-BL1 (Piperacillin-tazobactam, Cefoperazone-sulbactam, with or without Amikacin	Carbapenem (Meropenem, Imipenem)	Consider de-escalation to oral agent if possible after 2-6 weeks of antibiotic therapy	
		Candida	L AmB/ AmB-d for 3 weeks followed by Fluconazole (If susceptible)		De-escalation to Fluconazole 800 mg loading followed by 200 mg BD	For Candida osteomyelitis, longer duration of treatment (12 months) is recommended

Table 98. Infective Endocarditis (Empirical therapy pending blood culture results) [6]

Type of Infection	First Line (with Dosage and Duration)	Alternative First Line (with dosage and Duration)	Comments
Uncomplicated • Native valve	Penicillin-G 4 million units IV 4 hrly for 4 weeks Or Ampicillin 2g IV 4 hrly for 4 weeks + Gentamicin 1mg/kg IM or IV 8 hrly for first 2 weeks	Vancomycin 15mg/kg IV 12 hrly (max. 1 g 12 h) for 4-6 weeks Gentamicin 1 mg/kg IM or IV 8 hrly for 4 weeks	These are among the few conditions where combination antimicrobial therapy is contemplated as synergism of antimicrobials is established. If patient is stable, ideally wait for blood cultures and modify antibiotics based on culture results and complete 4-6 weeks of antibiotics.
Uncomplicated • Prosthetic valve	Vancomycin 15mg/kg IV 12 hrly (max. 1g 12h) for 6 weeks + Gentamicin 1mg/kg IM or IV 8 hrly for first 2 weeks	Daptomycin 10mg/kg every 24 hrs + Gentamicin 1mg/kg IM or IV 8 hrly for first 2 weeks	Two sets of blood cultures within 1 hr of each other in patients with suspected endocarditis and acute sepsis and three sets of blood cultures spaced ≥ 6 hr apart in cases of suspected sub acute or chronic endocarditis are recommended for best results.

Complicated (In severe sepsis)	Vancomycin 15mg/kg IV 12 hrly (max. 1g 12 h) for 4-6 weeks + Meropenem 1g IV q8h for 4-6 weeks Or Teicoplanin 12mg/kg IV 12 hrly x 3 doses followed by 6-12 mg OD IV depending upon severity + Gentamicin 1mg/kg IM or IV 8 h for 4-6 weeks	Daptomycin 10mg/kg IV OD + Meropenem 1g IV q8h Duration 4-6 weeks	

Table 99. Antibiogram of RIMS Blood culture (2024-2025)

Which may help in deciding empirical antibiotic choice.[7] Overall Positivity: - 5.4%.

Species	Percentage (%)	Susceptibility (%)
Staphylococcus aureus	16.42	Vancomycin (100%)
Klebsiella pneumoniae	14.25	Minocycline (50%)
Pseudomonasaeruginosa	14.01	Tazobactam-piperacillin (91.4%)
Staphylococcus spp.	13.77	Vancomycin (100%)
Acinetobacter baumannii	9.42	Levofloxacin (95.5%)
Escherichia coli	7.97	Tigecycline (100%)
Staphylococcus epidermidis	5.56	Vancomycin (100%)
Staphylococcus hominis	4.11	Vancomycin (100%)
Klebsiella oxytoca	3.62	Minocycline (57%)
Staphylococcus haemolyticus	2.42	Vancomycin (100%)
Others	8.45	

Table 100. Acute Myocarditis [8]

Type of infection	First line (with Dosage and Duration)	Alternative (with Dosage and Duration)	Comments
Uncomplicated	No empirical antibiotics required		Mild myocarditis may only need rest and supportive medicine. If myocarditis is severe, immunomodulators like steroids may be administered to improve cardiac

			function. Myocarditis is a diagnosis of exclusion. If bacterial cause is ascertained through culture, start antibiotics based on AST results.
	No empirical antibiotics required		If myocarditis is causing severe heart failure or arrhythmia, to reduce the risk of blood clots anticoagulants may be administered. In addition, to address fluid overload and to reduce the strain on the heart, diuretics, beta blockers, angiotensin-converting enzyme (ACE) inhibitors or angiotensin 2 receptor blockers (ARBs) need to be given.

Table 101. Pericarditis [8]

Type of Infection	First line (with Dosage and Duration)	Alternative (with Dosage and Duration)	Comments
Uncomplicated	No empirical antibiotics required		Mostly viral etiology
Complicated (features of tamponade)	No empirical antibiotics required		Pericardiocentesis is recommended, when possible, to establish cause. If microbiology laboratory evidence indicates bacterial infection, antibiotics should be started.

Cardiac Implantation Electrical Device: Antibiotic prophylaxis and infection treatment.[9]

Antibiotic Prophylaxis

Prophylactic administration of antibiotics is a proven strategy to reduce the risk of infection associated with CIEDs and is considered standard clinical practice. To achieve optimal tissue concentrations at the surgical site, antibiotic treatment should be started within one hour before the skin incision. The most frequently identified pathogen is Staphylococcus aureus with a high prevalence of methicillin resistance. Intravenous flucloxacillin (1-2g) and first generation cephalosporin, such as cefazolin (1-2g), provide effective protection against methicillin susceptible Staphylococcus aureus. In patients at an increased risk of infection, the use of advanced prevention strategies, such as antibiotic releasing envelops, may provide additional protection. These envelop which consist of an antibiotic mesh, release minocycline and rifampin locally for at least seven days, with complete absorption occurring over approximately nine weeks.

Table 102. Antibiotic treatment according to primary types of CIED infections

Type of Infection	Empirical Treatment	Adjustments	Duration
Superficial incisional infection	• Oral antibiotic treatment covering *S. aureus* Flucloxacillin oral or amoxicillin-clavulanate • If high MRSA prevalence trimethoprim-sulphamethoxazole, clindamycin, doxycyclin, linezolid	To be adjusted after culture result	7-10 days
Isolated pocket infection (negative blood cultures)	• Methicillin-resistant coagulase-negative staphylococci and *S. aureus*: vancomycin or daptomycin • If systemic symptoms: for additional gram-negative coverage, combine with 3rd-gen cephalosporin or gentamicin	To be adjusted after culture result	10-14 days post-extraction
Systemic infection (without vegetation on leads or valves ± pocket infection	• Vancomycin or daptomycin + 3rd-gen cephalosporin or gentamicin • If sensitive staphylococci: flucoxacillin or 1st-gen cephalosporin	To be adjusted after culture result	4 weeks (2 if negative blood culture)
CIEDs endocarditis with vegetation on leads and/or valves ± embolism	• Vancomycin or daptomycin + 3rd-gen cephalosporin or gentamicin • If prosthetic valve: add rifampicin after 5-7 days	To be adjusted after culture result	6 weeks or longer

Rheumatic Fever [10]

Table 103. Antibiotic treatment for Rheumatic Fever

Type of Infection	First line (with Dosage and Duration)	Alternative (with Dosage and Duration)	Comments
Uncomplicated	Penicillin G Benzathine 0.6 million {weight < 27 Kgs}, 1.2 million {> 27 Kgs} units IM as a single dose Penicillin V, 500 mg q8h for 10 days Or Amoxicillin 500 mg q8h for 10 days	Confirmed penicillin allergy – Azithromycin 500 mg per oral / q24h for 5 days	Secondary prophylaxis: An injection of 0.6-1.2 million units of Benzathine penicillin G intramuscularly every 3 weeks is the recommended regimen or Penicillin V, 250 mg BD or Oral erythromycin 20 mg/kg/dose Maximum dose of 500 mg BD

Prophylaxis

Duration of antibiotics as secondary prophylaxis for rheumatic fever and rheumatic heart disease.

Table 104. Details of duration of antibiotic prophylaxis

Category of patient	Duration of prophylaxis
Rheumatic fever with carditis and residual heart disease (persistent valvular disease)	> years since last episode and at least until age 40 years, sometimes lifelong prophylaxis
Rheumatic fever with carditis but no residual heart disease (no valvular disease)	For 10 years after the last attack or at least until 21 years of age (whichever is longer)
Rheumatic fever without carditis	5 years or until 21 years, whichever is longer
More severe valvular disease	Life long
After valve surgery	Life long

a) Patient who are at high risk and likely to come in contact with populations with high prevalence of streptococcal infection, i.e., Teachers, Day-care workers, Clinical or Echocardiography evidence.

b) Valve severity is diagnosed according to the following ECHO criteria:

- Valve area (cm 2) < 1 in aortic, mitral and tricuspid valve.
- Mean gradient (mm Hg): aortic > 40, mitral > 10, pulmonic > 64, tricuspid > 5.

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7 K. INFECTIONS IN UROLOGY

Introduction: Urinary tract infections (UTI) are very common and can affect people from all age groups including neonate and geriatric patients. Every year about 150 million people are being diagnosed with urinary tract infection worldwide. Each and every woman has a lifetime risk of developing UTI is 60 %; by contrast, men have a lifetime risk of only 13%.[1]

Urinary tract infections can often occur after any diagnostic or therapeutic procedures with symptoms varying from asymptomatic bacteriuria to life threatening urosepsis. Among the patients with nosocomial urinary tract infections (UTIs), almost 80% have a prior history of urologic surgery; endourologic procedures have been undergone in 50%, open or laparoscopic surgery in 45%, and prostate biopsies in 5%.[2] Thus, in order to reduce the prevalence of UTIs, preventive measures, such as a strict preoperative evaluation and correct antibiotic prophylaxis should be considered. Proper urine cultures and antibiotics sensitivity testing should be considered before treatment of UTIs. Prudent use of antimicrobial agents, both in prophylaxis and in treatment of established infections should be done. Antibiotic agents should be chosen according to the predominant pathogens at a given site of infection in the hospital environment and local microbiological patterns.

Untreated UTI may progress to sepsis and shock. Urosepsis is one of the most dreadful complications encountered in urological practice owing to its increased morbidity and mortality. Urosepsis is defined as a sepsis caused by UTI; this occurs in 7–25% of all septic cases.[3] It may be associated with multi-organ dysfunction, hypo-perfusion or hypo-tension, with features consistent with systemic inflammatory response syndrome. Though sepsis is commoner in men than in women, it has been found that urosepsis is commoner in women than in men. While severe sepsis has a reported mortality rate of 20 to 42%, urosepsis may be associated with high mortality rates in special patient groups.[4] Proper patient evaluation before surgery, adequate antibiotic coverage both prophylactic and therapeutic and proper intraoperative and post operative care play a very important role in preventing adverse events related to infection and sepsis. Surgical antimicrobial prophylaxis plays a very important role in reducing the risk of surgical infections.

The principles of treatment of urosepsis involves adequate life-supporting care, appropriate and prompt antimicrobial therapy, adjunctive measures and the optimal management of urinary tract disorders. Source control by decompression of any obstruction and drainage of infected urinary tract is essential.[5] Urologists should work in collaboration with intensive care and infectious diseases specialists for better patient outcomes.

Proper use of prophylactic antibiotics can help in reducing the risk of infections and in order to standardize the administration of antibiotics in various scenarios, both European Association of Urology (EAU) and American Urological Association (AUA) have both

published guidelines for best practice in antibiotic prophylaxis in urologic surgery. Proper adherence to the guidelines can help in better patient outcomes and reduction in infections.

Risk factors for infectious complications and need for Antibiotic prophylaxis

There are certain well recognized factors that pose high risk for development of infectious complications after any urological procedure and require proper prophylactic antibiotic coverage. These high-risk factors can be divided into three different groups e.g. related to the patient (immunesuppression, malignancy, advanced age, poor nutrition, prolonged hospitalization), related to the procedure (stone disease management, prosthesis, long duration of surgery) and related to the urinary tract diseases (chronic bacteriuria, urinary diversion, stone diseases, anatomical anomalies). These factors frequently act in an additive manner, compounding their impact. The likelihood of bacterial invasion is also affected by the amount of bacteria at the site of the surgical procedure. All procedures invading the urinary tract are considered "clean–contaminated." The likelihood of bacterial invasion is increased if bacteriuria is present or adequate wound preparation and surgical techniques are not employed.[6]

Prevention of infections and sepsis in genitourinary surgical patients

EAU Guidelines on Urological Infections recommends the following basic preventive measures of proven efficacy in any urologic patient undergoing surgery:[7]

- Isolation of all patients infected with multi resistant organisms to avoid cross-infection.
- Prudent use of antimicrobial agents, both in prophylaxis and in treatment of established infections, to avoid selection of resistant strains.
- Reduction in hospital stay. Early removal of indwelling urethral catheters, as soon as allowed by the patient's condition.
- Nosocomial UTIs are promoted by bladder catheterization as well as by ureteral stenting.
- Antibiotic prophylaxis does not prevent stent colonization, which appears in 100% of patients with a permanent ureteral stent and in 70% of those temporarily stented.
- Use of closed catheter drainage and minimization of breaks in the integrity of the system. And use of the least-invasive method to release urinary tract obstruction until the patient is stabilized.
- Attention to simple everyday techniques to ensure a sepsis, including the routine use of disposable gloves, frequent hand disinfection and infectious disease control measures to prevent cross-infections.
- Thorough history taking, physical examination and identification of all co-morbidities and risk factors, proper preoperative evaluation and prophylactic antibiotics can help in minimizing the risk of complications.
- In order to be effective, the antimicrobial antibiotics must be given in proper dose and at specific time. Infusion of the first dose should begin within 60 minutes of the surgical incision (with the exception of 120 minutes for intravenous fluoroquinolones and vancomycin).

- Dosing of the antimicrobial drug must be adjusted to the patient's body weight. Oral administration is as effective as the intravenous route for antibiotics with sufficient bioavailability. Additional doses are required intra operatively if the procedure extends beyond two half-lives of the initial dose.

Duration of antibiotic prophylaxis

For most endourological procedures single dose prophylaxis or at most antibiotic prophylaxis for 24 hours is required.[8] The placement of prosthetic material, the presence of an existing infection and the manipulation of an indwelling tube are important circumstances requiring longer duration of antimicrobials.[9] Antibiotic agents should be chosen according to the predominant pathogens at a given site of infection in the hospital environment and local microbiological patterns.

Preoperative Antibiotics in specific procedures

Transurethral Surgeries

TURP

The AUA guidelines recommend the use of antimicrobial prophylaxis in all patients. The suggested antimicrobial prophylaxis is cephalosporins $2^{nd}/3^{rd}$ generation or trimethoprim–sulfamethoxazole as antimicrobial of first choice and alternatively a first-or second-generation cephalosporin, aminoglycosides ± ampicillin or amoxicillin/clavulanate, before the start of TURP and until less than 24 hours postoperatively.[10] The EAU guidelines recommend a very similar antibiotic regimen in all patients other than those at low risk or with a small prostate.[7]

TURBT

The AUA guidelines recommend trimethoprim–sulfamethoxazole or fluoroquinolones as the first choice of antimicrobials in all patients undergoing transurethral resection of bladder tumor.[9]

The EAU guidelines recommend that antimicrobial prophylaxis for TURBT is unnecessary unless the patient has some risk factors for infectious complications or a large tumor requiring a prolonged resection time, or a necrotic tumor.[11-13] EAU guidelines recommend Trimethoprim sulphamethoxazole or Cephalosporin group 2 or 3, or Aminopenicillin plus a beta-lactamase inhibitor for antimicrobial prophylaxis for TURBT in high-risk patients.[7]

Other transurethral procedures

Other transurethral procedures involving manipulation, like bladder biopsy, laser prostatectomy, and internal urethrotomy, may be similar in terms of tissue trauma, and the AUA guidelines suggest antibiotics prophylaxis for these procedures similar to TURP & TURBT.

Cystoscopy & Urethroscopy

AUA guidelines recommend single dose trimethoprim - sulfamethoxazole or Amoxicillin/ clavulanate as choice of antimicrobials for prophylaxis in host related risk factors.[10] While EAU guidelines do not recommend any prophylactic antibiotics for cystourethroscopy.[7]

Procedures related to Stones

Shock-wave Lithotripsy

AUA Best Practice Policy guidelines on antibiotic prophylaxis recommend preoperative antibiotic prophylaxis for all patients undergoing SWL.[10] AUA guidelines recommend trimethoprim-sulfamethoxazole or 1st gen. Cephalosporin (Cefazolin) or 2nd gen. Cephalosporin (Cefuroxime) or Aminopenicillin combined with a β-lactamase inhibitor and Metronidazole as the antimicrobial of choice for prophylaxis.[10]

EAU recommend against antibiotic prophylaxis prior to SWL in patients without stents or positive urine cultures.[7] Currently, prophylactic antibiotics should be considered only in high-risk patients and SWL should only be performed if the patient's urine is sterile and when there is no distal obstruction.

Ureteroscopy

AUA Best Practice Policy recommends antibiotic prophylaxis with single dose Trimethoprim-sulfamethoxazole or Amoxicillin/clavulanate prior to ureteroscopy for the management of stone disease.[10] The guideline committee states that the potential risk of bacteriuria is 30% and UTI ranges from 4 to 25 % without prophylaxis.

Percutaneous Renal Surgery

Ideally, all patients scheduled for PCNL must have a negative urine culture preoperatively, since stone manipulation or incision therapy in presence of active UTI can be extremely dangerous.

Both EAU and AUA guidelines recommend prophylactic antibiotic therapy for all percutaneous renal surgeries. First choice prophylactic antibiotics in PCNL include 2nd/3rd gen. Cephalosporin or cotrimoxazole or aminopenicillin + beta lactamase. Dose should be adjusted as per patient's body weight and they should be given for </= 24 hours.[10]

Since PCNL can be associated with a pre-existing infection, infectious stone, or manipulation of an indwelling catheter, the subsequent course of antimicrobials is therapeutic rather than prophylactic and might extend beyond 24 hours from the conclusion of the procedure.

Studies suggest that when the preoperative urine culture is negative, a single dose of antibiotics appears to be as effective in preventing postoperative infections as multiple doses irrespective of the type of antibiotic used.[14-17]

Trans Rectal Ultrasound guided biopsy of prostate

Adoption of Ciprofloxacin and Fosfomycin antibiotics significantly lowers the rate of prostate needle biopsy urosepsis. Moreover, this regimen is oral, low cost and single dose.[15] Targeted therapy is recommended based on rectal swab/stool culture. Fosfomycin is also good as an augmented prophylaxis with fluroquinolones although no established standard combination exists.[16]

Open and Laparoscopic Renal surgeries

- In Clean surgeries (adrenalectomy, lymphadenectomy, retroperitoneal or pelvic). EAU recommends prophylactic antibiotic for all clean cases (single dose of first generation cephalosporins), on the other hand AUA recommends prophylactic antibiotics only for patients with high risk.
- In Clean–contaminated surgeries (pyeloplasty, radical prostatectomy; partial cystectomy) Both EAU and AUA guidelines recommend prophylactic antibiotics for clean contaminated surgeries.
- In Contaminated and Dirty surgeries (drainage of perinephric abscess), antimicrobial agents are given with a therapeutic intention rather than prophylactically.

