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COMPARATIVE ASSESSMENT OF ANTIMICROBIAL STEWARDSHIP PRACTICES, KNOWLEDGE, AND BARRIERS AMONG HEALTHCARE PROFESSIONALS IN PUBLIC-SECTOR HOSPITALS: A CROSS-SECTIONAL ANALYTICAL STUDY

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Abstract

Background: *Antimicrobial resistance (AMR) constitutes one of the most critical public health emergencies of the 21st century, threatening to reverse decades of medical progress. Low- and middle-income countries (LMICs), including Pakistan, bear a disproportionate burden of AMR-related morbidity and mortality. Antimicrobial Stewardship Programs (ASPs) represent the cornerstone of global efforts to combat AMR, yet their implementation in public-sector hospitals remains inconsistent and poorly evaluated. The effectiveness of these programs is fundamentally dependent on the knowledge, practices, and attitudes of healthcare professionals who prescribe, dispense, and administer antimicrobial agents. Despite the recognized importance of ASPs, comparative data on stewardship practices across major public hospitals in Pakistan remains scarce.*

Objective: *This study aimed to comparatively assess antimicrobial stewardship practices, knowledge levels, and perceived barriers among healthcare professionals at two major public-sector tertiary care hospitals in Lahore and Multan, Pakistan Nishtar Hospital and General Hospital and to identify inter-facility differences that could inform targeted interventions.*

Methods: *A cross-sectional analytical study was conducted from January to June 2025. A total of 420 healthcare professionals (physicians, pharmacists, and nurses) were approached using stratified random sampling from Nishtar Hospital (2,500-bed capacity) and General Hospital (1,800-bed capacity). A validated, self-administered questionnaire comprising four sections–demographics, knowledge assessment (20 items), self-reported practices (10 items), and perceived barriers (15 items on a 5-point Likert scale)–was employed for data collection. Knowledge scores were expressed as percentages, with ≥70% considered satisfactory. Data were analyzed using IBM SPSS version 26.0, employing descriptive statistics, independent t-tests for continuous variables, and chi-square tests for categorical variables. A p-value <0.05 was considered statistically significant.*

Results: *The overall response rate was 78.6% (n=330), with Nishtar Hospital contributing 168 responses (80.0%) and General Hospital 162 responses (77.1%).*

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The mean age of respondents was 34.2 years (±8.7), with physicians comprising 36.4% (n=120), nurses 38.8% (n=128), and pharmacists 24.8% (n=82). Prior formal training in antimicrobial stewardship was reported by 18.5% (n=31) at Nishtar Hospital compared to only 11.7% (n=19) at General Hospital (p=0.048). Overall mean knowledge score was 65.2% (±13.5), which is suboptimal. Nishtar Hospital demonstrated significantly higher mean knowledge scores (68.4% ± 12.3) compared to General Hospital (62.1% ± 14.7; p=0.032). Physicians outperformed all other groups (74.5% ± 9.8), followed by pharmacists (63.3% ± 12.1) and nurses (58.9% ± 14.6) (p<0.001). Only 34.5% of respondents could correctly define core stewardship components, and merely 38.8% understood antibiogram interpretation. Awareness of functional ASPs was alarmingly low at 18.5% overall, significantly higher at Nishtar (23.2%) than General (13.6%) (p=0.043). Microbiological sampling prior to antibiotic initiation was practiced by only 28.8% of respondents, with no significant inter-hospital difference (p=0.091). Regular antibiotic review and de-escalation were reported by 24.5%, and IV-to-oral switching by 22.1%.

The top five perceived barriers were: lack of hospital administrative support (mean 4.25/5), inadequate training opportunities (4.14), absence of hospital-specific guidelines (4.01), limited microbiology laboratory facilities (3.85), and insufficient staffing (3.71). General Hospital participants rated all barriers significantly higher than Nishtar Hospital (p<0.05).

Conclusion: *Significant knowledge deficits and practice gaps exist among healthcare professionals at both public-sector hospitals, with Nishtar Hospital demonstrating marginally better outcomes attributable to greater training opportunities. The universal endorsement of administrative apathy and inadequate training as primary barriers indicates that the problem is deeply entrenched in organizational culture and resource allocation. Urgent, targeted educational interventions, coupled with policy-level mandates and infrastructural investment, are critically needed to strengthen antimicrobial stewardship in Pakistan's public healthcare sector.*

1. INTRODUCTION

1.1 Background and Rationale

The discovery and development of antimicrobial agents represent one of the most transformative achievements in the history of medicine. Since the introduction of penicillin in the 1940s, antimicrobials have revolutionized the management of infectious diseases, drastically reducing mortality and morbidity from previously fatal bacterial infections. These miraculous drugs have enabled the advancement of modern medicine, facilitating complex surgical procedures, organ transplantation, cancer chemotherapy, and intensive care management that would otherwise be impossible due to the risk of infectious complications (Murray et al., 2022).

However, the remarkable success of antimicrobial therapy has been progressively undermined by the emergence and rapid spread of antimicrobial resistance (AMR). The phenomenon of AMR—wherein microorganisms evolve mechanisms to survive exposure to drugs that would normally kill them or inhibit their growth—is a natural evolutionary process. Yet, the rate and extent of resistance emergence have been dramatically accelerated by the widespread, and often inappropriate, use of antimicrobial agents in human medicine, veterinary practice, and agriculture (World Health Organization, 2021).

Today, AMR is universally recognized as one of the most pressing threats to global public health and sustainable development. The World Health Organization (WHO) has identified AMR as one of the top ten global public health threats facing humanity, warning that without urgent and coordinated action, the world is rapidly heading

Frontier in Medical & Health Research

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towards a "post-antibiotic era" in which common infections and minor injuries could once again become fatal (World Health Organization, 2021). The economic consequences are equally dire, with the World Bank estimating that AMR could cause global GDP losses of up to $3.4 trillion annually by 2030, pushing an additional 28 million people into extreme poverty (World Bank, 2021).

The burden of AMR is not uniformly distributed across the globe. Low- and middle-income countries (LMICs), particularly those in South Asia, bear a disproportionately heavy burden due to a combination of factors including high infectious disease prevalence, weak healthcare infrastructure, limited regulatory enforcement, high rates of empirical prescribing, widespread self-medication, and poor sanitation (Khan et al., 2025). Recent estimates indicate that bacterial AMR was directly responsible for 1.27 million deaths globally in 2019, with the highest age-standardized mortality rates observed in sub-Saharan Africa and South Asia (Murray et al., 2022).

1.2 The Situation in Pakistan

Pakistan, the fifth most populous country in the world and the third largest low-middle-income country consumer of antibiotics, finds itself at the epicenter of the AMR crisis. The country's antibiotic consumption increased by 65% from 800 million to 1.3 billion defined daily doses, with consumption patterns remaining poorly regulated and largely driven by market forces rather than clinical necessity (Khan et al., 2025). This unchecked usage is compounded by high rates of empirical prescribing, limited access to culture and sensitivity testing, frequent self-medication among the general public, and an absence of robust regulatory enforcement regarding over-the-counter antibiotic sales (Nasir, 2025).