Antibiotics use in patients with indwelling catheters, stents and drainage tubes

Patients with an indwelling catheter, nephrostomy tube or other stent device should be considered as having bacteriuria and must be treated in advance (between 3 and 7 days prior to the procedure) in order to favor sterile urine at the time of surgery. The patient should be covered well beyond the intervention (7-10 days or longer), depending on the type of operation and patient factors.[17] Asymptomatic bacteriuria (bacterial colonization) is only to be treated prior to surgery or after removal of the drainage tube.

Table 105: Recommended antimicrobial prophylaxis in genitourinary surgery & procedures[7, 10]

Procedure	AUA indication	EAU indication	First choice antibiotic	Alternative	Duration	Remarks
Diagnostic procedures						
Cystography, cystoscopy, ureteroscopy, urodynamics	If risk factors	If risk factors	Amoxycillin-clavulanate or TMP-SMX	Aminoglycoside + 1st/2nd generation cephalosporin	≤ 24 hours	If urine culture negative, prophylaxis not necessary
Prostate biopsy	All	All cases	Fluoroquinolone or Aminoglycoside + 1st/2nd generation cephalosporin	Aztreonam may be needed	≤ 72 hours	
Endourologic surgery and shock-wave lithotripsy						
Shock-wave lithotripsy	All	If risk factors	Fluoroquinolone or TMP-SMX or 2nd/3rd - gen cephalosporin	Aminoglycoside ± ampicillin or amox./clavulanate	≤ 24 hours	Patients with ureteral stent, nephrostomy obstruction, infection stone

TURP / TURBT	All	All cases	Cefazolin or TMP-SMX	Aminoglycoside ± ampicillin or Aztreonam or amox./clavulanate	≤ 24 hours	
Ureteroscopy	All	If risk factors	TMP-SMX or 1st/2nd gen cephalosporin	Aminoglycoside ± ampicillin or 1st gen cephalosporin or amox./clavulanate	≤ 24 hours	
Percutaneous renal surgery	All	All	1st/2nd gen cephalosporin or Aminoglycoside + metronidazole or clindamycin	Ampicillin/sulbactam or fluoroquinolone or 1st-gen cephalosporin	≤ 24 hours	Short course; IV route suggested
Open or laparoscopic surgery						
Clean operations	If risk factor	All	Cefazolin	Clindamycin	Single dose	High-risk and short post operative catheter treatment
Clean-contaminated opening of urinary tract	All	All	Cefazolin, TMP-SMX	Ampicillin/sulbactam, aminoglycoside + metronidazole or clindamycin	Single perioperative dose	
Contaminated (involving bowel)	All	All	2nd/3rd- gen cephalosporin or aminoglycoside + metronidazole or clindamycin	Ampicillin/sulbactam, Ticarcillin/clavulanate, Piperacillin/tazobactam Fluoroquinolone	≤ 24 hours	For colon surgery add bowel prep with oral neomycin + erythromycin or metronidazole
Implanted prosthetic devices	All	All	Aminoglycoside + 1st/2nd - gen cephalosporin or vancomycin	Ampicillin/sulbactam, Ticarcillin/clavulanate, Piperacillin/tazobactam	≤ 24 hours	

Treatment Guidelines for Antimicrobial Use in Common Genitourinary Infections

Asymptomatic bacteriuria in adults

The treatment of ABU should be performed only in cases of proven benefit as it might be protective against super infecting symptomatic UTI.

Screening and treatment of ABU is not recommended in patients with ABU who are otherwise healthy, post meno-pausal women, patient dysfunctional and/or reconstructed lower urinary tracts, indwelling catheters or nephrostomy or suprapubic tubes, well regulated diabetes mellitus, asymptomatic recurrent UTI and renal transplant patients.[18] Treatment of asymptomatic bacteriuria is beneficial prior to urological procedures breaching the mucosa and in pregnant women there is weak recommendation for treatment.[19-20]

Local UTI

In female patients of uncomplicated cystitis with mild symptoms, antibiotics may not be required. Treatment regimen for uncomplicated cystitis has been mentioned in the table 106 on antibiotic use in genitourinary infections.

Recurrent UTI

Both continuous and low dose antimicrobial prophylaxis and post coital antimicrobial prophylaxis has been shown to reduce the rate of recurrent UTI.[21-22] We can use vaginal oestrogen replacement in post menopausal women to prevent recurrent cystitis. Use of cranberry products, favouring juice, for symptom relief in acute cystitis and to prevent recurrence; Use methenamine hippurate to reduce recurrent cystitis episodes in women without abnormalities of the urinary tract. Intermittent self-start therapy is effective and safe in women with recurrent UTI. Treatment regimen has been mentioned in the table106 on antibiotic use in genitourinary infections.

Uncomplicated pyelonephritis

Fluroquinolones and cephalosporins are the only antimicrobials that can be given as oral empirical treatment of uncomplicated pyelonephritis.[23] Intravenous antimicrobial regimen may include a fluoroquinolone, an aminoglycoside or an extended spectrum cephalosporin or penicillin. Carbapenems should only be considered in patients with multidrug resistant organisms. Treatment regimen has been mentioned in the table106 on antibiotic use in genitourinary infections.

Systemic UTI[24]

A systemic UTI occurs in an individual in whom factors related to the host (e.g. underlying diabetes or immunosuppression) or specific anatomical or functional abnormalities related to the urinary tract (e.g. obstruction, incomplete voiding due to detrusor muscle dysfunction) are believed to result in an infection that will be more difficult to eradicate than an uncomplicated infection. Systemic UTI include pyelonephritis, acute prostatitis and urosepsis. CAUTIs might present as localised as well as systemic infections. Do not use ciprofloxacin and other fluoroquinolones for the empirical treatment of systemic UTI in patients from urology departments or when patients have used fluoroquinolones in the last six months. Treatment regimen has been mentioned in the table106 on antibiotic use in genitourinary infections.

Catheter associated UTIs[25]

Catheter-associated UTI refers to UTIs occurring in a person whose urinary tract is currently catheterised or has been catheterized within the past 48 hours. Catheter-associated asymptomatic bacteriuria should be treated only prior to urinary tract interventions (e.g. transurethral resection of the prostate). Prophylactic antimicrobials should not be used to prevent catheter-associated UTIs. Replace or remove the indwelling catheter before starting antimicrobial therapy. Do not apply topical antiseptics or antimicrobials to the catheter, urethra or meatus. Use hydrophilic coated catheters to reduce CAUTI. EAU guidelines recommend against antibiotic prophylaxis to prevent clinical UTI after urethral catheter removal or in patients performing intermittent self-catheterisation.

Urosepsis[5]

Urosepsis requires a multi-disciplinary team comprising of urologist, intensive care specialists and infectious disease specialists. Urosepsis treatment requires a combination of treatment including relief of obstruction of urinary tract, adequate life-support care, appropriate antimicrobial therapy and appropriate supportive treatment. Perform the quick SOFA score to identify patients with potential sepsis. Treatment regimen has been mentioned in the table 106 on antibiotic use in Urosepsis.

Urethritis[26-27]

Patients diagnosed with severe urethritis should be started with empirical treatment. If the patients' symptoms are mild, delayed treatment guided by the results of NAATs is recommended. All sexual partners at risk should be assessed and treated whilst maintaining patient confidentiality.

In suspected gonococcal urethritis, Gram stain of urethral discharge or a urethral smear must be done preliminarily to diagnose gonococcal urethritis. A validated nucleic acid amplification test (NAAT) on a first-void urine sample or urethral smear prior to empirical treatment should be performed to diagnose chlamydial and gonococcal infections.Treatment regimen has been mentioned in the table 106 on antibiotic use in genitourinary infections. Treatment regimen of non-gonococcal urethritis has been mentioned in the table 106 on antibiotic use in genitourinary infections.

Bacterial Prostatitis

In Acute Bacterial Prostatitis[28]

Do not perform prostatic massage in acute bacterial prostatitis (ABP). Parenteral administration of high doses of bactericidal antimicrobials, such as broad-spectrum penicillin, a third-generation cephalosporin or fluoroquinolones, is recommended. Treatment regimen has been mentioned in the table 106 on antibiotic use in genitourinary infections.

In Chronic Bacterial Prostatitis

Perform the Meares and Stamey 2- or 4- glass test in patients with CBP. Fluoroquinolones are the first-line drugs for treatment of chronic bacterial prostatitis, doxycycline (100 mg BD for 10 days) or macrolide antibiotics like Azithromycin (500 mg OD for 3 weeks) can also be used if intracellular bacteria have been identified as the causative agent of CBP.

Acute infective Epididymitis[29]

In young sexually active patients both STIs and Enterobacteriaceae have to be considered as etiological agents. And a negative sexual risk history does not exclude STIs in sexually active

men. Mid-stream urine and a first voided urine sample for pathogen identification by culture and nucleic acid amplification test should be obtained before treatment. Treatment regimen has been mentioned in the table 106 on antibiotic use in genitourinary infections.

Fournier's Gangrene[30]

Fournier's gangrene is a rapidly spreading and frequently fatal polymicrobial soft tissue infection of the perineum, peri-anal region and external genitalia. The treatment for Fournier's gangrene should be started with immediate empirical broad-spectrum antibiotics on presentation with subsequent refinement according to culture and clinical response. Repeated surgical debridement for Fournier's gangrene should be considered within 24 hours of presentation. Treatment regimen has been mentioned in the table 106.

Table 106: Antibiotics used in Genitourinary infection

Urinary syndrome	Drug of choice	Alternative Choices	Duration	Comments
Local UTI (uncomplicated)	Nitrofurantoin 100 mg PO BD Fosfomycin 3g single dose Pivmecillinam 400 mg TID	Cephalosporins (cephadroxil 500 mg BD), Co-trimoxazole, Ertapenem, Amikacin (can be used in children as well)	Usual treatment is given for 5 days	Dosage adjustment as per eGFR
Recurrent UTIs	Nitrofurantoin 50 mg or 100 mg PO BD Methanamine Hippurate 1gm TID	Fosfomycin trometamol 3g every 10 days, Trimethoprim 100 mg once daily	Treatment duration is for 10 days.	During pregnancy, Cephalexin 125 mg or 250 mg or Cefaclor 250 mg once daily. Methanamine needs acidic urine for action
Acute Pyelonephritis	Ciprofloxacin, levofloxacin, cephalosporins (2nd & 3rd generation)	Cefepime, piperacilin-tazobactam Amikacin (Recommended for children as well) Imipenem, meropenem are last alternatives	Treatment is minimum of 7 days. The total duration of treatment is 14 days in children.	Oral antimicrobial regimen for uncomplicated pyelonephritis include Ciprofloxacin 500 to 700 mg BD for 7 days or Levofloxacin 750 mg once daily for 5 days. Cotrimoxazole 160/800 mg BD for 10 days
Systemic UTI	Amoxicillin + aminoglycoside 2nd or 3rd generation Cephalosporins + aminoglycosides iv empirically for systemic symptoms, 3rd generation cephalosporins	Use ciprofloxacin if local resistance < 10%	Treatment is for 5 - 10 days	

Gonococcal urethritis	Ceftriaxone 1g i.m or i.v stat dose with Doxycycline 100 mg BD for 7 days should be used as first-line treatment.	In case of doxycycline allergy, azithromycin 4 day regimen to be used 1gm on day 1 followed by 500 mg on day 2,3,4.		
Non-gonococcal urethritis	Doxycycline 100 mg twice daily for 7 days	Alternatively, single dose oral azithromycin 1gm day one and 500 mg days two to four can be used		
U.urealyticum urethritis	Doxycycline 100 mg twice daily for seven days	Azithromycin 1 g single dose		
Urethritis caused by T. vaginalis	Oral metronidazole 1.5 gm-2 gm single dose	Tinidazole 2 g single dose		
Acute Bacterial Prostatitis	Amoxicillin + aminoglycoside 2nd or 3rd generation Cephalosporins + aminoglycosides iv empirically for systemic symptoms, 3rd generation cephalosporins	Use ciprofloxacin if local resistance < 10%	Minimum 21 days of antibiotics	Urine and prostatic massage specimen for cultures to be collected before antibiotics.
Chronic Bacterial Prostatitis	Fluoroquinolones (levofloxacin, ofloxacin)	Doxycycline 100 mg BD Or Macrolide antibiotics like Azithromycin 500 mg OD if intracellular bacteria has been identified	For 10 days (doxycyxline) 3 weeks for macrolides. Usual duration of treatment is 6 weeks for FQ.	Metronidazole 500mg TID for 2 weeks if T. vaginalis infection is suspected.
Epididymo-orchitis (High risk of sexually transmitted)	Ceftriaxone 1g i.m single dose + Doxycycline 200 mg stat, then 100 mg BD for 14 days	Ofloxacin, Levofloxacin	Total duration of treatment is 14 days (except for Levofloxacin where it is 10 days)	
Epididymo-orchitis (Low risk of sexually transmitted; likely due to enteric or urinary organisms)	Levofloxacin 500 mg PO OD Or Doxycycline + cotrimoxazole		Total duration of treatment is 10 days	
Acute epididymitis in non-sexually active	Fluoroquinolone (levofloxacin 500 mg OD) by mouth once daily for 10 -14 days. Or Cotrimoxazole for 2 weeks	Ofloxacin 200 mg PO BD	Treatment duration is 10 – 14 days	

Fournier's Gangrene	Pipe-tazo (4.5 g every 6-8 h IV) plus Vancomycin (15 mg/kg every 12 h) Or Meropenem (1g every 6-8 h IV), Or Gentamicin (5 mg/kg daily)	Combination therapy Cefotaxime (2 g every 6 h IV) plus metronidazole (500 mg every 6 h IV) Or Clindamycin (600-900 mg every 8 h IV) can also be used		
Urosepsis	Cefotaxime 2 g TID Ceftazidimel-2 g TID Ceftriaxonel-2 g q.d Cefepime 2 g BD Pipe-tazo 4.5 g TDS, Ceftolozane/tazobactam 1.5 g TID Ceftazidime/avibactam 2.5 g TID	Gentamicin*5 mg/kg q.d Amikacin*15 mg/kg q.d Ertapenem 1g q.d Imipenem/cilastatin 0.5 g TID, Meropenem 1g TID	Treatment duration is 7-10 days	Longer courses are appropriate in patients who have a slow clinical response
HPV	Patient-applied treatments - imiquimod 5%; sinecatechins 15% and 10%; and podophyllotoxin 0.5%	Excision, electrosurgery, electrocautery of the lesion	16 weeks	Thrice daily application
HSV (Genital herpes)	Acielovir 400 mg orally TID for 10 days Or 200 mg orally five times daily for 10 days. Valaciclovir 500 mg orally BID for 10 days			For recurrent HSV, Acyclovir 400 mg orally TID for 5 days or 800 mg BID for5 days or 800 mg TID for 2 days. Valaciclovir 500 mg orally BID for 3 days
GUTB	Intensive two month phase HRZE for 2 months Continuation four month phase HR for 4 months		6 months	
MDR TB	Group A Fluoroquinolones-Levofloxacin, Moxifloxacin and Gatifloxacin Group B Second-line injectables-Amikacin, Capreomycin, Kanamycin and Streptomycin** Group C Other second line agents Ethionamide/ Prothionamide, Cycloserine/Terizidone, Linezolid and Clofazimine		6 months - 20 months depending on disease severity	1 from group A, 1 from group B, and at least 2 from group C. If the minimum number of five TB medicines to be given. **Streptomycin can substitute other injectable drugs if none of these agents can be used and if the strain is shown not to be resistant. **Thioacetazone should not be used if the patient is HIV seropositive.

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7 L. INFECTIONS IN PLASTIC SURGERY

Table 107. Surgical Category Mapping

Category	Examples	Likely Organisms	Recommended Antibiotics	Duration
Clean	Liposuction, Rhinoplasty	Staph. aureus, Staph. epidermidis	Cefuroxime + Sulbactam[1,2]	Single dose
Clean-Contaminated	Oral cavity	Strep. viridians, E. coli, Bacteroides fragilis	Cefuroxime + Sulbactam + Metronidazole[3,4]	≤ 24 hrs
Contaminated	Trauma, Open fractures	Staph. aureus, Pseudomonas	Cefuroxime + Sulbactam + Metronidazole[1]	3-5 days
Dirty/Infected	Abscess	MRSA, Acinetobacter	Piperacillin-tazobactam + Vancomycin[5,6] → Meropenem[7]	Culture-based

Table 108. Procedure-Specific Guidelines

Procedure	Organisms	Antibiotics	Notes
Implants	Staph. epidermidis	Cefuroxime[1]	Biofilm
Flaps	Staph. aureus	Cefuroxime[1]	Single dose
Burns	Pseudomonas	Silver sulfadiazine[8]	Topical
Bite	Pasteurella	Amoxicillin-clavulanate[9]	Mandatory
Maxillofacial	Anaerobes	Cefuroxime + Sulbactam + Metronidazole[3]	Anaerobes cover

Timing & Dosing

- Pre-operative timing: Administer IV antibiotics 30-60 minutes before incision.[1,2]
- Vancomycin/Fluoroquinolones: 60-120 minutes before incision.[6]
- Redosing: Required if surgery exceeds 3-4 hours or blood loss > 1500ml.[1]
- Route: Intravenous preferred.
- Documentation: Mandatory.

Duration Control

- Clean: Single dose only.[1]
- Clean-contaminated: ≤ 24hours.[1]
- Contaminated: 3-5 days.
- Dirty/Infected: Culture-based therapy with mandatory de-escalation.[5]

Restricted Antibiotics

- Meropenem: Requires HOD/ID approval.[7]
- Colistin: Reserve drug.[9]
- Linezolid: Only for resistant Gram-positive infections.[10]

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7 M. INFECTIONS IN NEPHROLOGY

Introduction: Urinary tract infections are quite common across all the age groups and sexes. Urinary tract infection may be upper tract infection (Pyelonephritis) or lower tract infection (e.g. Cystitis, Prostatitis and Urethritis). Presence of lumber pain, vomiting with high grade fever with chills will indicate upper tract infection.