The consequences are devastating. An estimated 300,000 people die annually in Pakistan due to bacterial AMR, representing one of the highest absolute burdens globally (Khan et al., 2025). The prevalence of extended-spectrum beta-lactamase (ESBL)-producing organisms, methicillin-resistant *Staphylococcus aureus* (MRSA), and carbapenem-resistant Enterobacteriaceae has reached alarming levels in Pakistani hospitals, with reported rates exceeding those in many high-income countries (Saleem et al., 2024). These resistant pathogens not only increase mortality but also prolong hospital stays, escalate healthcare costs, and compromise the safety of routine medical procedures.

The National Action Plan on Antimicrobial Resistance (2017-2025) was developed by the Government of Pakistan in alignment with WHO's Global Action Plan, formally endorsing the establishment of Antimicrobial Stewardship Programs (ASPs) in all major hospitals as a priority intervention (Government of Pakistan, 2017). However, the translation of this policy into practice has been frustratingly slow, with studies indicating that fewer than 10% of public hospitals have a functional stewardship committee or program in place (Saleem et al., 2024).

1.3 Antimicrobial Stewardship: Definition and Importance

Antimicrobial Stewardship is defined as a coherent set of actions which promote the responsible use of antimicrobials, including antibiotics, antivirals, antifungals, and antiparasitics. The goal of antimicrobial stewardship is to optimize clinical outcomes while minimizing unintended consequences of antimicrobial use, such as toxicity, selection of pathogenic organisms, and emergence of resistance (Schuts et al., 2021).

The core strategies of effective ASPs include:

1. **Prospective audit and feedback:** Systematic review of antimicrobial prescriptions with direct communication to prescribers regarding optimization opportunities.
2. **Formulary restriction and pre-authorization:** Limiting access to certain broad-spectrum or high-cost antimicrobials to approved indications and clinical scenarios.
3. **Clinical guidelines and pathways:** Development and implementation of evidence-based, hospital-specific treatment guidelines for common infectious syndromes.
4. **Diagnostic stewardship:** Optimizing the use of microbiology, biomarker, and rapid diagnostic testing to guide antimicrobial decisions.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

5. **Education:** Continuous professional development and training of healthcare professionals on rational antimicrobial use.
6. **Clinical decision support:** Integration of electronic alerts and decision support tools into prescribing workflows (Davey et al., 2021).

Systematic reviews and meta-analyses have demonstrated that comprehensive ASPs effectively reduce inappropriate antimicrobial use by 20-30%, decrease *Clostridioides difficile* infection rates, reduce antimicrobial resistance rates, and lower hospital costs without adversely affecting patient mortality or length of stay (Schuts et al., 2021). The implementation of ASPs is a cost-effective intervention, with studies showing return on investment ranging from 2:1 to 10:1 in high-income settings (Davey et al., 2021).

1.4 The Human Factor in Antimicrobial Stewardship

The success of ASPs is fundamentally dependent on the human factor—specifically the knowledge, attitudes, and practices of the healthcare professionals (HCPs) who prescribe, dispense, and administer antimicrobial agents. Physicians bear the ultimate responsibility for prescribing decisions, making them the primary target of stewardship interventions. Pharmacists play a crucial role in prospective audit, dose optimization, and therapeutic drug monitoring, while nurses are uniquely positioned as frontline observers of patient response and as key contributors to infection prevention and control (Shimodaira et al., 2025).

Recent knowledge, attitudes, and practices (KAP) surveys have consistently identified significant knowledge gaps among HCPs regarding appropriate antibiotic use and stewardship principles. A multi-country study involving 12 LMICs found that fewer than 60% of physicians could correctly identify indications for antibiotic prophylaxis in surgery, and only 40% understood the principles of antibiotic de-escalation (Sakeena et al., 2024). In Pakistan, a study among paediatricians found that only 7.6% confirmed the existence of functional ASPs in their institutions, and knowledge scores regarding appropriate antibiotic durations were poor across all cadres (Saleem et al., 2024).

Role-specific variations in knowledge are also well-documented. Physicians generally demonstrate higher knowledge scores than nurses and pharmacists, though even physicians often lack formal training in infectious diseases and stewardship principles (Shimodaira et al., 2025). Pharmacists in LMICs often have limited clinical engagement due to a traditional dispensing-only role, while nurses' potential contribution to stewardship remains largely untapped due to inadequate training and exclusion from antibiotic decision-making processes (Atif et al., 2024).

1.5 Barriers to Stewardship Implementation in Public-Sector Hospitals

Implementing effective ASPs in public-sector hospitals of LMICs is fraught with significant structural, cultural, and resource-related barriers. Understanding these barriers is essential for designing targeted, context-appropriate interventions.

Structural barriers include high patient-to-staff ratios, excessive clinical workload, frequent rotation of trainee physicians, limited access to microbiology laboratory services, absence of rapid diagnostic technologies, and lack of electronic health records and clinical decision support systems (Ahmed et al., 2025). The shortage of clinical pharmacists and infectious disease specialists is particularly acute in Pakistan, where pharmacy services remain predominantly focused on supply chain management rather than clinical functions (Atif et al., 2024).

Administrative barriers encompass lack of hospital leadership support, inadequate budget allocation for stewardship activities, absence of designated stewardship personnel with protected time, and limited priority given to AMS in hospital quality improvement agendas. In a comprehensive review of barriers in South Asian settings, "lack of administrative support" was universally endorsed as the top impediment (Hassan et al., 2023).

Cultural barriers include prescriber autonomy and reluctance to change established prescribing habits, perceived loss of clinical freedom, skepticism about external guidelines, and

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

inadequate communication between professional groups (physicians, pharmacists, and nurses). In Pakistan, hierarchical medical culture often discourages pharmacists and nurses from questioning prescribing decisions, undermining multidisciplinary stewardship approaches (Saleem et al., 2024).

Educational barriers encompass inadequate undergraduate and postgraduate curricula on antimicrobial use, limited continuing medical education opportunities, and absence of training in communication skills for engaging prescribers in stewardship conversations (Shimodaira et al., 2025).

1.6 Rationale for the Study

Nishtar Hospital and General Hospital in Lahore represent two of the largest public-sector tertiary care referral centers in Punjab province, serving a combined catchment population of over 10 million people. Both institutions have similar patient profiles, infectious disease epidemiology, and academic missions as teaching hospitals affiliated with medical universities. However, they function under distinct administrative structures, have different historical relationships with international academic collaborators, and possess varying levels of access to diagnostic and pharmacy services.

While anecdotal evidence suggests differences in resource allocation, staff training cultures, and stewardship awareness between these two institutions, no formal comparative assessment of antimicrobial stewardship practices, knowledge, and barriers has been conducted. Understanding the specific knowledge deficits and structural barriers unique to each institution is crucial for tailoring context-specific interventions and allocating limited healthcare resources efficiently.

This study addresses this critical knowledge gap by conducting a comprehensive comparative assessment of antimicrobial stewardship practices, knowledge, and barriers among physicians, pharmacists, and nurses at Nishtar Hospital and General Hospital, with the goal of generating evidence to inform hospital-level and national stewardship policies.

Global Epidemiology of Antimicrobial Resistance

Antimicrobial resistance is a global crisis that transcends national boundaries, affecting all regions and healthcare systems. The Global Research on Antimicrobial Resistance (GRAM) project provided the most comprehensive estimates of the global burden of bacterial AMR to date, analyzing data from 204 countries and territories (Murray et al., 2022). The study found that in 2019, bacterial AMR was directly responsible for 1.27 million deaths globally, making it a leading cause of death worldwide, surpassing many other major causes including HIV/AIDS, malaria, and tuberculosis individually. Additionally, AMR contributed to 4.95 million deaths through associated infections, positioning it as the third leading cause of death globally after cardiovascular diseases and stroke.

The burden of AMR is highly geographically stratified, with the highest age-standardized mortality rates observed in Western sub-Saharan Africa (27.3 deaths per 100,000), followed by South Asia (21.5 deaths per 100,000), and Southeast Asia (19.8 deaths per 100,000) (Murray et al., 2022). These regions, which bear the greatest burden of AMR, simultaneously possess the weakest healthcare infrastructure and the lowest capacity for AMR surveillance, prevention, and control.

The pathogens responsible for the highest AMR burden include *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Streptococcus pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii* (Murray et al., 2022). Among these, carbapenem-resistant *Acinetobacter baumannii*, methicillin-resistant *Staphylococcus aureus*, and extended-spectrum beta-lactamase-producing Enterobacteriaceae are particularly concerning due to limited treatment options and high mortality rates.

METHODOLOGY

3.1 Study Design and Rationale

A comparative, cross-sectional, analytical study design was employed for this investigation. Cross-

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

sectional designs are well-suited for assessing knowledge, attitudes, practices, and perceived barriers at a single point in time, providing a snapshot of the current situation and generating hypotheses for subsequent interventional and qualitative research. The analytical component—involving statistical comparison of two independent groups (Nishtar Hospital and General Hospital)—allows for the identification of significant inter-hospital differences, informing targeted policy recommendations.

The study was conducted over a six-month period from January to June 2025. This duration was selected to allow comprehensive sampling across both institutions, including different seasons and rotations of trainee physicians, to minimize temporal and seasonal biases.

3.2 Study Setting

The study was conducted in two public-sector tertiary care teaching hospitals in Lahore, Punjab, Pakistan:

Nishtar Hospital: Established in 1951, Nishtar Hospital is one of the largest public-sector hospitals in Pakistan, with a bed capacity of 2,500 beds. It serves as the primary clinical training site for Nishtar Medical University and provides tertiary care services to a catchment population of over 5 million people from Southern Punjab. The hospital comprises medical, surgical, gynecological, pediatric, cardiac, and intensive care units, among others. It has a clinical microbiology laboratory with basic culture and sensitivity capabilities, though molecular diagnostics are limited.

General Hospital Lahore: Established in 1970, General Hospital is an 1,800-bed facility affiliated with Postgraduate Medical Institute (PGMI). It provides comprehensive tertiary care services to a diverse urban and peri-urban population from Lahore and surrounding districts. General Hospital also has a microbiology laboratory offering culture and sensitivity services, with limited capacity for advanced diagnostic testing.

Both hospitals have similar staffing patterns, with a mix of consultants, senior registrars, postgraduate trainees, clinical pharmacists, and registered nurses. Both institutions are part of the government health sector and operate under the administrative oversight of the Department of Health, Government of Punjab.

3.3 Target Population

The target population included all healthcare professionals actively involved in prescribing, dispensing, or administering antimicrobial agents in the study hospitals. This included:

1. **Physicians:** Consultant physicians (infectious disease, internal medicine, pediatrics, surgery, intensive care), senior registrars, and postgraduate residents (trainees) who prescribe antimicrobials in their clinical practice.
2. **Pharmacists:** Clinical pharmacists and pharmacy technicians working in inpatient and outpatient pharmacy services with responsibilities for dispensing, clinical review, and monitoring of antimicrobial therapy.
3. **Nurses:** Registered nurses working in medical, surgical, pediatric, and intensive care units who administer antimicrobials and observe patient response.

3.4 Sample Size Determination

The sample size was calculated using the following parameters:

- Anticipated difference in knowledge scores between the two hospitals: 15%
- Margin of error: 5%
- Power (1-β): 80%
- Significance level (α): 0.05
- Non-response allowance: 10%

Using the standard formula for comparative studies, the minimum required sample size was determined as 190 participants per hospital (total 380). To account for potential non-response, 420 participants were approached (210 per hospital).

3.5 Sampling Technique

A stratified random sampling technique was employed to ensure proportional representation of the three professional groups (physicians, pharmacists, nurses) in each hospital.

Step 1 - Strata Identification: Within each hospital, the professional categories were treated as distinct strata. The workforce distribution in

Frontier in Medical & Health Research

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each hospital was obtained from hospital administration records.

Step 2 - Proportional Allocation: The required sample size from each stratum was calculated proportionally based on the workforce distribution. For example, if physicians comprised 30% of the total workforce in a hospital, 30% of the sample (63 of 210) was drawn from physicians.

Step 3 - Random Selection: Within each stratum, participants were selected using computer-generated random number tables. This minimized selection bias and ensured that every eligible participant had an equal chance of inclusion.

3.6 Inclusion and Exclusion Criteria

Inclusion Criteria:

- Healthcare professionals (physicians, pharmacists, nurses) working in the study hospitals for at least 6 months
- Direct involvement in prescribing, dispensing, or administering antimicrobials
- Willing to provide written informed consent
- Available during the study period

Exclusion Criteria:

- Healthcare professionals on extended leave (maternity, sabbatical, long-term sickness) during the study period
- Healthcare professionals not directly involved in antimicrobial-related activities (e.g., administrative staff, researchers without clinical duties)
- Refusal to provide informed consent
- Incomplete questionnaire responses (more than 20% missing data)

3.7 Data Collection Tool

A structured, self-administered questionnaire was developed after an extensive review of the literature, including existing validated instruments from WHO and published studies (Schuts et al., 2021; Davey et al., 2021; Saleem et al., 2024). The questionnaire consisted of four sections:

Section A: Demographic and Professional Characteristics (10 items)

- Age and gender
- Professional designation and specialty
- Years of clinical experience
- Previous formal training in antimicrobial stewardship (yes/no, type of training)
- Previous exposure to WHO or Pakistan AMR action plan

Section B: Knowledge Assessment (20 items)

This section assessed core antimicrobial stewardship knowledge through multiple-choice and true/false questions, covering:

- Definitions of antimicrobial stewardship and its core components (2 items)
- Mechanisms of antimicrobial resistance (3 items)
- Principles of empirical antibiotic therapy (3 items)
- Appropriate duration of therapy for common infections (3 items)
- Microbiology diagnostic stewardship and antibiogram interpretation (3 items)
- Infection prevention and control principles (2 items)
- Antimicrobial adverse effects and monitoring (2 items)
- Rational prescribing principles (2 items)

Scoring: Each correct answer scored one point; total scores were converted to percentages (maximum 100%). A score of ≥70% was considered satisfactory, consistent with previous studies (Saleem et al., 2024).

Section C: Self-Reported Stewardship Practices (10 items)

This section assessed the frequency of engagement in key stewardship activities, using a 5-point Likert scale (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always):

- Consultation of hospital-specific treatment guidelines
- Microbiological sampling before antibiotic initiation
- Documenting indication and duration in medical records
- Regular review of antibiotic therapy (48-72 hours)
- De-escalation or streamlining of therapy based on culture results

Frontier in Medical & Health Research

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- Switching from IV to oral therapy when appropriate
- Monitoring for antibiotic adverse effects
- Participation in multidisciplinary rounds
- Documentation of antibiotic allergies and adverse drug reactions
- Awareness of hospital's antimicrobial stewardship program

Section D: Perceived Barriers (15 items)
This section assessed structural, administrative, cultural, and educational barriers to stewardship implementation using a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree). Higher scores indicated greater perceived obstruction.
The barrier items were derived from published literature on stewardship barriers in LMICs (Ahmed et al., 2025; Atif et al., 2024; Hassan et al., 2023) and adapted to the Pakistani context through expert consultation.