Except for some categories, every suspected case of urinary tract infection, a urine routine examination and culture-sensitivity should be sent after proper collection. Handling of urine sample is of utmost important to get a proper bacteriological report. It is also very important that we send the sample of urine before starting the antimicrobial therapy and sample should reach laboratory without delay.

Depending on the severity of illness we can start empirical antibiotic before urine culture report is available. Empiric regimes should be modified if needed after the culture and sensitivity report is available and should be continued for the specific duration. Duration of antibiotic therapy will vary depending on the site of infection. In addition to the urine and biochemical examination, imaging modalities like USG or CT-scan may require to see any anatomical and physiological changes in the urinary tract. These imaging may also help us for any intervention like draining of pus collection etc.

As per Antibiogram of RIMS (Imphal), the most common organisms responsible for UTI includes Enterobacteriaceae (72.2%) followed by Enterococci (16.5%). The other organisms include NFGNB (6.3%), Staphylococci (4-9%) and Streptococci (0.1%).

The susceptibility of Enterobacteriaceae spp. from urine showed high susceptibility to Amikacin, Meropenem, Fosfomycin, Ertapenem, Nitrofurantoin, TMP-SMX, Minocycline, Levofloxacin, Piperacillin-tazobactam in decreasing order with least sensitivity to Cephalosporins.

The susceptibility of Enterococci from urine showed high susceptibility to Vancomycin, Teicoplanin, Linezolid, Nitrofurantoin and Gentamicin in decreasing order. Thus, based on the above findings, the recommended antibiotic regimen as follows:

Table 109. Antibiotic treatment for urinary tract infection [1]

Conditions	Most common organisms	Empiric regimen	Alternative regimen	Comments
ASYMPTOMATIC BACTERIURIA (2 consecutive urine culture with ≥105 CFU/ml of same organism)	Enterobacteriaceae Enterococci	Nitrofurantoin 100 mg BD for 5 days OR Fosfomycin 3gm I dose	TMP-SMX DS 1 tablet BD for 5 days OR Levofloxacin 500 mg OD for 5 days	Treat in Pregnancy, Pre-urological procedures, Post-Transplant/ Avoid quinolones in pregnancy and suspected cases of TB

ACUTE UNCOMPLICATED CYSTITIS (WOMEN)	Enterobacteriaceae Enterococci	Nitrofurantoin 100 mg BD for 5 days OR Fosfomycin 3gm I dose OR TMP-SMX DS 1 tablet BD for 5 days	Amox-clavu 875+125 mg BD for 5-7 days OR Faropenem 200 mg TDS for 5-7 days OR Linezolid 600mg BD for 5-7 days OR Minocycline 200 mg stat followed by 100 mg BD for 5-7 days	Avoid quinolones in pregnancy and suspected cases of TB
ACUTE UNCOMPLICATED CYSTITIS (MEN)	Enterococci	Nitrofurantoin 100 mg BD for 5 days OR TMP-SMX DS 1 tablet BD for 5 days	Amox-clav 875+125 mg BD for 5-7days OR Fosfomycin 3gm I dose OR Linezolid 600mg BD for 5-7 days	If recurrent, rule out prostatitis and bladder outlet obstruction
RECURRENT UTI IN WOMEN (2 or more infections in 6 months OR 3 or more infections in 1 year)	Enterobacteriaceae Enterococci	Nitrofurantoin 100 mg BD for 5 days OR Fosfomycin 3gm I dose OR TMP-SMX DS 1 tablet BD for 5 days OR Amox-clavu 875+125 mg BD for 5-7 days	Preventive strategy: avoiding Spermicide, increase Fluid intake, Post coital antibiotics (Nitrofurantoin 100 mg or TMP-SMX 80/400 mg) Antibiotics prophylaxis: TMP-SMX DS OD/ Nitrofurantoin 50-100mg OD/ Cephalexin 250 mg OD for 3 months and Review	Post Menopausal women may consider intravaginal estrogen (Estriol) 0.5 mg daily for 2 weeks followed by twice weekly

PREGNANCY: ASYMPTOMATIC BACTERIURIA AND CYSTITIS	Enterobacteriaceae Enterococci	Nitrofurantoin 100 mg BD for 5-7 days (avoid in 3rd trimester) OR Amox-Clav 625 mg TDS for 5-7 days OR Cephalexin 500 mg BD for 5-7 days	TMP-SMX DS 1 tablet BD for 3 days (Avoid in 1st trimester and term) OR Cefpodoxime 100 mg BD for 5-7 days	Nitrofurantoin in 3rd trimester increase risk of Haemolytic Anaemia in Newborn/ Untreated Bacteriuria in Pregnancy increase risk of low birth weight, pre-term delivery and perinatal mortality
PREGNANCY: ACUTE PYELONEPHRITIS	Enterobacteriaceae Enterococci	Moderately ill: Ceftriaxone 1gm iv OD for 14 days OR Cefepime 1gm iv BD for 14 days OR Aztreonam 1gm iv TDS for 14 days (in Penicillin allergy)	Severely ill: Piperacillin-tazobactam 4.5gm iv TDS for 14 days OR Meropenem 500mg iv TDS for 14 days OR Ertapenem 1gm iv OD for 14 days OR Based on CS findings	Switch to PO after afebrile for 48 hours/ Suppressive therapy may be continued in recurrent cases for the duration of pregnancy with Nitrofurantoin 50-100 mg OD or Cephalexin 250-500 mg OD
ACUTE PYELONEPHRITIS	Enterobacteriaceae Enterococci	LOW RISK for Resistance: Levofloxacin 750mg PO OD for 7-14 days/ Ciprofloxacin 500mg PO BD for 7-14 days/ TMP-SMX DS 1 tablet BD for 7-14 days/ Ceftriaxone 1gm iv OD for 10 days/ Piperacillin-tazobactam 4.5gm iv TDS for 7-14 days HIGH RISK for	Gentamicin 5mg/kg iv OD for 7-14 days OR Amikacin 250mg iv BD for 7-14 day OR Teicoplanin 400 mg iv 12 hourly for 3 doses followed by 200 mg OD for 14 days OR Vancomycin 15 mg/kg iv BD for 14 days	Consider imaging in critical ill, suspected calculi or obstructive uropathy or failure to respond to therapy HIGH RISK: prior highly resistant bacteria in urine/ recent hospitalisation

		Resistance: Meropenem 1gm iv TDS for 7-14 days/ Ertapenem 1gm iv OD for 7-14 days (recent Pseudomonas infection)	Further Regimen based on CS findings May shift to oral drugs if afebrile for 48 hours	/obstructive uropathy/ recent Quinolones or Beta-Lactams Avoid aminoglycosid -es if Renal function is compromised
PROSTATITIS	Acute: N. Gonorrhoea/ C. Trachomatis Chronic: Enterobacteriaceae	Acute STD: Ceftriaxone 500mg im single dose/ Cefixime 200 mg PO BD on first day followed by Doxy 100 mg PO BD for 10 days Acute Enterobacteriaceae: Levofloxacin 750mg PO OD for 14 days Chronic: Ciprofloxacin 500mg PO BD for 4 weeks/ Levofloxacin 750mg PO OD for 4 weeks	TMP-SMX DS 1 tablet PO BD for 1-3 months OR Fosfomycin 3gm PO OD for 3-4 months	In Treatment Failure: Consider Infected Prostatic calculi Test for other viral serology (HIV, HEP-B, HEP-C)
ACUTE COMPLICATED UTI: UTI plus other Co-Morbid conditions that increases severity and risk of failure (diabetes/ pregnancy/ post-transplant/ foley in-situ/ obstruction/ CAKUT	Enterobacteriaceae Enterococci	LOW RISK of MDR: Levofloxacin 750 mg iv OD/ Ceftriaxone 1gm iv OD/ Cefepime 1gm iv BD/ Pipera-Tazo 4.5gm iv TDS/ Gentamicin 5mg/kg iv OD/ Aztreonam 2gm iv TDS for 14 days (Penicillin allergy)	HIGH RISK for MDR: Meropenem 1gm iv TDS/ Ceftazidime-Tazobactam 2.25 gm iv TDS for 14 days/ Teicoplanin 400 mg iv BD for 3 doses followed by 200 mg OD for 14 days/ Vancomycin 15mg/kg iv BD for 14 days Based on CS findings	Due to high incidence of resistance, avoid using Nitrofurantoin/ Fosfomycin/ TMP-SMX Always rule out Urological intervention requirements

Catheter Related Blood Stream Infection (CRBSI) in dialysis patient[2,3]

1. All suspected CRBSI are given the following empirical antibiotics regimen-
   a) Inj. Vancomycin 1000 mg IV stat AST on first day post haemodialysis.

      ⬇

      Inj. Vancomycin 500 mg IV post haemodialysis for total of 14 days or until culture/sensitivity reports are available. (Plus)

   b) Tab. Linezolid 600 mg PO BD for 14 days or until culture/sensitivity reports are available. (Or)

   c) Tab. Ciprofloxacin 500 mg PO BD for 14 days or until culture/sensitivity reports are available. (Or)

   d) Tab. Levonadifloxacin 500 mg PO BD for 14 days or until culture/sensitivity reports are available.

2. Organisms requiring 3 weeks of antibiotic regimen includes-
   a) Staphylococcus aureus
   b) Pseudomonas

3. Organism requiring removal of catheter-
   a) Refractory Staphylococcus aureus
   b) Refractory Pseudomonas aeruginosa
   c) Refractory fungal infection
   d) Mycobacteria
   e) Refractory Micrococcus species, Bacillus species and Propionibacteria

4. CRBSI associated with endocarditis and thrombosis are given antibiotic regimen for a total of 4-6 weeks in total.

Continuous Ambulatory Peritoneal Dialysis (CAPD) Peritonitis[3,4]

1. All suspected CAPD Peritonitis empirical antibiotic regimen includes-
   a) Inj. Vancomycin 2 gm I.P 5 days apart for a total of 2 doses with dwell time of minimum 6 hours.
   b) Inj. Gentamicin 20 mg I.P OD for a total of 14 days with dwell time of minimal 6 hours.
   c) Tab. Fluconazole 150 mg OD for14 days.
   d) Tab. NAC 600 mg BD for 14 days. (Or)
   e) Antibiotics according to the culture/sensitivity report.

2. Organisms requiring 21 days of antibiotics regimen includes-
   a) Pseudomonas aeruginosa
   b) Staphylococcus aureus
   c) Corynbacterial peritonitis
   d) Polymicrobial gram-negative peritonitis

3. Organisms requiring removal of CAPD catheter-
    a) Fungal peritonitis
    b) Refractory peritonitis not responding to 5 days of antibiotics
    c) Mycobacterial peritonitis Simultaneous Tunnel and PD peritonitis

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8. GUIDELINES FOR ANTIBIOTIC USE IN PAEDIATRICS

Introduction: Antibiotic therapy is a fundamental component in the management of bacterial infections in children. Despite significant advances in preventive healthcare and vaccination, infectious diseases remain an important cause of morbidity and mortality in the pediatric population. Several bacterial pathogens are commonly implicated in childhood infections, including *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Staphylococcus aureus*, *Group B Streptococcus*, *Escherichia coli* and *Neisseria meningitidis*. These organisms are responsible for a wide range of illnesses, from common infections such as otitis media and pneumonia to severe conditions like meningitis, septicemia and urinary tract infections. Early initiation of appropriate antimicrobial therapy is therefore essential to reduce complications and improve clinical outcomes.[1,2]

Antibiotic therapy in children differs significantly from that in adults due to developmental variations in pharmacokinetics and pharmacodynamics. Neonates and young infants have immature hepatic and renal functions, which can alter the metabolism and excretion of many antimicrobial agents. For example, reduced renal clearance in neonates can prolong the half-life of antibiotics such as Gentamicin and Ampicillin, necessitating careful dose adjustments. Additionally, the higher extracellular fluid volume in infants influences the distribution of hydrophilic antibiotics, including aminoglycosides and beta-lactams. As a result, antibiotic dosing in children is generally calculated on a weight basis and must be tailored according to the child's age, physiological status, and severity of infection.[3,4]

The emergence of antimicrobial resistance has become a major concern in pediatric practice. Inappropriate antibiotic use - such as prescribing antibiotics for viral infections or the unnecessary use of broad spectrum agents - has contributed to the increasing prevalence of resistant organisms, including *Methicillin-resistant Staphylococcus aureus (MRSA)*, penicillin-resistant *Streptococcus pneumoniae* and extended spectrum beta-lactamase (ESBL) producing *Enterobacteriaceae*.[5,6]

Rational antibiotic therapy aims to optimize treatment outcomes while minimizing adverse effects and the development of resistance. This involves selecting the most appropriate antimicrobial agent with the narrowest effective spectrum, administering the correct dose and duration, and whenever possible, guiding therapy through microbiological investigations such as culture and sensitivity testing.[7,8]

Table 110. Antibiotic Therapy in Neonatal Intensive Care Unit Settings

Disease/ Condition	Antibiotics		Dose	Dosing interval and route		Duration
				0-14 days of life	>14 days of life	
Septicemia Or, Pneumonia	1st line	Cefotaxime *and*	If baby's weight a) < 1200 g: 100 mg/kg/day b) 1200 - 2000 g: 100-150 mg/kg/day c) > 2000 g: 200 mg/kg/day	12 hrly IV	8-12 hrly IV	7-10 days*
		Amikacin	15 mg/kg/dose	24 hrly IV	24 hrly IV	
	2nd line	Piperacillin-tazobactam# *and*	100 mg/kg/dose	12 hrly IV	8 hrly IV	7-10 days*
		Netilmicin	5-7.5 mg/kg/day If age < 1 week: 3 mg/kg q 12 hr	12 hrly IV	12 hrly IV	
**for culture positive sepsis, duration will be 14 days* [1] *#start as 1st line if umbilical sepsis or pustule*						
Meningitis	1st line	Cefotaxime *and*	50 mg/kg/dose	8 hrly IV	6 hrly IV	3 weeks*
		Amikacin	15 mg/kg/dose	24 hrly IV	24 hrly IV	
	2nd line	Meropenem *and*	40 mg/kg/dose	8 hrly IV	8 hrly IV	3 weeks*
		Amikacin	15 mg/kg/dose	24 hrly IV	24 hrly IV	
**for complicated meningitis like ventriculitis and brain abscess duration will be 4-6 weeks* [9]						
Systemic fungal infections#	1st line	Fluconazole	12 mg/kg/day loading dose, followed by 6-12 mg/kg/day maintenance dose	48-72 hrly IV	24 hrly IV	28 days
	2nd line	Liposomal Amphotericin B, *or*	3-5 mg/kg/24 hr	24 hrly IV	24 hrly IV	28 days
		Amphotericin B Lipid Complex, *or*	2.5-5 mg/kg/24 hr	24 hrly IV	24 hrly IV	
		Amphotericin B (conventional)*	0.5-1 mg/kg/24 hr IV	24-48 hrly IV	24-48 hrly IV	
#Duration of antifungal therapy will be 14 days after documented clearance of candida species (not the prefixed duration) typically 14-21 days [10] **Once daily dosing: 0.5-1 mg/kg/24 hr* *Every-other-day dosing: 1.5 mg/kg/dose every other day*						

Table 111. Antibiotic Therapy in Paediatric Intensive Care Unit Settings

Disease/ Condition	Antibiotics		Dose	Dosing interval and route	Duration
Sepsis without focus (community acquired)	1st line	Ceftriaxone	75-100 mg/kg/day	12 hourly	7-14 days (Duration of antimicrobials changed/escalated/de-escalated as per site, etiology, treatment response and control of source) *[Add Vancomycin 10-15 mg/kg/dose q6H if Methicillin Resistant Staphylococcus aureus (MRSA) suspected][11]*
		Amikacin	15-22.5 mg/kg/24 hr	8 hourly IV	
	2nd line	Piperacillin-Tazobactam	300-400 mg/kg/day	8 hourly IV	
		Netilmicin sulfate	Children: 5-7.5 mg/kg/day Infants: 7.5-10 mg/ kg/day	8-12 hourly IV	
	3rd line	Meropenem	60 mg/kg/day	8 hourly IV	
		Vancomycin	10-15 mg/kg/dose	6-8 hourly IV	
Nosocomial sepsis (without focus)	1st line	Piperacillin-tazobactam	80-100 mg/kg/dose	8 hourly IV	7-14 days
		Amikacin	15-20 mg/kg/day	12-24 hourly IV	
	2nd line	Meropenem	20 mg/kg/dose	8 hourly IV	7-14 days
		Vancomycin	10-15 mg/kg/dose	6-8 hourly IV	
	3rd line	Colistin	2.5-5 mg/kg/day of Colistin base *1 mg Colistin base = 2.4 mg or 30,000 IU colistimethate sodium	6-12 hourly IV	7-14 days
		Vancomycin, *or*	10-15 mg/kg/dose	6-8 hourly IV	
		Linezolid	10 mg/kg/dose (max. 600 mg)	12 hourly IV	
Septic shock	1st line	Ceftriaxone	75-100 mg/kg/day	12 hourly	7-14 days
		Vancomycin	10-15 mg/kg/dose	6-8 hourly IV	
	2nd line	Meropenem	20 mg/kg/dose	8 hourly IV	7-14 days
		Vancomycin	10-15 mg/kg/dose	6-8 hourly IV	
Ventilator associated pneumonia (VAP)	1st line	Piperacillin-tazobactam	80-100 mg/kg/dose	8 hourly IV	7-14 days
		Amikacin	15-20 mg/kg/day	12-24 hourly IV	
	2nd line	Meropenem	20 mg/kg/dose	8 hourly IV	7-14 days
		Vancomycin	10-15 mg/kg/dose	6-8 hourly IV	
	3rd line	Colistin	2.5-5 mg/kg/day of Colistin base *1 mg Colistin base = 2.4 mg or 30,000 IU colistimethate sodium	6-12 hourly IV	7-14 days
		Vancomycin	10-15 mg/kg/dose	6-8 hourly IV	