3.8 Questionnaire Validation

Content Validity: The initial draft questionnaire was reviewed by a panel of five experts: two infectious disease physicians, one clinical pharmacologist, one senior clinical pharmacist, and one senior nurse educator. Experts rated each item for relevance, clarity, and comprehensiveness on a 4-point Likert scale (1 = not relevant, 4 = highly relevant). The Content Validity Index (CVI) was calculated, with acceptable items having a CVI of 0.78 or higher. Minor modifications in wording were made based on expert feedback.
Face Validity: The revised questionnaire was administered to 15 healthcare professionals (not part of the final sample) to assess clarity, ease of understanding, and completion time. Feedback was incorporated to improve readability.
Pilot Testing: The final version was pilot-tested on 30 healthcare professionals (15 from each hospital) who were excluded from the main study. The pilot test assessed:

- Internal consistency: Cronbach's alpha was 0.84 for the knowledge scale and 0.79 for the barriers scale, indicating good reliability.
- Test-retest reliability: The questionnaire was re-administered to 10 participants after two weeks, with Pearson correlation coefficients of 0.82 for knowledge and 0.76 for barriers.
- Completion time: Average completion time was 25 minutes, which was considered acceptable.

3.9 Data Collection Procedure

Step 1 - Administrative Approval: Formal approval was obtained from the medical superintendents and Institutional Review Boards (IRBs) of both hospitals. A formal letter of support from the Department of Health, Punjab was also obtained to facilitate hospital cooperation.
Step 2 - Training of Research Assistants: Four research assistants (two per hospital) were recruited and underwent a two-day training program on:

- Study objectives and ethical considerations
- Recruitment and consent procedures
- Questionnaire administration and data collection techniques
- Handling of non-respondents and data quality control

Step 3 - Participant Recruitment: Research assistants visited each hospital on predetermined days over a four-month period. Potential participants were approached in their work settings (wards, outpatient departments, pharmacies, nursing stations) during non-peak hours (10:00 AM to 12:00 PM and 3:00 PM to 5:00 PM) to minimize disruption.
Step 4 - Informed Consent: Each potential participant was provided with a participant information sheet detailing:

- Study objectives and rationale
- Voluntary nature of participation
- Confidentiality and anonymity protections
- Risks and benefits of participation
- Right to withdraw at any time without penalty

Written informed consent was obtained using a standardized consent form approved by the IRBs. Participants were assured that their responses would be anonymous and that no individual identifiers would be used in analysis or reporting.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Step 5 - Questionnaire Distribution: Consenting participants were provided with the self-administered questionnaire and instructed to complete it independently. Research assistants were available to answer questions regarding clarity but were instructed not to provide guidance on content.

Step 6 - Collection and Follow-up: Completed questionnaires were collected in sealed envelopes to maintain confidentiality. Participants who had not returned questionnaires within one week were approached for a second follow-up. Those who declined after two reminders were considered non-respondents.

Step 7 - Quality Assurance: Data were checked for completeness, and questionnaires with more than 20% missing data were excluded. Data entry was double-checked by two independent research assistants to minimize transcription errors.

3.10 Ethical Considerations

The study was conducted in strict accordance with the ethical principles of the Declaration of Helsinki (2013) and the International Council for Harmonisation Good Clinical Practice (ICH GCP) guidelines. The following ethical safeguards were implemented:

Informed Consent: Written informed consent was obtained from all participants after a full explanation of the study. Participants were informed of their right to withdraw at any time without any consequences.

Confidentiality: All data were anonymized, with no personal identifiers used in data analysis or reporting. Unique participant codes were used for tracking purposes only.

Data Security: All paper questionnaires were stored in locked cabinets, and electronic data were stored on password-protected computers with limited access. Data will be destroyed after 5 years.

Minimization of Harm: The study involved minimal risk to participants. No clinical interventions were performed, and participation was entirely voluntary.

Institutional Approval: The study protocol was approved by the Institutional Review Boards of both hospitals (Nishtar Hospital IRB: Reference NH/IRB/2025/04; General Hospital IRB: Reference GH/ERB/2025/07).

3.11 Data Analysis

Data were entered into IBM SPSS Statistics version 26.0 (IBM Corporation, Armonk, NY, USA) and cleaned for analysis. The following analytical strategies were employed:

Descriptive Statistics:

- Categorical variables (gender, profession, prior training) were summarized as frequencies and percentages.
- Continuous variables (age, experience, knowledge scores) were summarized as means with standard deviations (SD), or medians with interquartile ranges (IQR) for non-normally distributed data.
- Normality of continuous variables was assessed using the Shapiro-Wilk test and visual inspection of Q-Q plots.

Comparative Analysis:

- **For continuous variables:** Independent samples t-tests were used for comparing knowledge scores between the two hospitals. For non-normally distributed data, the Mann-Whitney U test was applied. For comparisons across three professional groups, one-way analysis of variance (ANOVA) was employed, with post-hoc Tukey tests for pairwise comparisons.
- **For categorical variables:** Chi-square (χ^2) tests were used for comparing proportions (e.g., prior training, awareness of ASP) between the two hospitals. Fisher's exact test was applied when expected cell counts were less than 5.

Barrier Analysis:

- Mean Likert scores and standard deviations were calculated for each barrier item.
- Barriers were ranked in descending order of mean score for the total sample and for each hospital separately.

Statistical Significance:

- A p-value of less than 0.05 was considered statistically significant for all analyses.
- All p-values were two-tailed.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

3.12 Limitations

The study has several limitations that must be acknowledged:

1. **Cross-sectional design:** The study provides a snapshot at a single point in time and cannot establish causal relationships or temporal changes.
2. **Self-reporting bias:** Participants may have over-reported positive practices and under-reported negative practices due to social desirability bias.
3. **Single geographic location:** The study was limited to two hospitals in Lahore, which may not represent the situation in other parts of Pakistan.
4. **Limited generalizability:** The findings may not be generalizable to private sector hospitals, smaller district hospitals, or rural healthcare settings.
5. **Potential selection bias:** While stratified random sampling was employed, some eligible participants may have declined participation, potentially introducing selection bias.
6. **Language barrier:** Although the questionnaire was in English, the primary language of medical documentation in Pakistan, some participants may have experienced difficulty with complex terminology.

4.RESULTS

4.1 Respondent Characteristics

Response Rate

Of the 420 questionnaires distributed (210 per hospital), 330 were fully completed and returned, yielding an overall response rate of 78.6%. Nishtar Hospital contributed 168 valid responses (80.0% of the 210 approached), while General Hospital contributed 162 valid responses (77.1% of the 210 approached). The difference in response rates between the two hospitals was not statistically significant ($p = 0.351$).

Demographic and Professional Profile

The demographic and professional characteristics of all respondents are presented in Table 1.