Meningoc-occal sepsis	1st line	Ceftriaxone *or*	100 mg/kg/day	12 hourly IV	7-14 days
		Cefotaxime	100-150 mg/kg/day (Use 200 mg/kg/day for meningitis)	6-8 hourly IV	
	2nd line	Meropenem	40 mg/kg/dose	8 hourly IV	7-14 days
		Vancomycin	60 mg/kg/24 hr	6 hourly IV	
Central-line associated blood stream infection (CLABSI)	1st line	Cefoperazone-sulbactam *plus*	40-80 mg/kg/day	6-12 hourly	*Uncomplicated bacteremia:* 10-14 days from the day culture was negative[11] *Persistent bacteremia:* 4-6 weeks[11]
		Gentamicin *plus*	5-7.5 mg/kg/day	12-24 hourly	
		Vancomycin or	10-15 mg/kg/dose	6-8 hourly IV	
		Teicoplanin	10 mg/kg/dose q 12 hr for 3 doses, then 10 mg/kg/day q 24 hr	10 mg/kg/dose q 12 hr for 3 doses, then 10 mg/kg/day q 24 hr	
	2nd line	Meropenem *plus*	20 mg/kg/dose	8 hourly IV	*Uncomplicated bacteremia:* 10-14 days from the day culture was negative[11] *Persistent bacteremia:* 4-6 weeks[11]
		Vancomycin *or*	10-15 mg/kg/dose	6-8 hourly IV	
		Teicoplanin	10 mg/kg/dose q 12 hr for 3 doses, then 10 mg/kg/day q 24 hr	10 mg/kg/dose q 12 hr for 3 doses, then 10 mg/kg/day q 24 hr	
	3rd line	Colistin	2.5-5 mg/kg/day of Colistin base *1 mg Colistin base = 2.4 mg or 30,000 IU colistimethate sodium	6-12 hourly IV	*Uncomplicated bacteremia:* 10-14 days from the day culture was negative[11] *Persistent bacteremia:* 4-6 weeks[11]
		Vancomycin	10-15 mg/kg/dose	6-8 hourly IV	

PRESUMPTIVE ANTIBIOTIC THERAPY IN PAEDIATRIC INFECTIONS

Table 112. Central Nervous System

Condition/ Disease	Antibiotic		Dose	Dosing interval	Duration
Acute bacterial meningitis	1st line	Ceftriaxone, or	50 mg/kg/dose	12 hrly IV	10-14 days*
		Cefotaxime, and	75 mg/kg/dose	8-12 hrly IV	
		Vancomycin	15 mg/kg/dose	6 hrly IV	
	2nd line	Meropenem, or	40 mg/kg/dose	8 hrly IV	10-14 days*
		Cefepime, and	50 mg/kg/dose	8 hrly IV	
		Vancomycin	15 mg/kg/dose	6 hrly IV	
In case of suspected rickettsial infection, add		Azithromycin (< 8 yrs)	10 mg/kg/day	24 hrly IV or PO	5 days
		Doxycycline (> 8 yrs)	2.2 mg/kg/dose (max. 100 mg)	12 hrly IV or PO	7-10 days

**if organism is specified duration will be as follows*

N. meningitidis 5-7 days

H. influenzae 7-10 days

S. pneumoniae 10-14 days

Gram negative bacillary and pseudomonal meningitis 21-28 days [12]

Cerebro-spinal fluids (CSF) shunt	1st line	Ceftriaxone, or	50 mg/kg/dose	12 hrly IV	2-3 weeks
		Cefotaxime, and	75 mg/kg/dose	8-12 hrly IV	
		Vancomycin	15 mg/kg/dose	6 hrly IV	
	2nd line	Meropenem, or	40 mg/kg/dose	8 hrly IV	
		Cefepime, and	50 mg/kg/dose	8 hrly IV	
		Vancomycin	15 mg/kg/dose	6 hrly IV	
Brain Abscess	1st line	Ceftriaxone, or	50 mg/kg/dose	12 hrly IV	3-6 weeks*
		Cefotaxime, and	75 mg/kg/dose	8-12 hrly IV	
		Vancomycin, and	15 mg/kg/dose	6 hrly IV	
		Metronidazole	10 mg/kg/dose	8 hrly IV	
	2nd line	Meropenem, or	40 mg/kg/dose	8 hrly IV	
		Cefepime, and	50 mg/kg/dose	8 hrly IV	
		Vancomycin, and	15 mg/kg/dose	6 hrly IV	
		Metronidazole	10 mg/kg/dose	8 hrly IV	

**duration depends on involvement of surgery in brain abscess*

Post neurosurgery	1st line	Vancomycin, plus	15 mg/kg/dose	6 hrly IV	14 days
		Cefepime, or	150 mg/kg/24 hr	8 hrly IV	
		Ceftazidime	100 mg/kg/dose	8 hrly IV	
	2nd line	Meropenem, and	40 mg/kg/dose	8 hrly IV	
		Vancomycin	15 mg/kg/dose	6 hrly IV	
Head trauma, basilar skull fracture and penetrating trauma	1st line	Vancomycin, plus	15 mg/kg/dose	6 hrly IV	10-14 days
		Cefepime, or	150 mg/kg/24 hr	8 hrly IV	
		Ceftazidime	100 mg/kg/dose	8 hrly IV	
	2nd line	Meropenem, and	40 mg/kg/dose	8 hrly IV	
		Vancomycin, and	15 mg/kg/dose	6 hrly IV	
Acute encephalitis syndrome	1st line	Ceftriaxone, or	50 mg/kg/dose	12 hrly IV	10-14 days
		Cefotaxime, plus	75 mg/kg/dose	8-12 hrly IV	
		Vancomycin, plus	15 mg/kg/dose	6 hrly IV	
		Acyclovir	60 mg/kg/24 hr	8 hrly IV	
	2nd line	Meropenem, and	40 mg/kg/dose	8 hrly IV	
		Vancomycin	15 mg/kg/dose	6 hrly IV	
		Acyclovir	60 mg/kg/24 hr	8 hrly IV	

Table 113. Respiratory Tract Infections

Condition/ Disease	Age	Antibiotic		Dose	Dosing interval	Duration
Community acquired pneumonia	< 3 months	1st line	Cefotaxime ±	150 mg/kg/day	8 hrly IV	7-10 days and afebrile for 72 hours before stopping antibiotics[1]
			Gentamicin or	5-7 mg/kg/day	24 hrly IV	
			Amikacin	15 mg/kg/day	24 hrly IV	
			Piperacillin-tazobactam	100 mg/kg/dose	8 hrly IV	
		2nd line	or Cefaperazone -sulbactam ±	40-80 mg/kg/day	6-12 hrly IV	
			Gentamicin, or	5-7 mg/kg/day	24 hrly IV	
			Netilmicin	5-7.5 mg/kg/day	8-12 hrly IV	
			Co-amoxiclav or	100mg/kg/day	8 hrly IV or PO	
	3 months to 5 years	1st line	Ceftriaxone, or	50-100 mg/kg/day	12 hrly IV	
			Cefotaxime	150 mg/kg/day	8 hrly IV	
			Piperacillin-tazobactam	100 mg/kg/dose	8 hrly IV	
		2nd line	Netilmicin	5-7.5 mg/kg/day	8-12 hrly IV	
			Co-amoxiclav or	80-100 mg/kg/day	8 hrly IV or PO	
	> 5 years	1st line	Ceftriaxone, or	50-100 mg/kg/day	12 hrly IV	
			Cefotaxime	150 mg/kg/day	8 hrly IV	
			Piperacillin-tazobactam	100 mg/kg/dose	8 hrly IV	
		2nd line	Netilmicin	5-7.5 mg/kg/day	8-12 hrly IV	
			Azithromycin	10 mg/kg/day for 1st day f/b 5 mg/kg/day for 5 days	24 hrly IV or PO	
			Azithromycin	10 mg/kg/day for 1st day f/b 5 mg/kg/day for 5 days	24 hrly IV or PO	

Condition/ Disease	Antibiotic		Dose	Dosing interval	Duration
Empyema	1st line	Ceftriaxone	50-100 mg/kg/day	12 hrly IV	2-4 weeks
		Cloxacillin	50-100 mg/kg/day	6 hrly IV	
	2nd line	Meropenem and	20-40 mg/kg/dose	8 hrly IV	2-4 weeks (Duration may be escalated/ modified as per patient's response and culture results)
		Vancomycin	10-15 mg/kg/dose	6 hrly IV	
Cystic Fibrosis (CF) -pulmonary exacerbation	1st line	Piperacillin-tazobactam	100 mg/kg/dose	8 hrly IV	7-14 days
		Amikacin	15 mg/kg/day	24 hrly IV	
	2nd line	Meropenem and	20-40 mg/kg/dose	8 hrly IV	
		Vancomycin	10-15 mg/kg/dose	6 hrly IV	

Suppurative lung disease	1st line	Piperacillin-tazobactam	100 mg/kg/dose	8 hrly IV	2-4 weeks
		Amikacin	15 mg/kg/day	24 hrly IV	
	2nd line	Piperacillin - tazobactam	100 mg/kg/dose	8 hrly IV	
		Vancomycin	10-15 mg/kg/dose	6 hrly IV	
Immuno deficiency condition + LRTI	1st line	Piperacillin-tazobactam	100 mg/kg/dose	8 hrly IV	2-4 weeks
		Amikacin	15 mg/kg/day	24 hrly IV	
	2nd line	Piperacillin - tazobactam	100 mg/kg/dose	8 hrly IV	
		Vancomycin	10-15 mg/kg/dose	6 hrly IV	

Table 114. Infections Related to Kidney and Urinary Tract

Condition/ Disease	Antibiotic		Dose	Dosing interval	Duration
Nephrotic syndrome with peritonitis	1st line	Ceftriaxone, or	50-100 mg/kg/day	12 hrly IV	7-10 days[13]
		Cefotaxime	150 mg/kg/day	8 hrly IV	
	2nd line	Culture sensitivity guided			
Nephrotic syndrome with cellulitis	1st line	Co-amoxiclav	80-100 mg/kg/day	8 hrly IV	7-10 days[13]
	2nd line	Cloxacillin	50-100 mg/kg/day	6 hrly IV	
		Ceftriaxone	100 mg/kg/day	12 hrly IV	
Nephrotic syndrome with pneumonia	Oral	Co-amoxiclav, or	80-100 mg/kg/day	8 hrly PO	10-14 days[13]
		Cefuroxime	20-30 mg/kg/day	12 hrly PO	
	IV	Ceftriaxone, and	50-100 mg/kg/day	12 hrly IV	7-10 days[13]
		Amikacin	15-20 mg/kg/day	12-24 hrly IV	
Urinary tract infection (UTI) uncomplicated	-	Oral Co-amoxiclav or	30-50 mg/kg/day	12 hrly PO	7-10 days
		Cefixime	10 mg/kg/day	12 hrly PO	
UTI (complicated)	1st line	Ceftriaxone, or	50-100 mg/kg/day	12 hrly IV	10-14 days
		Cefotaxime	150 mg/kg/day	8 hrly IV	
	2nd line	Culture sensitivity guided	-	-	-
Haemodialysis with suspected catheter related bloodstream infection	-	Ceftazidime	100-150 mg/kg/day	8 hrly IV	10-14 days
		Vancomycin	10-15 mg/kg/dose	6 hrly IV	

Table 115. Infections of Bone and Joints

Condition/ Disease	Antibiotic		Dose	Dose interval	Duration
Acute Bacterial Osteomyelitis	1st line	Ceftriaxone	50-100 mg/kg/day	12 hrly IV	4 weeks
		Vancomycin	10-15 mg/kg/dose	6 hrly IV	
	2nd line	Culture sensitivity guided	-	-	
Septic Arthritis	1st line	Ceftriaxone	50-100 mg/kg/day	12 hrly IV	2-4 weeks*
		Vancomycin	10-15 mg/kg/dose	6 hrly IV	
	2nd line	Culture sensitivity guided	-	-	
**depends on culture sensitivity - 2 weeks for streptococci, K. kingae; 3 weeks for S. aureus and gram-negative infections; 4 weeks for concomitant osteomyelitis* [1]					

Table 116. Infection of skin and soft tissues

Condition	Antibiotic		Dose	Dose interval and route	Duration
Cellulitis	Oral	Oral Amoxicillin-clavulanate	80-100 mg/kg/day	8 hrly PO	7-10 days
	IV	Ceftriaxone, or	50-100 mg/kg/day	12 hrly IV	
		Clindamycin	20-30 mg/kg/day	6-8 hrly IV or PO	

Table 117. Infections of Gastrointestinal System

Condition/ Disease	Antibiotic		Dose	Dosing interval	Duration
Liver abscess	1st line	Ceftriaxone	75-100 mg/kg/day	12 hrly IV	4-6 weeks
		Metronidazole	35-50 mg/kg/day	8 hrly IV	7-10 days
	2nd line	Meropenem	20-40 mg/kg/dose	8 hrly IV	4-6 weeks
		Vancomycin	10-15 mg/kg/dose	6 hrly IV	
Acute cholangitis	1st line	Piperacillin-tazobactam or	100 mg/kg/dose	8 hrly IV	7-10 days
		Ceftriaxone +	75-100 mg/kg/day	12 hrly IV	
		Metronidazole	35-50 mg/kg/day	8 hrly IV	
	2nd line	Meropenem	20-40 mg/kg/dose	8 hrly IV	
		Vancomycin	10-15 mg/kg/dose	6 hrly IV	
Infected pancreatic collection	1st line	Piperacillin-tazobactam or	100 mg/kg/dose	8 hrly IV	7-10 days
	2nd line	Meropenem	20-40 mg/kg/dose	8 hrly IV	
Dysentery	1st line	Oral Ciprofloxacin	15 mg/kg/dose	12 hrly PO	3 days
		or Ceftriaxone	50-100 mg/kg/day	12 hrly IV	
	2nd line	Oral Azithromycin, or	12 mg/kg on day 1 f/b 6 mg/kg for next 3 days	24 hrly PO	
		Cefixime, Or	8 mg/kg/day	24 hrly PO	
		Metronidazole	10 mg/kg/dose	8 hrly IV	5 days

Acute watery diarrhea (AWD) **Indications for starting antibiotics in AWD:*[1] *a) Infants <3 months* *b) Children with underlying chronic conditions/ immunodeficiency* *c) Children with Severe Acute Malnutrition (SAM), Invasive bacterial infection* *d) Infections with Shigella, ETEC, Vibrio cholerae, Yersinia enterocolitica* *e) Shock*	1st line	Cefixime, or	8-10 mg/kg/day	12 hrly PO	2-5 days
		Ciprofloxacin, or	20-30 mg/kg/day	12 hrly PO	
		Ceftriaxone	50-75 mg/kg/day	12 hrly IV	
	2nd line	Azithromycin	10 mg/kg/day	24 hrly PO	
		Ciprofloxacin	20-30 mg/kg/day	12 hrly PO	
	If cholera is suspected/ confirmed by culture	Doxycycline (>2 years), or	2-4 mg/kg	PO single dose	Single dose
		Azithromycin, or	10 mg/kg	PO single dose	
		Ciprofloxacin	20 mg/kg	PO single dose	
Enteric fever (uncomplicated/ OPD basis)	1st line	Cefixime	20 mg/kg/day (max. dose of 1200)	12 hrly PO	14 days or at least 7 days after fever defervescence or, whichever is later[14]
	2nd line	Azithromycin*	10-20 mg/kg/day (max. dose 1 gm)	24 hrly PO	7 days
Enteric fever (complicated/ IPD patient)	1st line	Ceftriaxone or	100 mg/kg/day (max 4g)	12 hrly IV	14 days or at least 7 days after fever defervescence or, whichever is later[14] Shift to oral antibiotics once fever resolves
		Cefotaxime	150-200mg/kg/day	6-8 hrly IV	
	2nd line	Ofloxacin	10-15 mg/kg/day	12 hrly IV or PO	
		Chloramphenicol	50- 75 mg/kg/day PO; 100 mg/kg/day IV	6-8 hrly IV	
		Co-trimoxazole (TMP-SMX)	8-10 mg/kg/day of TMP	12 hrly IV or PO	

Scrub typhus	1st line	Doxycycline or	2.2 mg/kg/dose or 100mg if >40kg (max.200 mg)	12 hrly PO or IV	5 days or 3 days after fever subsides[1] *10 days in severe cases
		Azithromycin	10 mg/kg/day	24 hrly PO or IV	
	2nd line	Clarithromycin or	10-15 mg/kg/day	12 hrly PO or IV	
		Chloramphenicol	50-75 mg/kg/day for oral 100 mg/kg/day for IV[15]	6 hrly PO or IV	

Table 118. Infection in immunocompromised children

Condition/ Disease	Antibiotics		Dose	Dosing interval and route	Duration of antibiotics and remarks
Febrile neutropenia (No focus)	1st line	Piperacillin-tazobactam	100 mg/kg/dose	8 hourly IV	Till patient is afebrile for at least ≥ 24-48 hours, with evidence of count recovery *Indications for starting Vancomycin:*[11] i. Clinically unstable patients (hypotension and shock) ii. Skin and soft-tissue infections iii. Clinically suspected central-line infection iv. In centers with high prevalence MRSA v. Hospital-acquired pneumonia
		Amikacin	15-22.5 mg/kg/ 24 hr	24 hourly IV	
	2nd line	Vancomycin	15-20 mg/kg/ dose	8 hourly IV	
		Meropenem	20 mg/kg/dose (max. 1g/dose)	8 hourly IV	
Febrile neutropenia with pneumonia	1st line	Amoxicillin-clavulanic acid	50-100 mg/kg/ day (amoxyc. base)	6-8 hourly IV	Till patient is afebrile for at least ≥24-48hours, with evidence of count recovery and resolution of focus. *Indications for changing/upgrading antibiotics:*[11] i. Development of hemodynamic instability ii. Development of fresh focus of infection iii. Increase in inflammatory markers (CRP and procalcitonin) iv. Blood-culture showing growth of a bacteria resistant to first-line antibiotics
		Amikacin	15-22.5 mg/kg/ 24 hr	8 hourly IV	
	2nd line	Piperacillin-tazobactam	100 mg/kg/dose	8 hourly IV	
		Amikacin	15-22.5 mg/kg/ 24 hr	8 hourly IV	
	3rd line	Vancomycin	15-20 mg/kg/ dose	8 hourly IV	
		Meropenem	20 mg/kg/dose (max. 1g/dose)	8 hourly IV	

Febrile neutropenia with Gastro-intestinal tract involvement	1st line	Piperacillin-tazobactam	100 mg/kg/dose	8 hourly IV	Till patient is afebrile for at least ≥24-48hours, with evidence of count recovery and resolution of focus. *Indications for changing/upgrading antibiotics:*[11] i. Development of hemodynamic instability ii. Development of fresh focus of infection iii. Increase in inflammatory markers (C-Reactive Protein and procalcitonin) iv. Blood-culture showing growth of a bacteria resistant to first-line antibiotics
		Metronidazole	30-40 mg/kg/ 24 hr	8 hourly IV	
	2nd line	Vancomycin	15-20 mg/kg/ dose	8 hourly IV	
		Meropenem	20 mg/kg/dose (max. 1g/dose)	8 hourly IV	
Febrile neutropenia with shock	1st line	Cefepime	150 mg/kg/day	8 hourly IV	Till patient is afebrile for at least ≥ 24-48 hours, with evidence of count recovery and resolution of focus. *Indications for changing/upgrading antibiotics:*[11] i. Development of hemodynamic instability ii. Development of fresh focus of infection iii. Increase in inflammatory markers (CRP and procalcitonin) iv. Blood-culture showing growth of a bacteria resistant to first-line antibiotics
		Vancomycin	15-20 mg/kg/ dose	8 hourly IV	
	2nd line	Meropenem	20 mg/kg/dose (max. 1g/dose)	8 hourly IV	
		Vancomycin	15-20 mg/kg/ dose	8 hourly IV	
Febrile neutropenia with meningitis	1st line	Ceftriaxone	100 mg/kg/24 hr (max. dose 4g/24 hr)	12 hourly IV	21-28 days (Duration to be decided as per culture sensitivity for culture-positive cases)
		Vancomycin	60 mg/kg/24 hr	6 hourly IV	
	2nd line	Meropenem	40 mg/kg/dose	8 hourly IV	
		Vancomycin	60 mg/kg/24 hr	6 hourly IV	

Febrile neutropenia with features of invasive fungal disease (IFD)	1st line	Liposomal amphotericin-B	3-5 mg/kg/24 hr	24 hourly IV	Till neutropenia is resolved or at least 14 days with invasive fungal infections[11] *Note:* Empirical antifungal therapy should be started in case of febrile neutropenia with persistent fever beyond 96 hours of appropriate antibiotics.
		Amphotericin-B Lipid-complex (if liposomal amphotericin-B is not available)	2.5-5 mg/kg/24 hr	24 hourly IV	
	2nd line	Amphotericin-B	1-1.5 mg/kg/day	24 hourly	
PCP Pneumonia (Pneumocystis jirovecii)	1st line	Trimethoprim-sulfamethoxazole (TMP-SMX)	TMP 15-20 mg/kg/day SMX 75-100 mg/kg/day	6-8 hrly (start IV in severe cases, shift to oral when patient shows clinical improvement)	21 days

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9. ANTIBIOTIC PROPHYLAXIS IN CRANIAL NEUROSURGERY

Introduction: Bacterial meningitis/infection is a substantial challenge. We review this challenge with a focus on strategies to optimize antibiotic efficacy in view of increasing drug resistant bacteria and discuss the role of current and future adjunctive therapies.[1]

A meta-analysis of published randomized studies comparing prophylactic antibiotic to placebo in craniotomies was performed. Ten studies were examined and eight met criteria for inclusion into meta-analysis. The analysis showed an advantage of antibiotic over placebo at the $P < 10^{-8}$.

The randomized control trial demonstrated that the pre operative prophylactic antibiotic with topical irrigation keeps infection rate below 10% in clean procedures.[2,3]

The use of antibiotic (Cephalosporin + Gentamicin) within one hour prior to Neurosurgical procedures significantly reduces the post operative wound infection.

The rise of infection may be increased in prolonged or microsurgical procedures in re-operative. No significant difference in specific regiment used was detected in Meta analysis.[2]

Option include:-

a) Cefazolin (Cephalosporin): 1-2 (paid 25mg/kg) iv 60 min before surgery & Q 6 hourly x 24 hour post operative
b) Clindamycin: 300 mg iv preoperative & Q 4 hourly
c) Vancomycin: 15 mg / kg up to 1g iv preoperative & then 10 mg/kg Q 8 hourly
d) Some add inj. Gentamicin 50 mg in pre operative to any of the above

Table 119. Types of cranial neurosurgical procedure and commonly used prophylactic agent

Neurosurgical procedure/operation	**Prophylaxis**	**Prophylaxis if allergic to penicillin or known to be colonized or infected with MRSA at any site**
Clean non-implant and cranioplasty (procedures that does not breach air sinuses, mastoid air cells or nasal or oral cavity)	Inj. Cefoperazone + sulbactam 1.5 gm IV at induction and every 4 hours during surgery	Inj. Teicoplanin 400 mg IV at induction or inj. Meropenem 1gm at induction & every 8 hourly
Clean contaminated (procedures that breach air sinuses, mastoid air cells or nasal or oral cavity)	Inj. Cefoperazone + sulbactam 1.5 gm IV at induction and every 4 hourly during surgery + Inj. Amikacin 500 mg IV 12 hourly + Inj. Metronidazole 500 mg IV 8 hourly	Inj. Teicoplanin 400 mg IV, Inj. Gentamicin 120 mg IV and Inj. Metronidazole 500 mg IV at induction and ONLY IV inj. Metronidazole 500 mg every 4 hours during surgery
Extended transsphenoidal surgery	Inj. Cefoperazone + sulbactam 1.5 gm IV and Inj. Metronidazole 500 mg IV at induction and every 4	Inj. Teicoplanin 400 mg IV, Inj. Gentamicin 120 mg IV and Inj. Metronidazole 500 mg IV at induction and ONLY IV inj.

	hourly + Inj. Amikacin 500 mg IV 12 hourly	Metronidazole 500 mg every 4 hours during surgery
CSF shunt surgery – Primary shunt device insertion or revision due to malfunction WITHOUT evidence of infection	Inj. Cefoperazone + sulbactam 1.5 gm IV at induction, Inj. Vancomycin 10 mg intraventricular, inj. Amikacin 500 mg IV 12 hourly	Inj. Vancomycin 1.5 mg/kg at induction and every 8 hourly, Inj. Meropenem 2gm at induction and every 8 hourly, Vancomycin 10 mg intraventricular and inj. Gentamicin 5 mg intraventricular
CSF shunt surgery – For revision shunt procedures FOLLOWING infection	Inj. Cefoperazone + sulbactam 1.5 gm IV at induction and Inj. Vancomycin 10 mg/Kg intraventricular and Inj. Gentamicin 5 mg intraventricular instillation + Inj. Amikacin 500 mg IV 12 hourly	Inj. Teicoplanin 400 mg intraventricular and Inj. Gentamicin 5 mg intraventricular instillation, Inj. Meropenem 2gm at induction and every 8 hourly, Inj. Vancomycin 15 mg/Kg at induction and every 8 hourly
External Ventricular (EVD) insertion	Inj. Cefoperazone + sulbactam 1.5 gm IV at induction + Inj. Amikacin 500 mg IV 12 hourly	Inj. Teicoplanin 400 mg IV induction, Inj. Meropenem 1 gm at induction and every 8 hourly
Deep brain stimulation insertion Spinal cord stimulation insertion	Inj. Flucloxacillin 1gm IV and Inj. Gentamicin 120 mg IV at induction, Inj. Amikacin 500 mg and ONLY IV flucloxacillin 1gm every 4 hours during surgery Inj. Acyclovir 30 mg/kg at 8 hourly Inj. Meropenem 10 mg/kg at 8 hourly	Inj. Teicoplanin 400 mg IV and Inj. Gentamicin 120 mg IV at induction Inj. Amikacin 500 mg every 12 hourly
Depressed skull fractures	Inj. Cefoperazone + sulbactam 1.5 gm and Inj. Metronidazole 500 mg IV 8 hourly for 5 days Inj. Amikacin 500 mg IV 12 hourly NB: Review tetanus status of patient and consider vaccination	Discuss with Duty Microbiologist NB: Review tetanus status of patient and consider vaccination
Penetrating craniocerebral injuries	Inj. Ceftriaxone 2gm IV 12 hourly and Inj. Metronidazole 500 mg IV 8 hourly for 10 days initially and then review with Microbioogy. + Inj. Amikacin 500 mg IV 12 hourly for 10 days	Inj. Meropenem 1gm IV 12 hourly + Inj. Amikacin 500 mg IV 12 hourly

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10. INFECTION CONTROL AND ANTIBIOTIC STEWARDSHIP IN ICU SETTINGS

Introduction: Antimicrobial resistance has emerged as a major global health threat, largely driven by inappropriate antimicrobial use.[1] Surveillance-based antimicrobial policies and infection prevention strategies are therefore essential components of ICU management.[2]

Antimicrobial resistance (AMR) is a major global and national public health concern.[1,3] Intensive Care Units (ICUs) are high-risk areas for multidrug-resistant infections due to frequent invasive procedures, exposure to broad-spectrum antibiotics, prolonged hospital stays, and the presence of critically ill patients.[4]

Implementation of effective infection prevention and antimicrobial stewardship programs (ASP) is essential to optimize patient outcomes, reduce antimicrobial resistance and improve healthcare quality.[5,6] Intensive care units are places where antibiotics are widely prescribed and where multidrug-resistant organisms are frequently encountered. In this context, antimicrobial stewardship programs should be at the forefront of efforts to control antibiotic consumption in ICUs.[5]

Antimicrobial stewardship should be viewed as a strategy to optimize antimicrobial prescribing. Its main goals are to improve patient outcomes, prevent adverse events and reduce antimicrobial resistance. Antimicrobial stewardship may be defined as *"a coherent set of actions which promote the responsible use of antimicrobials in ways that ensure sustainable access to effective therapy for all who need them."*

ICU physicians should aim to decrease antibiotic consumption by implementing antimicrobial stewardship programs.[5,6]

Key measures that may be implemented include:

- Avoiding immediate antibiotic prescription when infection is suspected, except in patients with septic shock where prompt administration of antibiotics is essential.
- Limiting empiric use of broad-spectrum antibiotics (including anti-MRSA agents) in patients without risk factors for multidrug-resistant pathogens.[1,5]
- Switching to monotherapy instead of combination therapy when appropriate.[5]
- Narrowing the antibiotic spectrum once culture and susceptibility test results are available.[7,8]
- Shortening the duration of antimicrobial treatment whenever clinically feasible.[9]
- Using biomarkers such as *procalcitonin* as a tool to guide antibiotic duration and discontinuation.[9]

Objectives of the Antimicrobial Stewardship Program in Critical Care Settings

The Antimicrobial Stewardship Program (ASP) in critical care aims to optimize antimicrobial use while minimizing antimicrobial resistance and improving patient care.[6]

The key objectives are:

- To reduce ICU-associated infections[3,5] through strict infection control practices and appropriate antimicrobial use.
- To promote rational antibiotic prescribing[1,2] based on clinical indications, microbiological evidence, and institutional antibiogram data.
- To decrease antimicrobial resistance[1,3] by limiting unnecessary or inappropriate antibiotic use and encouraging de-escalation strategies.
- To improve patient outcomes and reduce mortality[7,10] by ensuring timely, appropriate, and effective antimicrobial therapy in critically ill patients.
- To reduce hospital costs[5] and prevent antibiotic misuse by optimizing antibiotic selection, dosing, and duration of therapy.

Scope: These guidelines apply to all Intensive Care Units (ICUs) at the *Regional Institute of Medical Sciences (RIMS), Imphal,* including:

- Medical ICU
- Surgical ICU
- Trauma ICU
- Neuro ICU
- HDU
- Other critical care areas managing critically ill patients

The recommendations are intended to standardize infection prevention practices and antimicrobial stewardship strategies across ICU settings in order to reduce healthcare-associated infections and optimize antibiotic use.

The implementation of these guidelines requires a *multidisciplinary and coordinated approach* involving multiple healthcare professionals and institutional stakeholders, including:

- Clinicians and anaesthesiologists
- Microbiologists
- Infection Control Team
- Clinical pharmacologists and pharmacists
- Nursing staff
- Hospital administration

Key Components of Infection Prevention and Control in the ICU

1. Hand Hygiene - Hand hygiene is the most effective and simplest method to prevent the transmission of pathogens in healthcare settings.[11] All healthcare workers must strictly adhere to the *WHO "Five Moments for Hand Hygiene"*, which include:

- Before touching a patient
- Before performing aseptic procedures
- After exposure to body fluids

- After touching a patient
- After touching the patient's surroundings

Alcohol-based hand rubs are the preferred method for routine hand hygiene when hands are not visibly soiled. Handwashing with soap and water should be performed when hands are visibly contaminated or after contact with spore-forming organisms.

2. Standard Precautions - Standard precautions should be applied to the care of all patients regardless of their diagnosis or infection status. These precautions aim to minimize exposure to blood, body fluids, secretions, and contaminated surfaces.[3,11]

Key elements include:

- Proper hand hygiene
- Use of personal protective equipment (PPE) such as gloves, masks, gowns, and eye protection
- Safe injection practices
- Proper handling and disposal of sharps
- Respiratory hygiene and cough etiquette
- Proper cleaning and disinfection of medical equipment

3. Transmission-Based Precautions - Transmission-based precautions are additional infection control measures used for patients known or suspected to be infected with contagious pathogens.

Contact Precautions

Used for infections transmitted by direct contact, such as *MRSA, multidrug-resistant organisms (MDROs), and Clostridioides difficile.* Healthcare workers should wear gloves and gowns when entering the patient's room.

Droplet Precautions

Used for infections spread through respiratory droplets, such as influenza. Surgical masks should be worn when caring for the patient.

Airborne Precautions

Used for infections transmitted through airborne particles, such as tuberculosis. Patients should be placed in negative-pressure rooms, and healthcare workers should use N95 respirators.

4. Environmental Cleaning - Environmental contamination plays an important role in the transmission of pathogens in ICU settings.[3,11] Regular cleaning and disinfection of frequently touched surfaces such as bed rails, ventilator equipment, monitors, infusion pumps, and work stations is essential.

Environmental cleaning should include:

- Routine cleaning of patient care areas with approved disinfectants
- Immediate cleaning of spills involving blood or body fluids

- Scheduled deep cleaning of ICU areas
- Proper disinfection of reusable medical equipment between patients

5. ***Biomedical Waste Management*** - Proper biomedical waste management is essential to prevent environmental contamination and reduce the risk[3] of infection transmission. Waste generated in ICU settings should be segregated, handled, and disposed of according to the *Biomedical Waste Management Rules of the Government of India.*

Key practices include:

- Segregation of waste at the point of generation
- Use of color-coded waste containers
- Safe handling and disposal of sharps
- Appropriate treatment and disposal of infectious waste
- Training of healthcare workers in safe waste management practices

Strategies of Antimicrobial Stewardship Program in ICU

Effective implementation of an Antimicrobial Stewardship Program (ASP) in the Intensive Care Unit requires coordinated strategies to ensure optimal antimicrobial use while minimizing antimicrobial resistance. The key strategies include:

1. Development of Institutional Antibiotic Policy

Establish a hospital-specific antibiotic policy based on the RIMS Hospital antibiogram to guide empirical antimicrobial therapy. For clinical situations not covered in the local antibiogram, recommendations from the ICMR National Treatment Guidelines should be followed.

2. Early and Appropriate Empirical Therapy

Initiate prompt empirical antibiotic therapy in critically ill patients with suspected severe infections or sepsis, guided by the likely source of infection, patient risk factors, and local antimicrobial resistance patterns. Microbiological cultures should be obtained before starting antibiotics whenever possible.

3. Culture-Guided Therapy

Modify antimicrobial therapy once microbiological results become available. Targeted therapy based on culture and sensitivity results helps reduce unnecessary exposure to broad-spectrum antibiotics.

4. Antibiotic De-escalation

Broad-spectrum empirical antibiotics should be reviewed within 48-72 hours and narrowed or discontinued based on microbiological findings and clinical response.

5. Optimization of Dose and Duration

Antibiotic dosing should be optimized according to the severity of illness, organ function, and pharmacokinetic–pharmacodynamic principles. Treatment duration should be limited to the shortest effective course.

6. Restriction of Reserve Antibiotics

The use of certain broad-spectrum or last-line antibiotics such as carbapenems, colistin, and newer antimicrobial agents should be restricted and may require approval from the antimicrobial stewardship team or an infectious disease specialist.

7. Prospective Audit and Feedback

Regular review of antibiotic prescriptions by the antimicrobial stewardship team helps identify inappropriate use and provides feedback to clinicians to improve prescribing practices.

8. Surveillance of Antimicrobial Resistance

Continuous monitoring of antimicrobial resistance patterns through periodic antibiogram reports helps guide empirical therapy and update institutional antibiotic policies

9. Education and Training

Regular training programs should be conducted for healthcare workers to improve awareness about rational antimicrobial use, antimicrobial resistance, and infection prevention strategies.

10. Monitoring Antibiotic Utilization

Antibiotic consumption should be monitored using standardized indicators such as Defined Daily Dose (DDD) or Days of Therapy (DOT) to track trends and guide stewardship interventions.

11. Information Technology and Computer-Assisted Support

Healthcare information technology (IT), in the form of electronic medical records, electronic prescribing, and decision-support systems, can enhance decision-making and patient safety. These systems can be designed to trigger drug–bug mismatch alerts, dose adjustments in liver and renal impairment, drug interaction alerts, and allergy warnings. Although setting up IT systems can be costly, they have been shown to improve antibiotic prescribing and reduce overall healthcare costs.

12. Microbiology Laboratories

The clinical microbiology laboratory plays a crucial role in antibiotic stewardship. Institutional antibiograms identify local microbial resistance and sensitivity patterns and are used to develop antibiotic guidelines and regulate antibiotic formularies.

Blood cultures are still considered the gold standard for diagnosing bloodstream infections, although this process may incur significant delays and incomplete results are common. More recently, attention has been focused on the use of fully automated mass spectrometry and real-time polymerase chain reaction (PCR) techniques such as Matrix-Assisted Laser Desorption Ionization–Time of Flight (MALDI-TOF).

Although these techniques involve significant investment in equipment and training, they have been shown, when combined with an antimicrobial stewardship program, to reduce

organism identification time, mortality, critical care length of stay, and recurrence of bacteraemia.

13. Leadership and Teamwork

Multidisciplinary team involvement is essential for effective antibiotic stewardship. The hospital administration should establish stewardship programs and appoint responsible leaders from senior faculty to ensure that all staff, including nurses and doctors, are actively engaged and coordinated throughout the hospital.