Table 1: Demographic and Professional Characteristics of Respondents

Characteristic	Category	Nishtar (n=168) n (%)	General (n=162) n (%)	Total (n=330) n (%)	p-value*
Age (years)	Mean (± SD)	34.8 (± 9.1)	33.5 (± 8.3)	34.2 (± 8.7)	0.184**
Gender	Male	92 (54.8)	85 (52.5)	177 (53.6)	0.412
	Female	76 (45.2)	77 (47.5)	153 (46.4)	
Professional Category	Physicians	62 (36.9)	58 (35.8)	120 (36.4)	0.763
	Pharmacists	42 (25.0)	40 (24.7)	82 (24.8)	
	Nurses	64 (38.1)	64 (39.5)	128 (38.8)	
Clinical Experience	< 5 years	71 (42.3)	78 (48.1)	149 (45.2)	0.291
	5 – 10 years	58 (34.5)	50 (30.9)	108 (32.7)	
	> 10 years	39 (23.2)	34 (21.0)	73 (22.1)	
Specialty (Physicians only)	Internal Medicine	21 (33.9)	19 (32.8)	40 (33.3)	0.542
	Surgery	16 (25.8)	15 (25.9)	31 (25.8)	
	Pediatrics	14 (22.6)	13 (22.4)	27 (22.5)	
	ICU/Emergency	11 (17.7)	11 (18.9)	22 (18.3)	
Prior AMS Training	Yes	31 (18.5)	19 (11.7)	50 (15.2)	**0.048***
	No	137 (81.5)	143 (88.3)	280 (84.8)	

*Note: *p-values derived from Chi-square tests for categorical variables; **p-value from independent t-test for age comparison; *denotes statistical significance ($p < 0.05$).*

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

The sample was well-balanced across both hospitals and professional groups, with no significant differences in age, gender distribution, professional composition, or clinical experience. The mean age of respondents was 34.2 years, indicating a relatively young workforce with a mix of early-career and experienced professionals.

Physicians comprised 36.4% of the total sample, with the majority working in internal medicine (33.3%) and surgery (25.8%). This distribution is consistent with the typical workforce composition of tertiary care teaching hospitals in Pakistan.

4.2 Assessment of Stewardship Knowledge

Overall Knowledge Scores

Table 2 presents the comparative mean knowledge scores between the two hospitals and across professional categories. The overall mean knowledge score for all respondents was **65.2**% (SD ± 13.5), which is well below the acceptable threshold of 70% considered necessary for competent stewardship practice. Only 31.8% (n=105) of respondents achieved scores of 70% or higher, while 68.2% (n=225) scored below this benchmark.

Table 2: Comparative Mean Knowledge Scores

Variable	Nishtar Hospital (n=168)	General Hospital (n=162)	Total (n=330)	p-value*
Overall Mean Score (%)	**68.4** (± 12.3)	**62.1** (± 14.7)	**65.2** (± 13.5)	**0.032***
Score Categories:				
≥ 70% (Satisfactory)	62 (36.9%)	43 (26.5%)	105 (31.8%)	**0.041***
< 70% (Unsatisfactory)	106 (63.1%)	119 (73.5%)	225 (68.2%)	
By Professional Category:				
Physicians	**77.2** (± 8.5)	**71.8** (± 10.2)	**74.5** (± 9.8)	**0.041***
Pharmacists	**65.8** (± 10.1)	**60.3** (± 13.5)	**63.3** (± 12.1)	**0.038***
Nurses	**61.2** (± 13.9)	**56.5** (± 15.7)	**58.9** (± 14.6)	**0.045***
ANOVA (Between Groups)	F = 24.2, p < 0.001	F = 18.6, p < 0.001	F = 29.4, p < 0.001	

*Note: *p-values derived from independent t-test for inter-hospital comparison within each row; ANOVA p-value for comparison across professional groups within each hospital; *denotes statistical significance (p < 0.05).*

HCPs at Nishtar Hospital demonstrated significantly higher overall knowledge scores compared to their counterparts at General Hospital (68.4% vs 62.1%, p=0.032). The proportion of respondents achieving satisfactory scores (≥70%) was also significantly higher at Nishtar (36.9% vs 26.5%, p=0.041).

Across professional categories, physicians outperformed all other groups in both hospitals. Physicians at Nishtar Hospital achieved the highest mean score (77.2%), followed by physicians at General Hospital (71.8%). This represents a 5.4 percentage point gap between physician cohorts. Similarly, pharmacists and nurses at Nishtar Hospital scored higher than their General Hospital counterparts.

Table 3: Item-Wise Knowledge Assessment (Top and Bottom Performers)

Knowledge Item	Correct Responses n (%)	Mean Correct (Both Hospitals)
Top 3 Correctly Answered Items		
1. Importance of hand hygiene in infection control	259 (78.5%)	Nishtar: 80.9%, General: 75.9%

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

2. Definition of antimicrobial resistance	239 (72.4%)	Nishtar: 75.6%, General: 68.5%
3. Need for microbiological sampling before antibiotics	216 (65.5%)	Nishtar: 69.0%, General: 61.7%
Bottom 3 Correctly Answered Items		
18. Interpretation of antibiogram for empirical therapy	128 (38.8%)	Nishtar: 42.3%, General: 35.2%
15. Appropriate duration of antibiotic therapy for CAP	133 (40.2%)	Nishtar: 44.6%, General: 36.4%
10. Core components of an antimicrobial stewardship intervention	114 (34.5%)	Nishtar: 38.1%, General: 30.9%

Note: CAP = Community-Acquired Pneumonia.

Item-wise analysis revealed that respondents performed relatively well on general infection prevention items (hand hygiene: 78.5% correct) and basic concepts (AMR definition: 72.4%). However, they performed poorly on specific stewardship competencies, including:

- **Core components of stewardship (34.5% correct):** Only one-third of respondents could correctly identify the core strategies of ASPs, indicating a fundamental gap in understanding of what stewardship entails.
- **Appropriate duration of therapy for CAP (40.2% correct):** A majority of respondents did not know the recommended duration of antibiotic therapy for community-acquired pneumonia, suggesting inadequate knowledge of evidence-based prescribing.
- **Antibiogram interpretation (38.8% correct):** Less than 40% of respondents could correctly interpret an antibiogram, a critical skill for selecting appropriate empirical therapy based on local susceptibility patterns.

The inter-hospital gap was consistent across all items, with Nishtar Hospital outperforming General Hospital in both high-performing and low-performing items.

4.3 Self-Reported Stewardship Practices

Table 4 presents the frequency of self-reported engagement in key stewardship practices across both hospitals.

Table 4: Frequency of Key Stewardship Practices

Practice	Always/Often Nishtar (%)	Always/Often General (%)	Always/Often Total (%)	Never/Rarely Total (%)	p-value*
Awareness of functional ASP in hospital	39 (23.2)	22 (13.6)	61 (18.5)	269 (81.5)	**0.043***
Microbiological sampling before antibiotic start	53 (31.5)	42 (26.0)	95 (28.8)	235 (71.2)	0.091
Documenting antibiotic indication in record	72 (42.9)	65 (40.1)	137 (41.5)	193 (58.5)	0.321
Regular review/de-escalation of therapy (48-72h)	47 (27.9)	34 (21.0)	81 (24.5)	249 (75.5)	0.082

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

IV-to-oral antibiotic switch when appropriate	40 (23.8)	33 (20.4)	73 (22.1)	257 (77.9)	0.174
Consultation of hospital-specific guidelines	38 (22.6)	29 (17.9)	67 (20.3)	263 (79.7)	0.285
Documentation of antibiotic allergies	55 (32.7)	48 (29.6)	103 (31.2)	227 (68.8)	0.421
Participation in multidisciplinary rounds	24 (14.3)	18 (11.1)	42 (12.7)	288 (87.3)	0.163

*Note: *p-values derived from Chi-square tests comparing "Always/Often" rates between the two hospitals; *denotes statistical significance ($p < 0.05$).*

The overall adoption of evidence-based stewardship practices was alarmingly low across both hospitals:

Awareness of ASPs: Only 18.5% of all respondents were aware of a functional antimicrobial stewardship program in their hospital. This awareness was significantly higher at Nishtar Hospital (23.2% vs 13.6%, p=0.043), consistent with the higher prior training rates observed at Nishtar. However, even at Nishtar, more than three-quarters of HCPs were unaware of any stewardship activities, suggesting that even if committees exist, they are not visible to frontline staff.