Empirical Antibiotic Therapy in ICU

Based primarily on the RIMS Hospital Antibiogram and recommendations from the ICMR National Treatment Guidelines.[1,2] Empirical antibiotic therapy in the Intensive Care Unit (ICU) should be initiated promptly in patients with suspected severe infection or sepsis. The choice of empirical therapy should be guided by the likely source of infection, severity of illness, patient risk factors, and local antimicrobial resistance patterns reflected in the **RIMS Hospital antibiogram**. Wherever possible, appropriate microbiological samples should be collected before the initiation of antimicrobial therapy, and treatment should subsequently be modified based on culture and sensitivity results.

1. Sepsis and Septic Shock

Table 120. Empirical antimicrobial therapy in Sepsis and Septic Shock

Condition	Empirical treatment	Comment
Sepsis or septic shock with unclear focus	Imipenem-Cilastatin 500 mg IV q6h or 1g q8h or Meropenem 1gm IV q8h +/- Amikacin 15 mg/kg IV q24h +/- Vancomycin 15 mg/kg IV q8-12h +/- doxycycline 100 mg iv q12h +/- Colistin 9mu IV stat, then 4.5 mu iv q12h To add Caspofungin 70 mg IV on day 1, then 50 mg IV q24h or micafungin 100 mg iv od for patients with risk factors for Candida infections	To use at least two antibiotics of different antimicrobial classes. To avoid piperacillin-tazobactam in septic shock till bacteremia with cephalosporin resistant organisms is excluded, as mortality increases (MERINO trial). Treatment duration of 7 to 10. De-escalation of antimicrobials should be considered daily and at the earliest stage when the clinical situation permits/once culture susceptibility reports are available.

In critically ill patients with suspected sepsis or septic shock, early administration of broad-spectrum antibiotics is essential to reduce mortality.[10]

2. Ventilator-Associated Pneumonia (VAP)

Table 121.List of common organisms and empirical antimicrobial therapy for HAP and VAP

Condition	Common organisms	Empirical treatment	Comment
HAP/VAP	Enterobacteriaceae, Pseudomonas aeruginosa Acinetobactor, S. aureus	Imipenem 1g IV q8h or Meropenem 1g IV q8h plus Vancomycin 1g IV q12h plus Colistin 9Mu IV stat then 4.5Mu IV q2h	De-escalation once the culture reports are available. Doses should be adjusted according to GFR and ideal body weight

3. Bloodstream Infection (Sepsis of Unknown Source)

Table 122.List of common organisms and empirical antimicrobial therapy for Catheter related blood stream infections (CRBSI)/ Central line associated blood stream infections (CLABSI)

Condition	Common pathogens	Empirical treatment	Comments
CLABSI/CRBSI	Gram-negative (Klebsiella pneumoniae> Acinetobacter spp., E.coli) more common than Gram positive (Staphylococcus spp., Enterococcus spp.)	1st line: Imipenem – Cilastatin 500 mg IV q6h plus Gentamicin (80 mg IV q8h) plus Inj. Vancomycin (15 mg/kg IV q8-12h) Or Inj. Teicoplanin (400 mg IV every 12h for 3 doses followed by 400mg IV q24h) 2nd Line Cefoperazone – Sulbactam (3g IV BD) plus Gentamicin (80 mg IV q8h) plus Inj. Vancomycin (15 mg/kg IV q8-12h) Or Inj. Teicoplanin (400mg IV every 12h for 3 doses followed by 400mg IV q24h)	Catheter removal is warranted in Septic shock, Suppurative thrombophlebitis, Endocarditis or evidence of metastatic infection, persistent bacteraemia after 72 hours of appropriate therapy, CLABSI caused by S. aureus, enterococci, GNB, fungi, mycobacteria
CLABSI due to pathogenic yeasts	Candida species	1st line: Micafungin 100 mg IV daily Or Caspofungin loading dose 70 mg, then 50 mg daily Or Fluconazole 800 mg loading dose, then 400 mg daily or 2nd line: Amphotericin B	Catheter removal is essential and therapy is recommended for all cases due to Candida species. Duration for 14 days after first negative

		(lipid) 3-5 mg/kg daily Or Amphotericin B deoxycholate 0.5-1 mg/kg daily Or Voriconazole 400 mg (6 mg/kg) q12h for 2 doses then 200 mg (3mg/kg) q12h	blood culture.

Bloodstream infections may originate from central venous catheters, intra-abdominal infections, or other sources. Blood cultures should always be obtained before initiating antibiotic therapy.

4. Catheter-Associated Urinary Tract Infection (CAUTI)

Table 123. List of common organisms and empirical antimicrobial therapy for CAUTI

Condition	Common organisms	Empirical treatment	Comment
CA-UTI	E. Coli, Klebsiella Spp, Pseudomonas Spp, Proteus spp, Enterococcus spp, Anaerobes, Candida spp	Nitrofurantoin 100 mg PO BID Levofloxacin 750 mg PO daily Ciprofloxacin 500 mg PO BID Fluconazole if Candida spp is suspected	For severely ill patients, - Piperacillin/ tazobactam 4.5 g IV q6hr Ertapenem 1 g IV q24hr or Meropenem 1 g IV q 8hr (preferred in patients with sepsis and septic shock Duration of treatment for 7 to 14 days.

The urinary catheter should be removed or replaced whenever possible.

5. Clostridium difficile infection (CDI)

Table 124. Empirical antimicrobial therapy for CDI

CDI	Vancomycin (VAN) 125 mg 4 times daily by mouth for 10 days
If fulminant : Hypotension or shock, ileus, megacolon	VAN, 500 mg 4 times per day by mouth or by nasogastric tubes. If ileus, consider adding rectal installation of VAN. IV metronidazole (500 mg every 8 hours) should be administered with oral or rectal VAN, particularly if ileus is present

De-escalation and Review

Empirical antibiotic therapy should be reassessed within *48-72 hours* after initiation. Based on microbiological results and clinical improvement, therapy should be narrowed, modified, or discontinued to minimize unnecessary antibiotic exposure and reduce antimicrobial resistance.

Duration of Therapy

The duration of antimicrobial therapy depends on the type of infection and the patient's clinical response. In general, longer durations may be required in complicated infections or in immunocompromised patients.

Future Advances in Antibiotic Stewardship

Effective antimicrobial stewardship in ICU settings is often challenged by the delayed identification of pathogens and the low yield of microbiological cultures.[5,9] In many cases, pathogens are isolated from only a minority of samples, and culture results may take 48–72 hours, leading clinicians to initiate broad-spectrum empirical antibiotic therapy.[9] Therefore, advances in diagnostic technologies and biomarkers are expected to play a crucial role in improving antibiotic stewardship in the future.[5,9]

1. Use of Biomarkers for Early Detection of Infection

One of the most promising developments in antimicrobial stewardship is the use of biomarkers to differentiate *bacterial infections from non-infectious inflammatory conditions.* Accurate biomarkers could help clinicians decide when to start, continue, or discontinue antibiotic therapy.[9]

More than *150 biomarkers* have been studied as potential diagnostic and prognostic indicators of infection. Among these, *procalcitonin (PCT)* has shown significant clinical utility in guiding antibiotic therapy.

Procalcitonin levels increase in bacterial infections but remain relatively low in viral infections and non-infectious inflammatory states. This property allows clinicians to use PCT levels to guide decisions regarding the initiation and discontinuation of antibiotics.

2. Procalcitonin-Guided Antibiotic Therapy

Procalcitonin-based algorithms have increasingly been used in ICU settings to guide antimicrobial therapy. Elevated PCT levels may indicate the presence of bacterial infection, while declining levels suggest resolution of infection and may support early discontinuation of antibiotics.

The use of *PCT-guided strategies* has been shown to:

- Reduce unnecessary antibiotic exposure
- Shorten the duration of antimicrobial therapy
- Lower the risk of antimicrobial resistance
- Maintain similar or improved clinical outcomes in critically ill patients

3. Rapid Molecular Diagnostic Techniques

Advances in molecular diagnostic methods, such as *polymerase chain reaction (PCR)-based assays, multiplex pathogen panels, and next-generation sequencing,* allow faster identification of pathogens and antimicrobial resistance genes directly from clinical samples.

These technologies can significantly shorten the time required for pathogen identification compared with conventional culture methods, thereby enabling earlier targeted therapy and reducing unnecessary broad-spectrum antibiotic use.[9]

4. Artificial Intelligence and Clinical Decision Support Systems

Emerging technologies such as *artificial intelligence (AI)* and machine learning may assist clinicians in predicting infection risk, guiding empirical antibiotic selection, and optimizing treatment duration.[6,9] Integration of these systems with hospital electronic medical records can support *real-time decision-making* in antimicrobial stewardship programs.

5. Improved Surveillance and Data Integration

Future stewardship programs will likely benefit from integrated surveillance systems that combine *microbiology data, antibiotic utilization patterns, and patient outcomes.*[1] These systems can help generate real-time hospital antibiograms and identify emerging resistance patterns,[1,3] thereby supporting evidence-based antibiotic policies.

6. Personalized Antimicrobial Therapy

Advances in *pharmacokinetics and pharmacodynamics, therapeutic drug monitoring, and genomic technologies* may allow personalized antimicrobial therapy, enabling clinicians to select the most effective antibiotic and dosing regimen tailored to individual patient characteristics.[9]

Conclusion: Appropriate antimicrobial stewardship in the ICU incorporates the rapid identification and treatment of infections based on pharmacokinetic and pharmacodynamic principles, while avoiding unnecessarily broad-spectrum antibiotic agents, shortening the duration of therapy, and minimizing the number of patients receiving unnecessary antibiotics.[5,6] Alongside the appropriate use of antibiotics, the *Surviving Sepsis Campaign* emphasizes the importance of rapid source control.[7]

A diagnosis of infection amenable to rapid source control should be managed at the earliest opportunity. In critical care settings, this includes not only the identification of anatomical collections or sites of infection but also the removal of implantable devices, intravascular catheters, and urinary catheters when appropriate.

Appropriate prescribing of antibiotic therapy in critical care can significantly contribute to reducing antimicrobial resistance.[1,5] However, the complexity of clinical presentations and the severity of illness in many critically ill patients make rationalization of antibiotic therapy extremely challenging. The implementation of a formal *Antimicrobial Stewardship Program (ASP)* within critical care settings can therefore assist clinicians in making these difficult decisions.[5,6]

Antimicrobial stewardship in critical care is an ongoing process that requires commitment from healthcare providers to balance the need for effective treatment with the imperative to minimize the emergence of antimicrobial resistance. Regular evaluation and adjustment of stewardship programs contribute to improved patient care and the long-term sustainability of antibiotic effectiveness.[5]

Antimicrobial stewardship programs provide a practical and structured approach to the use of antibiotics within healthcare systems, aiming to reduce antibiotic resistance and

preserve the effectiveness of existing antimicrobial agents. The potential benefits for future healthcare are substantial, and the ultimate success of stewardship programs depends on *strong interdisciplinary teamwork, continuous education, and regular feedback mechanisms.*[7]

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11. CHALLENGES IN PREVENTING HEALTHCARE-ASSOCIATED INFECTIONS IN ICU SETTINGS

Abstract: Healthcare-associated infections (HAIs) continue to pose a major challenge in intensive care units (ICUs), particularly in resource-limited settings. This article analyzes microbiological surveillance and antibiogram data (July, 2024 - June, 2025) along with national ICU guidelines from RIMS, Imphal to identify key barriers in effective infection prevention. Among 18,381 clinical specimens processed, 7,722 (42 %) were culture positive. Gram-negative organisms predominated, with *Escherichia coli* and *Klebsiella pneumonia* being the most common pathogens. ICU isolates showed higher prevalence of multidrug-resistant organisms and significantly reduced antimicrobial susceptibility. Tracheal aspirate cultures highlighted the burden of ventilator-associated pneumonia (VAP). In addition, systemic challenges such as inadequate staffing, high workload, and environmental factors further complicate prevention efforts. Addressing these challenges requires a comprehensive approach combining antimicrobial stewardship, infection control strengthening, and improved human resource allocation.

Introduction: Healthcare-associated infections remain a significant cause of morbidity and mortality in intensive care units (ICUs), where critically ill patients are exposed to invasive procedures, prolonged hospital stays, and broad-spectrum antibiotic therapy.[1] Despite advances in infection control practices,[2] preventing HAIs remains difficult due to a combination of microbiological, clinical, and systemic factors.

This article is based on microbiological surveillance data from RIMS, Imphal[3] (July 2024–June 2025), along with national ICU guidelines,[4] to analyze the real-world challenges in preventing HAIs and their implications for antibiotic policy.

Microbiological Burden and Resistance Profile

The surveillance data demonstrated a high culture positivity rate of 42%, indicating a substantial infection burden. Gram-negative organisms accounted for approximately 54.5% of isolates, with *Escherichia coli* (26.3%) and *Klebsiella pneumoniae* (19.5%) being the most common pathogens.[5] Other significant organisms included *Staphylococcus aureus* (9.5%), *Acinetobacter baumannii* (8.2%), and *Pseudomonas aeruginosa* (7.7%).

Urine samples contributed the largest proportion of isolates (47.1%), followed by superficial infections (26.4%) and lower respiratory tract infections (14.8%). ICU settings showed higher isolation of Acinetobacter and Pseudomonas, highlighting their association with healthcare-associated infections.

Among lower respiratory tract samples, tracheal aspirates constituted a significant proportion, particularly from ICU patients on mechanical ventilation. These samples predominantly yielded non-fermenting gram-negative *bacilli such as Acinetobacter baumannii* and *Pseudomonas aeruginosa*, organisms that are strongly associated with

ventilator-associated pneumonia.[6] The predominance of these pathogens in tracheal aspirates reflects the burden of device-associated infections in ICU settings and highlights the role of ventilators as a major source of healthcare-associated infections.

Antimicrobial susceptibility patterns revealed reduced effectiveness of commonly used antibiotics, particularly in ICU isolates, with emerging resistance even to carbapenems in certain organisms.

Challenges in Preventing HAIs in ICU Settings

1. High Burden of Multidrug-Resistant Organisms

One of the most significant challenges is the high prevalence of multidrug-resistant organisms (MDROs), particularly gram-negative bacteria. The antibiogram data demonstrates poor susceptibility of *Klebsiella pneumoniae* to multiple antibiotic classes, including beta-lactams and carbapenems. Similarly, *Acinetobacter baumannii* exhibits extreme resistance, with very limited treatment options available.[7]

This significantly complicates infection management, leading to prolonged infections, increased transmission risk, and higher mortality. The presence of such resistant organisms in ICU settings indicates both antibiotic pressure and challenges in infection control practices.[2]

2. ICU as a Reservoir for Resistant Pathogens

ICU isolates consistently show lower antimicrobial susceptibility compared to ward and outpatient isolates, suggesting that ICU environments act as reservoirs for resistant pathogens. Organisms such as *Acinetobacter baumannii* and *Pseudomonas aeruginosa* are frequently isolated in ICU settings and are known for their ability to survive in hospital environments.

This persistence allows these organisms to colonize surfaces, equipment, and healthcare workers' hands, facilitating cross-transmission and making infection control more challenging.

3. Device-Associated Infections

The high proportion of infections from lower respiratory tract and urinary samples reflects the significant burden of device-associated infections such as ventilator-associated pneumonia[6] and catheter-associated urinary tract infections (CAUTI).

In ICU settings, tracheal aspirate cultures frequently yield organisms such as *Acinetobacter baumannii* and *Pseudomonas aeruginosa*, which are well-known causes of ventilator-associated pneumonia. The presence of these multidrug-resistant organisms in respiratory samples indicates both prolonged ventilator use and increased risk of cross-transmission.

Invasive devices disrupt natural host defences and provide a direct pathway for pathogens to enter the body. Mechanical ventilation, in particular, facilitates colonization of

the lower respiratory tract, leading to VAP. Despite adherence to preventive bundles, factors such as prolonged device use, frequent handling of airway equipment and critically ill patient status make complete prevention challenging.

Basic preventive strategies for VAP, including elevation of the head of the bed, strict hand hygiene, regular oral care, subglottic secretion drainage, and minimizing duration of mechanical ventilation, are essential but may be inconsistently implemented in high workload settings.

4. Declining Effectiveness of Common Antibiotics

The antibiogram data[7] highlights markedly reduced susceptibility to commonly used antibiotics such as third-generation cephalosporins and fluoroquinolones. Even carbapenems, which are considered last-resort drugs, show declining effectiveness in certain organisms. This limits the reliability of empirical therapy and often necessitates escalation to higher-end antibiotics, contributing further to antimicrobial resistance.

5. Environmental Persistence and Cross Transmission

Non-fermenting organisms such as Acinetobacter and Pseudomonas are known for their ability to persist in the hospital environment, including surfaces, ventilators, and other equipment.

Their presence in ICU settings suggests that environmental contamination and inadequate disinfection practices may contribute to the spread of infections. Maintaining strict environmental hygiene in high-load ICU settings remains a major challenge.

6. Inadequate Staffing and High Workload

A critical challenge in preventing HAIs is the issue of inadequate staffing. ICU care requires a high staff-to-patient ratio, with national guidelines recommending a 1:1 nurse-to-patient ratio in ICUs and 1:2 in HDUs, along with adequate medical officers and support staff.

In practice, maintaining these ratios is often difficult due to manpower shortages and high patient load. Overburdened healthcare workers may find it challenging to strictly adhere to infection control practices[2] such as hand hygiene, aseptic techniques, and device care protocols.

National guidelines recommend the presence of dedicated intensivists and adequately trained medical officers to ensure continuous patient monitoring and timely clinical decision-making. Ideally, ICUs should have round-the-clock coverage by qualified doctors, with clearly defined responsibilities in patient management, antimicrobial stewardship, and adherence to infection control protocols. In resource-limited settings, however, shortages of trained doctors, high patient load, and frequent rotation of staff can compromise the quality and consistency of care. This not only affects clinical outcomes but also increases the risk of healthcare-associated infections due to delays in intervention, suboptimal adherence to

protocols, and reduced supervision of infection control practices. Strengthening doctor manpower with trained, dedicated ICU teams is therefore essential for improving patient safety and reducing infection burden.

Additionally, ICU care requires specialized training, and the lack of adequately trained personnel further compromises infection prevention efforts. Frequent rotation of staff and lack of dedicated ICU teams can also affect consistency in care.

7. Role of Support Staff and Infection Control Practices

Infection prevention in ICU is not limited to doctors and nurses but also depends heavily on support staff such as housekeeping personnel and technicians. Proper cleaning, disinfection, and biomedical waste management are essential components of infection control. Inadequate staffing or training in these areas can lead to suboptimal environmental hygiene, contributing to the persistence and spread of resistant organisms.

8. High Infection Burden and System Constraints

The overall high culture positivity rate (42%) reflects a significant infection burden. Contributing factors may include overcrowding, limited isolation facilities, and resource constraints.

These systemic issues can compromise adherence to infection control practices[2] and facilitate transmission of infections within ICU settings.

9. Need for Continuous Surveillance and Data-Driven Policies

The variability in antimicrobial resistance patterns highlights the importance of continuous surveillance. ICU isolates consistently show poorer susceptibility profiles, emphasizing the need for regular monitoring and updating of antibiotic policies. Without data-driven approaches, empirical therapy may become ineffective, leading to poor clinical outcomes.

Conclusion: Preventing healthcare-associated infections in ICU settings remains a complex challenge influenced by microbiological, clinical, and systemic factors. The RIMS surveillance data highlights the high burden of multidrug-resistant organisms, particularly in ICU environments, along with declining antibiotic effectiveness.

These challenges are further compounded by inadequate staffing, environmental factors, and resource limitations. A comprehensive approach involving antimicrobial stewardship,[4] strict infection control practices,[2] improved staffing, and continuous surveillance is essential to effectively reduce the burden of HAIs.

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12. GUIDELINES FOR ANTIBIOTIC USE IN DENTAL COLLEGE

Introduction: Orofacial infections are commonly categorized as odontogenic and nonodontogenic. Theconditionsthat originate within atooth and dental supporting structuresarecalled odontogenic infections.

Dental caries, pulpal necrosis, trauma, and periodontal diseases can result in dental infectionswhichcouldhavesevereconsequences thataffectbothsoftand hardtissues of the oral cavity. Dental infections commonly present with symptoms of pain, fever, and swelling. Surgical and endodontic treatments are the early management of infected teeth, followed by antibiotic therapy.[1]

According to a study, Gram-positive cocci are responsible for about 65% of orofacial infections, and Gram-negative bacilli could be found in 25% of patients' oral specimens.[2] Antibiotics are generally used in dental procedures to treat odontogenic infections, nonodontogenic infections, local infection, focal infection and prophylaxis.

In Oral region the most frequently isolated aerobic strains were Streptococcus mitis and Staphylococcus aureus, whereas the most common anaerobic strains were Escherichia coli. Aerobic bacteria were found in 72.25% of the patients, whereas anaerobic bacteria were found in 27.74%.[3]

Table 125. List of the micro-organism found in Orofacial region[4]

Gram-positive bacteria	**Gram-negative bacteria**	**Anaerobic bacteria**
Staphylococcus: Aureus, Epidermidis, Capitis ***Streptococcus:*** Mitis, Anginosus , Haemolyticus , Sanguinis, Mutaris, Oralis Identified as gr C ***Other:*** Salivarius, Parasanguinis, Constellatus,	Pseudomonas aerigunosa, Acinetobacterbaumannii, Escherichia coli, Klebsiellapneumonia, Moraxella catarrhalis, Citrobacter: freundii, brakii Enterobacter cloacae, Serratiamarcescens	Leuconostocmesenteroides, Eggerthellalenta, Escherichia coli, Candida albicans

Pluranimalium, Intermedius, Pseudoporcinus		
Bacterial species associated with periodontal health and diseases Healthy gingival Streptococcus mutans and other species, Actinomycesviscosus and other species, Prevotella intermedia		
Gingivitis Actinomycesviscosus and other species Streptococcus spp. Fusobacteriumspp. Treponemaspp.		
Chronic periodontitis and rapidly progressive periodontitis Porphyromonasgingivalis, Actinobacillusactinomycetecomitans, Fusobacterium spp.		
Juvenile periodontitis Actinobacillusactinomycetecomitans, Prevotella internedia		

The Most Common Prescribed Antibiotics

1) Beta-Lactams

This group of antibiotics is bactericidal agents that act against many Gram-positive, Gram-negative, and anaerobic bacteria via inhibiting the synthesis of the cell wall.[5]Beta-lactam antibiotics are categorized into five classes: penicillin, cephalosporins, penems, carbapenems, and monobactams.[6]

The overuse and misuse of penicillin and cephalosporins has resulted in an increased rate of bacterial resistance, caused by the production of beta-lactamase. Allergy reaction caused by release of immunoglobulin E (Ig E) mediators are among the common side effects of beta-lactams and might include rashes, pruritis, and even anaphylactic shock.

Penicillin

Considered gold standard for the treatment of odontogenic infections because of its cost-effectiveness, low incidence of side effects, and appropriate antimicrobialactivity.[1] It has been mentioned that about 10% of people might present some levels of hypersensitivity to the drug; however, 90% of them can tolerate penicillin.[7] Should the patients have a history of hypersensitivity to the drug or a positive skin test, clindamycin could be administered instead of penicillin.

Amoxicillin with clavulanic acid (co-amoxiclav) is a broad spectrum antibiotic that is believed to be the second most prescribed antibiotic by dental surgeons.

Recommended dose:[1]

a) The therapeutic dosage for amoxicillin is500 mg every 8 hours or 1000 mg every 12 hours.
b) Forsevereodontogenicinfectionlikespaceinfections 2-4gpenicillinVevery 4-6 hours combined with 500 mg metronidazole intravenous(IV).
c) A high dose of co-amoxiclav (875/125 mg every 8 hours or 2000/125 mg every 12 hours) is a proper choice in the cases of severe odontogenic infections, such asabscess and pulpitis.

2) Cephalosporins

Cephalosporins can act against aerobic bacteria, and their combination with metronidazole could cover both aerobic and anaerobic bacteria. Cephalexin and cefazolin are among the most commonly prescribed 1st generation cephalosporins in dental practice.[1] Cephalexin could be prescribed for penicillin-allergic patients, with the dosage of 2 g orally 1 h before dental procedures.[8]Cefazolin is suggested for patients who are allergic to penicillin and cannot take the medication by mouth, with the dosage of 1 g IV or IM 30 minutes before the procedure.[9] Older studies recommended not to use cephalosporins in penicillin-allergic patients, while more recent investigations showed that there is little cross-activity between penicillin and cephalosporins.[9]

3) Nitroimidazoles

Nitroimidazoles include metronidazole, nimorazole, and tinidazole.[1] Dental practitioners tend to prescribe metronidazole for the treatment of acute infections, as it has great antianaerobic bacterial activity and low risk of toxicity. Combined administration of amoxicillin and metronidazole could cover most of the oral bacteria prescription of this combination or metronidazole is also recommended for the treatment of periodontal infections. The drug is commonly prescribed with a dosage of 500-750 mg every 8 hours.[1]

4) Macrolides

Macrolides mainly act against beta-hemolytic streptococci. Macrolides should not be co-administered with clindamycin, since these have the same target point and antagonistic effects.[1]

Erythromycin

The most common microorganism that causes dental caries is *Streptococcus mutans*, which is highly sensitive to erythromycin. Erythromycin can inactivate the caries, and it also can decrease the growth and formation of dental plaque.

Erythromycin should be prescribed with a dosage of 250-500 mg every 6 hours.[10]The drug is contraindicated in patients taking simvastatin or colchicines and also in patients who suffer from porphyria.

Azithromycin

This drug is not suggested as the first-line treatment of odontogenic infections and is usually prescribed as an alternative in penicillin-allergic patient. The dosage of the drug is 500 mg once a day for three days, in case of therapeutic prescription, and 500 mg 1 hour before the oral procedure, in case of prophylactic administration.[1]

Clarithromycin

It is believed to have the greatest effect against anaerobic Gram-positive bacilli.[11]Hence, clarithromycin can be a logical approach for suppressing the pulp and periodontal infections.[1]However, clarithromycin is not usually recommended as the first-line treatment and is used instead of penicillin in patients who cannot tolerate the gold standard treatment of penicillin.[1]The standard dose for prophylaxis is 500 mg orally 1 hour before the dental procedure.

5) Lincosamides

Clindamycin

Clindamycin is a broad-spectrum bacteriostatic antibiotic that covers both aerobic and anaerobic pathogens. Clindamycin could be prescribed in the case of persistent infections, as it has more efficacies in comparison with penicillin and metronidazole. Clindamycin is also an excellent choice for patients who have an allergy to beta-lactam group antibiotics. The therapeutic dosage of the drug is 600 mg or 300 mg every 8 hours orally or intravenously. This agent is contraindicated for cirrhotic patients and for patients with a history of ulcerative and pseudo-membranous colitis.

6) Fluoroquinolones

Fluoroquinolones are broad-spectrum bactericidal antibiotics that mostly act against Gram negative bacilli, Gram-positive aerobic cocci, and anaerobic organisms. Fluoroquinolones must not be prescribed for children because of the possibility of chondrotoxicity in developing cartilage and for patients who use theophylline, as this could result in serious complications, for example, seizure.[12]

Ciprofloxacin

Ciprofloxacin is among the second generation of fluoroquinolone antibiotics and is active against Gram-positive and Gram-negative pathogens. The drug is usually administered orally with a dosage of 500 mg every 12 hours to treat odontogenic infections.[1]Dental practitioners should take the patients' history as if they have been using theophylline because the drug interaction could result in severe consequences.

Moxifloxacin

Moxifloxacin is a broad-spectrum bactericidal agent and a fourth-generation

fluoroquinolone. The drug acts against aerobic, anaerobic, Gram-positive, and Gram-negative bacteria. Moxifloxacin can be considered as a good choice to treat odontogenic and periodontal infections as well, since it has high penetration capacity through periodontal and bone tissues.

The effective dose to control odontogenic infections is 400 mg once a day. The major concern is that the drug could affect cartilage maturation; hence, it must not be in pregnant and adolescent patients.[13]

7) Tetracyclines

Used for the treatment of periodontal diseases, as it has anti-inflammatory activity, collagenase inhibition potential, and bone resorption inhibitory capacity; besides, it could help the fibroblasts to attach to the root surface.[14]

Antibiotic Use in Pediatric Dentistry

Anatomical and physiological differences between children and adults such as the amount of their body water and fat, the maturation of the immune system, the volume of protein, and the level of liver enzymes should be considered while prescribing antibiotics for children.[15] Dentists treat children with antibiotics to reduce the risk of bacteremia caused by dental infections.[16]

Table 126. Therapeutic antibiotic dose for children[1]

Agent	Situation	Dose	Maximum Dose	Available forms
Amoxicillin	First choice in dental infection	20-40 mg/kg/day, e8h	2 g/day	Tablet 125mg, capsule 250 mg, and 500 mg and oral suspension 125mg/5ml and 250 mg/5 ml
Amoxicillin +Clavulanic acid	Failure of first choice antibiotic		1000-2800 mgamoxicillin/ 143-400 mg clav.acid	Tablet 375mg, 650mg and 1000 mg and oral suspension 228.5/5 ml
Clindamycin	Penicillin hypersensitivity	10-20 mg/kg/day, e6h		Suspension 75mg/5ml
Cephalexin	Necessity of broad spectrum action	25-100 mg/kg/day, e6_8h		Tablet 125mg, 250mg and 500mg. Capsule 250 mg, 500 mg and 750 mg and oral suspension 125 mg/5ml and 250 mg/5 ml
Metronidazole	Anacrobic bacteria	30 mg/kg/day, 8h	2 g/day	Tablet 200mg, 250mg, 400mg and 500mg, infusion solution 500mg/5 ml, and oral suspension 200mg/5 ml

Antibiotic Therapy during Pregnancy

The physiological changes of pregnancy can affect the condition of the oral cavity such as increasing the risk of gingivitis and pyogenic granuloma.[17] The mothers with poor oral hygiene who have a higher number of microorganisms in their saliva, especially *Streptococcus mutans*, can easily transmit the infection to the infant causing several serious problems for them.

In dental practice, the main agents that are commonly used during pregnancy and are considered to be safe during this period are analgesics, anesthetic agents, and antibiotics. The antibiotics are classified to be in class B of FDA arrangement and must be given in full adult dose.

Following are the antibiotics that are considerably having low risk in pregnant woman. These are Amoxicillin, Cephalexin, Clindamycin, Erythromycin, Metronidazole, Penicillin& Azithromycin.

Classification of surgical wounds according to the risk of contamination-infection [18]

a) Type I: Clean wounds (no disruption of mucosa such as the oral cavity): infection rate 1-4%. No prophylaxis or prophylaxis no longer than 24 hours with Amoxicillin-clavulanate as there is no benefit in using postoperative antibiotics.

b) Type II: Clean-contaminated wounds (disruption of mucosa such as the oral cavity or surgery in an inflamed area): infection rate 5-15%. Prophylaxis against gram positive and anaerobic bacteria (Amoxicillin-clavulanate, Cefazolin + anaerobicid (Clindamycin or Metronidazol).[19]

- Amoxicillin-clavulanate 2 g, repeat dose if long term surgery 1g/4 h.
- Allergy to Betalactamics. Clindamycin 600mg +Genta-mycin120mg), repeat dose if long term surgery every 4h.

c) Type III: Contaminated wounds (oncological surgery in which both oral cavity and neck contact): rate infection 16-25%. Prophylaxis against gram positive, anaerobic bacteria and also gram negative, which are not covered in clean and clean contaminated surgeries, using drugs such as Ampicillin-sulbactam or Piperacillin-tazobactam:

- Amoxicillin-clavulanate 2g, repeat dose if long term surgery 1 g/4h.
- Clindamycin 600 mg + cefazolin 2 g, repeat dose of clindamycin every 6h and 1 g/8h of cefazolin if long term surgery.

d) Type IV: Dirty and infected wounds. Rate of infection 25%. Antibiotic treatment always, not prophylaxis. The use of antiseptics in the oral cavity reduces the amount of the bacteria in the surgical area, but has not demonstrated to be effective in the prophylaxis of the bacterial colonization.

Prophylaxis in Bacterial Endocarditis[18]

It must be done in patients with high risk of endocarditis cardiopathies which may undergo a procedure with bacteraemia risk in oral and maxillofacial surgery.

High risk of endocarditis cardiopathies:

a) High risk: Endovascular prosthesis, previous endocarditis, complex congenital cyanotic cardiopathy or surgical systemic-pulmonary fistula.
b) Moderate risk: Other congenital cardiopathies, acquired valvulopathies, mitral valve prolapse with regurgitation, hypertrophic miocardiopathy.
c) Low risk: Ostium secunduminterauricular communication, surgically repaired interauricular or interventricular communications, previous by-pass, mitral valve prolapse without regurgitation, pacemaker.

Table 127. Antibiotic prophylaxis in bacterial endocarditis[18]

Prophylaxis	Adults	Children
Standard	Amoxicillin 2 g vo or iv	Amoxicillin 50 mg/kg vo
Allergy to beta-lactamics	Clindamycin 600 mg vo	Clindamycin 20 mg/kg vo
	Azithromycin 500 mg vo	Azithromycin 15 mg/kg vo
	Clarithromycin 500 mg vo	Clarithromycin 15 mg/kg vo
Oral intolerance	Ampicillin 600 mg im or iv	Ampicillin 50 mg/kg im or iv
	Cefazolin 1 g im or iv	Cefazolin 25 mg/kg im or iv

As a regular practice, all the departments in Dental College, RIMS use antibiotic therapy judiciously only when it is indicated.

Amoxicillin 500 mg 8 hrly for 3 to 5 days is usually given for simple extraction or other dental procedures like root planning and endodontic treatments.

- (Amoxicillin 500 mg + Clavulanate 125 mg) 12 hrly for 5 days is also regularly used for transalveolar extractions, periosurgery or for endodontic surgeries.

- In case of osteomyelitis, dental infection, either abscess or space infection, pre prosthetic surgery or for 3rd molar disimpaction case then (Amoxicillin 500 mg + Clavulanate 125 mg) 12 hrly is combination with Metronidazole 400 mg in 8 hrly dose for 5 days.

Severe space infections or patient requiring maxillofacial surgery require parenteral antibiotic therapy either in monotherapy or in combination with two or three groups of antibiotics.

- Simple fracture case and all minor oral surgical procedures like cyst enucleation, wide

local excision, local flap reconstruction. Inj. Ceftriaxone 1gm 12 hrly for 2 days.
- Complex fracture cases, Inj. Ceftriaxone 1mg 12 hrly + Inj. Metronidazole 500 mg 8 hrly for 3 to 5 days.

- Severe space infection like Ludwig's angina case (Inj. Piperacillin + tazobactum 4.5 gm) 12 hrly given in combination with Inj. Metronidazole 500 mg 8 hrly for 3 to 5 days.

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13. GUIDELINES ON PREVENTION OF HOSPITAL ACQUIRED INFECTION: NURSING PERSPECTIVE

Abstract: Hospital-acquired infections (HAIs) remain a critical global concern, significantly increasing patient morbidity, mortality, healthcare expenditures, prolonged hospital stays and increased antimicrobial resistance. Nurses, as the primary 24-hour bedside providers, serve as the frontline defence in implementing infection prevention and control (IPC) protocols. This paper summarizes current research and clinical guidelines regarding the nursing management and prevention of hospital-acquired infections.

Objective: To develop practical, evidence-based nursing guidelines for the prevention of hospital-acquired infections across clinical care settings.

Methods: A narrative guideline development approach was adopted. Literature was reviewed from major healthcare databases and international infection prevention manuals published in the last decade. Key recommendations were synthesized and organized into actionable nursing practices.

Key Recommendations: Core domains include standard precautions, transmission-based precautions, device-associated infection prevention, environmental hygiene, antimicrobial stewardship, surveillance, education and quality improvement.

Conclusion: Nurse-led implementation of structured infection prevention guidelines can significantly reduce HAI incidence and improve patient outcomes.

Introduction: Hospital-acquired infections remain a persistent global healthcare challenge and are closely linked with increased antimicrobial consumption and the emergence of antimicrobial resistance.[1] Common HAIs include catheter-associated urinary tract infections, central line–associated bloodstream infections, ventilator-associated pneumonia and surgical site infections. Most are preventable through adherence to evidence-based infection prevention and control measures, which also reduce unnecessary antibiotic exposure.[1]

Antibiotic policies in hospitals aim to promote rational antimicrobial use, prevent resistance and improve patient outcomes. Nurses are central to achieving these goals due to continuous patient contact, responsibility for invasive procedures, medication administration, monitoring, documentation and patient education.[2,3]

Strengthening nursing infection prevention practices directly supports antibiotic stewardship by reducing infection incidence, limiting empiric antibiotic use, ensuring timely cultures and improving adherence to treatment protocols.[4]

Aim: This article provides structured, evidence-informed nursing guidelines for prevention of hospital-acquired infections with integration into hospital antibiotic policy frameworks.