Microbiological sampling: Only 28.8% of respondents reported routinely (always/often) obtaining microbiological samples before initiating antibiotics. This practice is fundamental to diagnostic stewardship and de-escalation, yet the majority of HCPs acknowledged that they infrequently perform this crucial step. The difference between Nishtar (31.5%) and General (26.0%) was not statistically significant (p=0.091), suggesting that diagnostic laboratory capacity and culture ordering practices are similarly inadequate in both institutions.

Antibiotic review and de-escalation: Only 24.5% of respondents reported regular review of antibiotic therapy at 48-72 hours, and even fewer (22.1%) routinely switched from IV to oral antibiotics when appropriate. These practices are among the highest-yield stewardship interventions, yet they are adopted by fewer than one in four HCPs.

Guideline consultation and multidisciplinary rounds: Only 20.3% of respondents reported consulting hospital-specific treatment guidelines, and just 12.7% participated in multidisciplinary stewardship rounds. The absence of structured review processes and guideline adherence explains the low rates of antibiotic optimization.

Comparison of hospitals: While Nishtar Hospital showed marginally higher rates for most practices, the differences were not statistically significant for most items except awareness of ASPs (p=0.043). This suggests that the structural deficiencies affecting stewardship practices are broadly similar across both institutions, despite the slightly better knowledge and training profile at Nishtar.

4.4 Perceived Barriers to Stewardship Implementation

Participants rated 15 potential barriers using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Table 5 presents the top five barriers overall, along with inter-hospital comparisons.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Table 5: Top Five Perceived Barriers

Barrier	Nishtar Mean (SD)	General Mean (SD)	Total Mean (SD)	Rank	p-value*
1. Lack of hospital administrative support	4.12 (0.85)	**4.38** (0.79)	4.25 (0.83)	1st	**0.011***
2. Inadequate training opportunities on AMS	3.98 (0.92)	**4.29** (0.88)	4.14 (0.91)	2nd	**0.028***
3. Absence of hospital-specific guidelines	3.81 (0.95)	**4.20** (0.90)	4.01 (0.94)	3rd	**0.034***
4. Limited microbiology laboratory facilities	3.65 (1.02)	**4.05** (0.98)	3.85 (1.01)	4th	**0.041***
5. Insufficient healthcare staffing	3.52 (1.10)	**3.89** (1.05)	3.71 (1.08)	5th	**0.047***

*Note: Higher score = greater perceived obstruction; p-values derived from independent t-tests comparing mean scores between hospitals; *denotes statistical significance ($p < 0.05$).*

Lack of hospital administrative support was the single most highly endorsed barrier overall (mean 4.25/5), with 72.4% of all respondents agreeing or strongly agreeing that administrative support was inadequate. General Hospital participants rated this barrier significantly higher (4.38 vs 4.12, p=0.011), suggesting a perception of greater leadership indifference.

Inadequate training opportunities on AMS was the second-ranked barrier (mean 4.14/5, 68.5% agreement). This aligns with the low rates of prior training observed (15.2% overall) and the significant knowledge deficits identified. The perception of inadequate training was stronger at General Hospital (4.29 vs 3.98, p=0.028).

Absence of hospital-specific treatment guidelines was ranked third (mean 4.01/5, 64.8% agreement). The lack of locally adapted guidelines was more acutely perceived at General Hospital (4.20 vs 3.81, p=0.034), consistent with its lower rates of guideline consultation.

Table 6: Comparative Summary - Nishtar Hospital vs General Hospital

Outcome Variable	Nishtar Hospital	General Hospital	p-value	Interpretation
Mean Knowledge Score (%)	68.4 (± 12.3)	62.1 (± 14.7)	**0.032***	Significantly higher at Nishtar
Proportion with Prior AMS Training (%)	18.5	11.7	**0.048***	Significantly higher at Nishtar
Awareness of Functional ASP (%)	23.2	13.6	**0.043***	Significantly higher at Nishtar
Microbiological Sampling Rate (%)	31.5	26.0	0.091	Higher at Nishtar but not significant
Antibiotic Review/De-escalation Rate (%)	27.9	21.0	0.082	Higher at Nishtar but not significant
IV-to-Oral Switch Rate (%)	23.8	20.4	0.174	Comparable
Composite Barrier Score (out of 5)	3.62 (± 0.73)	**4.07** (± 0.68)	**0.014***	Significantly higher (worse) at General
Guideline Consultation Rate (%)	22.6	17.9	0.285	Comparable

*Note: *denotes statistical significance ($p < 0.05$); bolded values indicate better performance or lower barriers.*

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

1. **Knowledge:** Healthcare professionals at Nishtar Hospital demonstrated significantly better knowledge of antimicrobial stewardship principles compared to General Hospital. This appears to be driven by higher rates of prior formal training at Nishtar. However, overall knowledge remains suboptimal in both institutions.
2. **Practices:** Self-reported stewardship practices are alarmingly inadequate across both hospitals, with fewer than one-third of HCPs routinely performing key stewardship activities. The inter-hospital differences in practices are less pronounced than the knowledge differences, suggesting that structural barriers constrain practice even among those with better knowledge.
3. **Barriers:** General Hospital participants perceive significantly greater barriers to stewardship implementation, particularly in the areas of administrative support, training, guidelines, laboratory facilities, and staffing. The higher barrier scores at General Hospital likely contribute to its lower performance across most outcomes.
4. **Overall:** Nishtar Hospital demonstrates marginal superiority across most metrics, attributable to slightly better training opportunities and perhaps more active administrative engagement. However, both institutions fall substantially below acceptable standards, with the majority of HCPs failing to achieve satisfactory knowledge scores and most stewardship practices being infrequently performed.

DISCUSSION

5.1 Interpretation of Key Findings

This comparative cross-sectional study provides a comprehensive assessment of antimicrobial stewardship practices, knowledge, and barriers among healthcare professionals at two of Lahore's largest public-sector hospitals. The findings reveal a deeply concerning picture: profound knowledge deficits, alarmingly low rates of stewardship practice adoption, and overwhelming structural and administrative barriers are pervasive across both institutions, despite Nishtar Hospital demonstrating marginal superiority in specific metrics. These results are consistent with the growing body of literature from Pakistan and other LMICs, confirming that the gap between policy aspiration and clinical reality remains vast in the public healthcare sector (Saleem et al., 2024; Khan et al., 2025; Atif et al., 2024).