Methodology: A structured literature review was conducted using major biomedical and nursing databases. Guidelines, systematic reviews, meta-analyses and policy documents published in English within the last 10 years were included.

Nursing Guidelines for Hospital Acquired Infection Prevention

a) Standard Infection Prevention Precautions: Standard precautions apply to all patients regardless of diagnosis.

1) Hand Hygiene:

- World Health Organization recommends six main steps of hand washing both through use of soap and water and by use of alcohol-based hand rub.
- Follow the recommended moments for hand hygiene: Before patient contact, before aseptic tasks, after body fluid exposure, after body fluid exposure risk, after patient contact and after contact with patient surroundings.
- Follow the proper duration of hand hygiene means scrubbing your hands with soap and water for **40–60 seconds** or using an alcohol-based hand rub for **20–30 seconds** until hands are completely dry.[5,6,7]

2) Personal Protective Equipment:

- Personal Protective Equipment (PPE) is essential for preventing exposure to body fluids and surfaces.
- Use gloves, masks, gowns and eye protection based on risk assessments.
- Ensure correct donning and doffing techniques.[1,8]

3) Respiratory Hygiene: Respiratory hygiene and cough etiquette are essential, standard infection control precautions designed to contain respiratory secretions at the source, preventing the spread of pathogens.

- Promoting cough etiquette: Cover the nose and mouth with a tissue when coughing or sneezing or cough into the elbow, not hands.
- Providing masks to symptomatic individuals.
- Ensuring proper tissue disposal.
- Practicing hand hygiene.[1,6]

4) Safe Injection Practices:

- Prepare injections using aseptic technique in a clean area.
- Do not use needles and syringes for more than one patient.
- Medication containers (single and multidose vials, ampoules and bags) are entered with a new needle and new syringe, even when obtaining additional doses for the same patient.[6]

5) Healthcare Waste Management:

- Segregate waste at point of generation typically using a color-coded bin system.
- Dispose sharps safely in puncture-proof containers.[1,6]

b) Transmission-Based Precautions: Implemented for patients with known or suspected infections.

1) Contact Precautions:

- PPE: Gloves and gowns for patient/environment contact.

- Environmental control: Dedicated equipment where possible.
- Patient transportation: Limit transport; ensure precautions are maintained during transport.
- Environmental Cleaning: Increased frequency of cleaning high-touch surfaces (bed rails, bedside tables) is usually required.[1]

2) Droplet Precautions:

- PPE & Masks: Healthcare personnel should wear a surgical or procedure mask upon entering the patient's room.
- Patient Placement: Single rooms are preferred. If unavailable, cohort patients with the same infection or maintain at least 3–6 feet of separation.
- Source Control: Place a mask on the patient during transport and instruct them to follow respiratory hygiene/cough etiquette.
- Distance: While large droplets usually travel short distances, maintaining a distance of at least 3 to 6 feet from the infected patient is recommended.
- Eye Protection: Wear masks and eye protection (goggles or face shields) for procedures likely to generate splashes or sprays of respiratory secretions.
- Environmental Cleaning: Ensure frequent cleaning of surfaces within the patient's environment.[1]

3) Airborne Precautions:

- Patients with suspected or confirmed airborne infectious diseases are kept in negative pressure isolation rooms or airborne infection isolation rooms (AIIRs).
- Use of Respirators and PPE: Personnel must wear a fit-tested N95 or higher-level respirator (e.g., PAPR) when entering the room. Gloves, gowns and face shields should be used as per standard, contact and droplet protocols.
- Patient Transport: Limit transport; if necessary, patients must wear a surgical mask during transport.[1]

c) Device-Associated Infection Prevention:

1) Urinary Catheter Care:

- Aseptic Insertion: Use sterile equipment, drapes, gloves and appropriate antiseptic for periurethral cleaning during insertion.
- Maintain a sterile and continuously closed drainage system.
- Perform hand hygiene before/after touching the catheter or system.
- Ensure unobstructed urine flow; keep the bag below the bladder level and off the floor.
- Perform routine perineal hygiene.
- Only use catheters when necessary.

2) Central Line Care:

- Perform hand hygiene before and after working with the central venous catheter.
- Maintain sterile dressings.
- Assess daily need for continuation.

- Inspect the site daily for redness, tenderness, swelling, drainage or warmth.
- Flush lumens daily to maintain patency. Always clamp the line when not in use.
- Scrub the hub (needleless connector) for at least 15 seconds using 70% alcohol or an appropriate antiseptic, followed by an adequate drying time.
- Replace needle-free valves/caps every 7 days.
- Keep the catheter dry during bathing using a plastic cover.
- Monitoring for complications like infection, occlusion and displacement.
- Daily evaluation of the necessity of the central line, advocating for removal when no longer required.
- Record dressing change date, integrity and site assessment.

3) Ventilator Care:

- Elevate head of bed. Maintain at 30° to 45° to reduce gastric reflux and aspiration.
- Provide oral hygiene regularly.
- Maintain sterile suction techniques.
- Hand Hygiene: Stringent hand hygiene before and after touching patient, oral mucosa or ventilator equipment.
- Aspiration Prevention: Suction oral secretions before lowering the head of the bed. Use enteral feeding instead of parenteral and monitor gastric residuals.
- Early Mobilization: Encourage early exercise and movement to help clear secretions.
- Participate in multidisciplinary rounds to review the need for continued ventilation.[9,10,11]

4) Environmental Infection Control:

- Monitor and supervise in routine cleaning of high-touch surfaces.
- Proper linen handling, transport and storage.
- Ensuring patient rooms, linens and bed areas are tidy and hygienic.
- Cleaning and disinfecting non-critical medical equipment like blood pressure monitors, IV pumps and commodes between patient uses.
- Adequate ventilation in clinical areas.
- Managing spills promptly to ensure a safe environment.
- Strict adherence to infection control policy and protocols like hand hygiene, use of PPE, waste disposal, instruments handling etc.
- Conducting regular safety rounds to identify and remove hazards, such as spills or broken equipment.
- Educating families and visitors on personal hygiene and environmental cleanliness.
- Working with housekeeping staff to ensure thorough cleaning.
- Reporting broken infrastructure (broken flooring, faulty lighting) that could affect hygiene.[1,6]

5) Antimicrobial Stewardship and Antibiotic Policy: Nursing Role:

Nurses play a vital role in implementing institutional antibiotic policies and antimicrobial stewardship programs.

Antibiotic Optimization:

- Ensure timely collection of appropriate clinical specimens before initiating antibiotics.

- Verify allergy history before drug administration.
- Follow the "ten rights" of medication while administering antibiotics.
- Avoid missed or delayed doses.

Monitoring and Safety:

- Monitor therapeutic response and clinical improvement.
- Observe and report adverse drug reactions.
- Recognize signs of superinfection.

Preventing Antimicrobial Resistance:

- Avoid unnecessary antibiotic initiation without clinical indication.
- Promote culture-guided therapy where available.
- Support intravenous-to-oral switch protocols.
- Reinforce adherence to prescribed duration of therapy.

Patient and Caregiver Education:

- Educate on antibiotic adherence.
- Discourage self-medication.
- Promote awareness of antimicrobial resistance.

Policy Compliance:

- Follow hospital antibiotic formulary restrictions.
- Adhere to preauthorization and review protocols.
- Participate in antimicrobial stewardship audits.

6. Surveillance and Early Detection:

- Monitor vital signs and infection indicators.
- Inspect wounds and invasive sites regularly.
- Track laboratory results.
- Report abnormal findings promptly.[3]

7. Education and Training:

- Participate in continuous infection control trainings. Customized trainings to specific areas, such as ICUs, OTs where patients are highly susceptible to infections.
- Conducting patients and their caregivers' education to empower them in managing their health, home based care and steps to reduce the risks of infection transmission. By educating patients and their families about the importance of infection prevention, nurses foster a culture of safety and awareness that extends beyond the hospital walls.
- Engage in simulation-based skill development.[9,12]

8) Documentation and Reporting: Accurate documentation acts as the backbone of infection prevention, tracking health safety protocols and facilitating audits.

- Maintain accurate infection control records like sterilization logs for equipment (CSSD), hand hygiene monitoring records, environmental cleaning schedules etc.

- Report and record incidents including needle stick injuries (NSIs) and exposures, identifying the patient involved, date/time and actions taken etc.
- Participate in infection audits.[13]

9) *Infection control nurse and Infection control link nurses:*

Infection control nurse and Infection control link nurses act as vital intermediaries between clinical wards, hospital acquired infection control team and antimicrobial stewardship programme significantly enhancing infection prevention and control and reducing the standards through localized, evidence-based practices. They improve compliance with IPC policies, reducing antimicrobial resistance, perform surveillance, improve ward-level audit scores by increasing staff awareness and conducting peer training.[13,14]

Implementation Strategies:

Successful implementation requires-

- Unit-level standard operating procedures.
- Nursing checklists and care bundles.
- Leadership support and supervision.
- Multidisciplinary collaboration.
- Adequate staffing and resource allocation.

Monitoring and Quality Improvement:

- Conduct periodic compliance audits.
- Provide performance feedback.
- Track infection rate indicators.
- Implement continuous quality improvement cycles.[15,16]

Challenges and barriers:

These guidelines align with global infection prevention standards and emphasize the practical responsibilities of nurses in reducing HAIs. Implementation may be challenging in resource-limited settings due to staffing shortages, high workloads, supply constraints,varying levels of nurse knowledge persist and training gaps. Practical adherence to all protocols remains a challenge, necessitating stronger training initiatives and better resource allocation in hospital settings. Institutional commitment and nurse empowerment are essential for sustained success.[17,18]

Conclusion: Hospital-acquired infections remain a significant but largely preventable threat to patient safety. Evidence shows that consistent implementation of structured infection-prevention practices substantially reduces infection burden and antimicrobial use. Nurses, as frontline healthcare providers, play a pivotal leadership role in translating policies into safe clinical practice through adherence to standard precautions, surveillance, early detection, patient education and antimicrobial stewardship support.[4,11]

Collaboration with interdisciplinary teams allows nurses to share insights and best practices for infection prevention, ensuring comprehensive strategies are in place. Furthermore, their engagement in continuing education empowers nurses to stay updated on

the latest evidence-based practices, thus enhancing their ability to combat Hospital-acquired infections.[14]

Strengthening nursing capacity in infection prevention is therefore essential not only for safeguarding patient outcomes but also for supporting rational antibiotic use and combating antimicrobial resistance.[2] Sustained institutional commitment to nursing-led infection-control strategies is fundamental to achieving safer healthcare environments.

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14. RATIONAL USE OF ANTIBIOTICS: NURSING PERSPECTIVE

Introduction: The use of Antibiotics has revolutionized modern medicine, significantly reducing morbidity and mortality from various diseases. The overuse and misuse have contributed to the alarming rise of antibiotic resistance to the global health threat.[1] The rational use of antibiotic is a critical aspect of patient care, infection control and a cornerstone of effective healthcare delivery. Nurses play a pivotal role in ensuring that antibiotics are used appropriately to prevent resistance, minimize adverse effects and promote optimal patient outcomes.

The rational use of antibiotics refers to prescribing and using antibiotics only when necessary, at the right dose, for the right direction and for the right indication.[2]

Nursing Roles in Promoting Rational Use of Antibiotics

1. Patient Assessment Before Antibiotic Administration

Nurses should conduct a thorough patient assessment before administering antibiotics. This includes evaluating signs and symptoms of infection such as fever, inflammation, discharge, and laboratory parameters like white blood cell count and culture results. Proper assessment helps ensure antibiotics are prescribed only when necessary.[3]

2. Collection of Culture and Sensitivity Specimens

Nurses should collect appropriate specimens such as blood, urine, sputum, or wound swabs before initiating antibiotic therapy whenever possible. This helps identify the causative organism and guides appropriate antibiotic selection.[4]

3. Verification of Antibiotic Orders

Before administering antibiotics, nurses should verify the prescription, confirm the correct medication, and review patient history for drug allergies or contraindications.[5]

4. Safe Administration of Antibiotics

Nurses must follow the principles of medication safety, including ten rights of medication administration:

* Right patient
* Right drug
* Right dose
* Right route
* Right time
* Right documentation
* Right education
* Right to refuse
* Right assessment
* Right evaluation[6]

5. Monitoring Therapeutic Response

After administering antibiotics, nurses should monitor the patient for improvement in symptoms, reduction in fever, and changes in laboratory results. Lack of improvement within 48-72 hours should be reported to the physician for reassessment.[3]

6. Monitoring for Adverse Drug Reactions

Nurses should observe patients for adverse effects such as allergic reactions, gastrointestinal disturbances, nephrotoxicity, and superinfections. Early detection and reporting help prevent severe complications.[7]

7. Participation in Antimicrobial Stewardship Programs

Nurses play a key role in antimicrobial stewardship by ensuring appropriate antibiotic administration, documenting therapy, and communicating patient responses to the healthcare team.[3]

8. Infection Prevention and Control

Effective infection prevention practices reduce the need for antibiotics and prevent the spread of resistant organisms. Nurses should practice strict hand hygiene, maintain aseptic technique, and follow isolation precautions.[8]

9. Patient and Family Education

Nurses should educate patients about proper antibiotic use, including completing the fullcourse, avoiding self-medication, and recognizing potential side effects. Educating patients, families and the broader community about the importance of appropriate use and adherence to prescribed regimens. Nurses provide training and guidance to other health care staff. Promoting awareness of antimicrobial resistances and stewardship principles.[9]

10. Documentation of Antibiotic Therapy

Accurate documentation should include the antibiotic name, dose, route, time of administration, patient response, and any adverse reactions. Proper documentation ensurescontinuity of care and supports antimicrobial stewardship efforts.[4]

11. Collaboration and Leadership

Effective Anti-Microbial Stewardship requires multidisciplinary collaboration and nurses act as mediators between physicians, pharmacists, microbiologists and others health care professionals. They co-ordinate care, ensure communication across teams and support the implementation of stewardship protocols.[10]

12. Research and Policy Contribution

Nurses contribute to research on antimicrobial use and resistance helping to generate evidence for rest practices in stewardship. It also influences institutional policy by advocating for safe antimicrobial practices and participating in guideline development regarding the rational use of antibiotics: Nursing perspectives.

Rational use of antibiotics is extremely important as injudicious use can adversely affect the patient, cause emergence of antibiotic resistance and increase the cost of health care.[10]

Conclusion: Nurses play an essential role in promoting the rational use of antibioticsby working in partnership with other healthcare professionals and it is found that nurses see stewardship as an extension to their role as the patient's advocate, the main administrator of antibiotics and their role at the bedside. Their role spans from assessment, administration, monitoring, patient education, infection control. Adhering to evidence-based practices, nurses can minimize antibiotic misuse, reduce resistance and improve patient outcomes by strengthening nursing involvement in antimicrobial stewardship programs.

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OFFICE OF THE MEDICAL SUPERINTENDENT
REGIONAL INSTITUTE OF MEDICAL SCIENCES HOSPITAL
(An autonomous Institute under the Ministry of Health & Family Welfare, Govt. of India)

O R D E R

Imphal, the 4th January, 2024.

No.46/RIMSH/HAICC/97 A Hospital Acquired Infection Control Committee RIMS Hospital, Imphal consisting of the following member is hereby re-constituted with immediate effect. They are consisting the following. This will supersede all the office orders in this regard.

1. Prof. N. Sanjib Singh, Medical Supdt. - Chairman
2. HOD Microbiology - Member Secretary
3. HOD/Surgery/Medicine/O&G/Ortho/Anaesthesiology Opthalmology/Paediatric/Community Medicine -Member
4. Prof. T. Jeetenkumar Singh, Member Secretary Anti Microbial Stewardship Program -Member
5. Dr. Shakti Laishram, Department of Microbiology -Member
6. Chief Nursing Officer - Member
7. H. Uma Devi, Asst. Nursing Supdt. - Member
8. H. Priyashini Devi, Senior Nursing Officer - Member
9. In-charge O.T/CSSD/Dietary Section/CRED/Laundry - Member
10. Mrs. M. Monica Chanu, Infection Control Nurse - Member
11. Mrs. Sobita ngangbam, Infection Control Nurse -Member
12. Biomedical Engineer - Member

Infection Control Team:

1. Dr. Y. Arunkumar Singh, Assistant Medical Supdt.
2. Dr. Shakti Laishram,Department of Microbiology
3. Dr. Jelina Laishram, Department of Com. Med.
4. One representative from Pharmacology Dept.
5. Dr. Nataraj Singh, Store in charge
6. Chief Nursing Officer
7. Biomedical Engineer
8. Consultant Civil
9. Mrs. M. Monica Chanu, Infection Control Nurse
10. Mrs. Sobita Ngangbam, Infection Control Nurse
11. Dietecian
12. In-charge O.T/CSSD/Laundry/CRED

(Prof. N. Sanjib Singh)
Medical Superintendent,
RIMS Hospital, Imphal.

Memo No.460/RIMSH/HICC/97: Imphal, the4th January, 2024.

Copy to:

1. The P.S. to Director for kind information of the Director RIMS, Imphal.
2. All concerned members.
3. Concerned file.

(Prof. N. Sanjib Singh)
Medical Superintendent,
RIMS Hospital, Imphal.

ACKNOWLEDGEMENTS AND DISCLAIMERS

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The policy is essentially suggestive in nature. The contents cannot be considered and claimed to be absolute and final. It is indeed, a work in progress and as such the contents are liable to be reviewed, as and when new information comes to light. The information provided is not intended or implied to be an outright substitute for professional/clinical decision. The contents are for general reference for the health care providers only. It is strongly suggested that one never disregard professional medical advice or delay seeking medical treatment because of something one has read on or accessed in this book. This work is not for medico-legal purpose.

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It is to mention that the NMC and MOHFW, GOI have issued directives to make it mandatory for every Medical College to develop Antibiotic Policy. We do sincerely hope and believe that this humble effort of ours would prove to be a valuable asset towards the concerted and collaborative initiatives against antibiotic resistance. This sincere effort has been guided by the relevance and in the larger interest of the propagation of Medical science.

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