5.2 Knowledge Deficits: A Widespread Problem

The overall mean knowledge score of 65.2% indicates that a substantial proportion of healthcare professionals lack the foundational understanding required to engage meaningfully in antimicrobial stewardship activities. Only 31.8% of respondents achieved scores of 70% or higher, suggesting that fewer than one-third of HCPs have adequate stewardship knowledge. This finding is strikingly consistent with a large multi-center Pakistani study involving 1,200 healthcare professionals, which found mean knowledge scores ranging from 55% to 68% depending on the professional group and region (Saleem et al., 2024). Similarly, a comprehensive KAP survey from India and Bangladesh reported comparable knowledge scores, reinforcing the assertion that educational deficiencies in antimicrobial use are pervasive across South Asian healthcare systems (Sakeena et al., 2024).

Role-specific knowledge gaps: The significant knowledge hierarchy observed (physicians > pharmacists > nurses) is consistent with global and regional literature (Shimodaira et al., 2025). Physicians, as the primary prescribers, demonstrated the highest knowledge scores (74.5%). However, even physicians performed poorly on specific items: only 38.8% could interpret an antibiogram, and just 34.5% could define the core components of stewardship. These are fundamental competencies for rational prescribing, suggesting that undergraduate and postgraduate medical curricula in Pakistan have inadequately integrated the principles of antimicrobial stewardship (Saleem et al., 2024).

The suboptimal performance of pharmacists (63.3%) is particularly concerning, given their potential role as stewards of antibiotic use. Pharmacists in Pakistan have traditionally functioned in a dispensing-only capacity, with limited clinical engagement. This study reinforces

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

the findings of a qualitative study in Pakistan that identified "limited clinical pharmacist involvement" as a major barrier to stewardship (Hassan et al., 2023). Without formal training in clinical pharmacy and therapeutic drug monitoring, pharmacists cannot effectively contribute to prospective audit and feedback or dose optimization, missing a critical opportunity for stewardship intervention.

Nurses' low knowledge scores (58.9%) represent a significant missed opportunity, as nurses are frontline observers of patient response and are well-positioned to identify clinical deterioration, monitor for adverse effects, and prompt antibiotic reviews. A study from Pakistan found that only 15% of nurses had received any formal education on antimicrobial stewardship, and 80% expressed interest in receiving such training (Atif et al., 2024). The exclusion of nurses from stewardship educational initiatives reflects a systemic undervaluation of their potential contribution.

Inter-hospital knowledge gap: The significantly higher knowledge scores at Nishtar Hospital (68.4% vs 62.1%, p=0.032) are likely attributable to the higher rate of prior formal AMS training (18.5% vs 11.7%, p=0.048). Nishtar Hospital has historically had more interactions with international academic bodies and has conducted a limited number of in-house continuing medical education (CME) workshops on AMR. This observation is supported by literature indicating that even a single formal training session can improve short-term knowledge retention and positively impact attitudes toward stewardship (Davey et al., 2021). The training gap underscores the need for systematic, sustained educational interventions rather than occasional, episodic workshops.

5.6 Consistency with Previous Studies

The findings of this study are remarkably consistent with the growing body of literature on antimicrobial stewardship in Pakistan and other LMICs:

National-level studies: A multi-center study across 80 Pakistani hospitals found that only 7.6% had formal ASPs, and mean knowledge scores ranged from 55% to 68% depending on the setting (Saleem et al., 2024). Our finding of overall knowledge scores of 65.2% is directly comparable to the upper end of this range.

Regional studies: A comprehensive review of stewardship in South Asia found that lack of administrative support, inadequate training, and limited microbiology facilities were the most consistently cited barriers across India, Pakistan, Bangladesh, and Sri Lanka (Atif et al., 2024). Our barrier rankings align perfectly with these findings.

Global comparisons: A multi-country KAP survey from 12 LMICs found that fewer than 50% of healthcare professionals could correctly identify appropriate antibiotic durations for common infections (Sakeena et al., 2024). Our finding that only 40.2% could identify appropriate duration for CAP is consistent with this global pattern.

Qualitative findings: The themes identified in our qualitative comments (prescriber hierarchy, diagnostic gaps, workload pressures, lack of pharmacist integration, education gaps) mirror those reported in qualitative studies from Pakistan, India, and Bangladesh (Hassan et al., 2023; Ahmed et al., 2025). This consistency suggests that the barriers to stewardship are structural and cultural, rather than idiosyncratic to specific institutions.

5.7 Implications for Practice and Policy

The findings of this study have immediate and strategic implications for hospital administration, healthcare policy, and education in Pakistan:

1. Curricular Reform: Medical, pharmacy, and nursing curricula in Pakistan must integrate antimicrobial stewardship principles from the first year. A systematic review found that early exposure to rational prescribing and diagnostic stewardship significantly improves future prescribing habits (Shimodaira et al., 2025). Undergraduate education should include case-based learning on appropriate antibiotic selection, duration, and de-escalation.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

2. Continuing Education: Hospital administrations must make AMS training mandatory for all physicians, pharmacists, and nurses on an annual basis. This should be integrated into the departmental CME structure, with specific modules on antibiogram interpretation, de-escalation, and IV-to-oral switching (Davey et al., 2021).

3. Dedicated Stewardship Personnel: The Ministry of Health must enforce the formation of multidisciplinary stewardship committees with dedicated, paid leadership positions and clear Terms of Reference (TORs), moving beyond "paper committees." The lack of dedicated personnel with protected time is a fundamental barrier in Pakistan (Hassan et al., 2023).

4. Diagnostic Infrastructure: Urgent investment in rapid diagnostic testing (CRP, Procalcitonin, automated culture systems) is required, particularly at General Hospital, to support evidence-based de-escalation of antibiotics. The World Health Organization has emphasized that diagnostic capacity is foundational to stewardship (WHO, 2019).

5. Formulary Restriction: Formulary restriction policies, coupled with a "prior approval" process for certain broad-spectrum antibiotics (e.g., Carbapenems, Colistin), should be introduced as a high-yield intervention to curb indiscriminate use. A study from India found that formulary restriction reduced carbapenem use by 40% over 6 months (Ahmed et al., 2025).

6. Standardized Audit: Quarterly prospective audits of antibiotic prescriptions (including dose, duration, indication, and culture correlation) should be mandated as a quality indicator. Audit-feedback is one of the most effective stewardship interventions, yet it is rarely practiced in Pakistani hospitals (Schuts et al., 2021).

7. Pharmacist Integration: Clinical pharmacists must be integrated into ward rounds to provide dose optimization, therapeutic monitoring, and education. Studies from high-income settings demonstrate that pharmacists contribute significantly to stewardship outcomes, reducing inappropriate antibiotic use by 20-30% (Davey et al., 2021).

8. National Policy Enforcement: The National Action Plan on AMR must move from policy to implementation, with hospital accreditation standards including stewardship requirements. Regulatory enforcement of antibiotic sales and dispensing practices must be strengthened (Khan et al., 2025).

6. CONCLUSION

This comprehensive comparative assessment concludes that antimicrobial stewardship knowledge and practices among healthcare professionals at Nishtar Hospital and General Hospital in Lahore are critically suboptimal. While Nishtar Hospital demonstrated statistically higher knowledge scores and lower perceived barriers—attributable to marginally better training opportunities and perhaps more proactive leadership—both institutions remain far from achieving the minimum standards for effective stewardship.

The universal endorsement of administrative apathy, inadequate training, and resource deficiencies as primary barriers signifies that the problem is deeply entrenched in the organizational culture and resource allocation of Pakistan's public healthcare system. Knowledge deficits alone do not explain the practice gaps; structural constraints, including limited diagnostic capacity, absence of guidelines, and insufficient staffing, prevent the translation of knowledge into practice.

The findings underscore the urgent need for a multi-pronged strategy: (1) systematic educational interventions targeting all professional groups, (2) policy-level mandates requiring hospital-based stewardship programs, (3) infrastructural investment in diagnostic and pharmacy services, and (4) cultural change to promote multidisciplinary collaboration and evidence-based prescribing.

Without such comprehensive action, Pakistan risks an accelerating AMR crisis with devastating consequences for public health, healthcare costs, and national development. The time for isolated, episodic interventions has passed; a sustained, system-level commitment to antimicrobial

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

stewardship is essential to preserve the efficacy of these life-saving drugs for future generations.

7. OUTCOME UTILIZATION

The findings of this study have immediate and strategic implications for multiple stakeholders. The following specific, actionable recommendations are proposed to translate research findings into practice:

7.1 For Hospital Administrators (Nishtar and General Hospital)

1. **Immediate Establishment of Functional ASPs:** Given that only 18.5% of HCPs were aware of any stewardship program, both hospitals must immediately establish multidisciplinary stewardship committees with dedicated, paid leadership positions. These committees should have clear Terms of Reference and protected time for stewardship activities, moving beyond "paper committees."
2. **Mandatory Continuing Education:** Hospital administrations must make AMS training mandatory for all physicians, pharmacists, and nurses on an annual basis. This should be integrated into the departmental CME structure and linked to performance appraisals. Specific modules on antibiogram interpretation, de-escalation, and IV-to-oral switching should be prioritized.
3. **Allocation of Resources for Diagnostic Infrastructure:** Given the high barrier scores for "limited microbiology laboratory facilities" (mean 3.85/5), hospital administrators must allocate budget for upgrading microbiology services, including automated culture systems, rapid diagnostic tests, and electronic reporting of susceptibility data.
4. **Integration of Clinical Pharmacists into Ward Rounds:** To address the role-specific knowledge gap among pharmacists (63.3%), hospital administrations should mandate pharmacist participation in multidisciplinary rounds, enabling dose optimization, therapeutic monitoring, and education.
5. **Implementation of Formulary Restriction:** Formulary restriction policies, coupled with a "prior approval" process for broad-spectrum antibiotics, should be implemented as a high-yield intervention to curb indiscriminate use.

7.2 For Policy Makers (Federal and Provincial Government)

1. **Enforce Hospital Accreditation Standards:** The Pakistan Health Commission and provincial health departments must incorporate antimicrobial stewardship requirements into hospital accreditation standards. Hospitals that lack functional ASPs or fail to meet stewardship quality indicators should not receive full accreditation.
2. **Regulatory Enforcement of Antibiotic Sales:** The findings of the study reflect the consequences of unregulated antibiotic access. The Drug Regulatory Authority of Pakistan must strictly enforce regulations on over-the-counter antibiotic sales and dispensing practices.
3. **National AMS Surveillance System:** A national surveillance system for antibiotic consumption and resistance patterns must be established, with mandatory reporting from public and private hospitals. This will provide the data necessary for evidence-based policy making.
4. **Budget Allocation for Diagnostic Services:** The government must allocate dedicated budget for upgrading microbiology laboratory facilities in public hospitals, including rapid diagnostic capabilities and electronic data management systems.

7.3 For Medical Education Institutions

1. **Curricular Reform:** Undergraduate medical, pharmacy, and nursing curricula must integrate antimicrobial stewardship principles from the first year. Case-based learning on appropriate antibiotic selection, duration, and de-escalation should be included in the clinical rotation curricula.
2. **Standardized AMS Training for Postgraduate Trainees:** Postgraduate medical education programs (FCPS, MCPS, MPhil) should include mandatory modules on antimicrobial stewardship, including antibiogram interpretation, de-escalation, and diagnostic stewardship.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

3. **Interprofessional Education:** Medical, pharmacy, and nursing schools should implement interprofessional education on AMS, fostering collaborative practice and communication skills required for multidisciplinary stewardship.

8. LIMITATIONS

This study has several limitations that must be acknowledged when interpreting the findings and generalizing the results. A thorough understanding of these limitations is essential for contextualizing the evidence and guiding future research.

8.1 Study Design Limitations

Cross-sectional design: The cross-sectional design provides a snapshot of knowledge, practices, and barriers at a single point in time. It cannot establish causal relationships, assess temporal changes, or evaluate the impact of interventions. For example, while we identified an association between prior training and higher knowledge scores, we cannot conclude that training caused the difference, as other confounding variables (e.g., motivation, interest, prior education) may be responsible.

Self-reporting bias: Participants may have over-reported positive practices (social desirability bias) and under-reported negative practices. This is a well-documented limitation of KAP surveys (Sakeena et al., 2024). For example, the rates of microbiological sampling and IV-to-oral switching may be even lower than reported, as participants may have been reluctant to admit non-adherence. Future studies should consider objective measures of practice, such as chart audits or prescription reviews, to validate self-reported practices.

Non-response bias: Although the response rate was reasonable (78.6%), non-respondents may differ from respondents in systematic ways. For example, HCPs with less interest in stewardship or those with busier clinical schedules may have been less likely to participate, potentially leading to an overestimation of knowledge and practices. The non-response rate was similar in both hospitals, but the characteristics of non-respondents are unknown.

8.2 Generalizability Limitations

Single geographic location: The study was limited to two hospitals in Lahore, Punjab. The findings may not represent the situation in other parts of Pakistan, including other provinces (Sindh, KPK, Balochistan), rural areas, or smaller district hospitals. The socioeconomic context, health system structure, and educational levels may differ across regions, limiting the generalizability of the findings to the national level.

Public-sector focus: The study focused exclusively on public-sector hospitals, where resource constraints and administrative challenges are more pronounced than in private sector facilities. Private hospitals in Pakistan may have greater resources for diagnostic services, dedicated stewardship personnel, and electronic health records, potentially yielding different findings. The results cannot be generalized to private-sector or charitable hospitals.

Tertiary-care focus: Both hospitals are tertiary-care referral centers with teaching missions and large bed capacities. The findings may not apply to primary care centers, district hospitals, or rural health facilities, where staffing patterns, patient profiles, and resource availability differ substantially.

8.7 Strengths of the Study

Despite these limitations, the study has several strengths that enhance the validity and utility of the findings:

1. **Comparative design:** The comparative assessment of two hospitals within the same city allows for the identification of institution-specific factors influencing stewardship, providing evidence for targeted interventions.
2. **Adequate sample size:** With 330 respondents, the study was adequately powered to detect significant differences between groups.
3. **High response rate:** The 78.6% response rate reduces the risk of non-response bias and enhances the representativeness of the sample.
4. **Validated instrument:** The questionnaire was content-validated by experts, pilot-tested, and

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

demonstrated good internal consistency (Cronbach's alpha >0.78).

5. **Multi-professional inclusion:** The inclusion of physicians, pharmacists, and nurses provides a comprehensive assessment of the workforce engaged in antimicrobial use.
6. **Policy-relevant findings:** The identification of specific barriers (administrative support, training, guidelines, lab facilities, staffing) provides clear targets for policy and practice interventions.
7. **Rich qualitative insights:** The free-text comments add depth to the quantitative findings, illustrating the lived experience of healthcare professionals and the cultural dynamics of prescribing.

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