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Adapting global guidelines to local contexts: optimising community-acquired pneumonia (CAP) specific prescribing in Pakistan to counter antimicrobial resistance

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ABSTRACT

Background/objectives Community-acquired pneumonia (CAP) imposes a significant health burden among low- and middle-income countries. The burden is exacerbated by antimicrobial resistance (AMR), often due to inappropriate antibiotic agent use and gaps in antimicrobial stewardship activities. This study aimed to explore physicians' perspectives on the diagnosis, treatment and prevention of CAP in Pakistan, with a focus on how international guidelines are interpreted and adapted to local clinical realities.

Methods A qualitative study was conducted using semistructured interviews with 33 purposively selected physicians from various specialties, followed by a focus group discussion with 19 of them. Data were analysed through thematic analysis.

Results Four cross-cutting themes were identified: (1) selective use of diagnostic agents based on severity and access; (2) pragmatic empiric prescribing influenced by resistance trends and antibiotic availability; (3) stewardship intentions constrained by delayed diagnostics and limited infrastructure and (4) underutilisation of preventive strategies including adult vaccinations due to cost and policy gaps. Physicians were aware of Infectious Diseases Society of America/American Thoracic Society guidelines but adapted them to local challenges and AMR concerns.

Conclusions Most physicians were unaware of the exact prevalence of causative pathogens and their resistance patterns in Pakistan due to the unavailability of robust local data. Consequently, international guidelines were adapted to local challenges including resistance patterns, limited diagnostics and resource constraints. Physicians prioritised beta-lactam antibiotics use and restricted moxifloxacin and azithromycin to mitigate resistance propagation linked to multidrug-resistant tuberculosis and extensively drug-resistant typhoid. Efforts to improve antimicrobial utilisation for CAP in Pakistan need to address implementation barriers and focus on enhancing diagnostic access, vaccine coverage and funding for treatment optimisation.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ International guidelines such as the Infectious Diseases Society of America/American Thoracic Society 2019 provide standardised recommendations for community-acquired pneumonia (CAP) management. However, their implementation in low-and middle-income countries (LMICs), including Pakistan, remains challenging due to limited diagnostic capacity, high antimicrobial resistance (AMR) rates and resource constraints.

WHAT THIS STUDY ADDS

⇒ This study explores how physicians in Pakistan adapt CAP management to AMR and resource constraints, offering context-specific empiric treatment guidance aligned with local realities.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The findings emphasise the need for national CAP guidelines in Pakistan that integrate local antibiogram data and stewardship principles, providing evidence to guide policies and interventions bridging international standards with LMIC healthcare realities.

INTRODUCTION

Community-acquired pneumonia (CAP) remains a major global health burden, with high morbidity, mortality and economic costs, especially in low-and middle-income countries (LMICs) including Pakistan.[1–9] A significant contributing factor to poor clinical outcomes among patients admitted to hospitals in Pakistan for CAP is the overuse and inappropriate prescribing of antibiotics when not clinically indicated, which contributes to antimicrobial resistance (AMR) in the region.[10–12] Despite advancements in diagnostics and treatment, CAP in Pakistan

is frequently misdiagnosed and inappropriately treated, leading to poor patient outcomes.[12 13] Similar to LMICs, there is widespread overuse of antibiotics among hospitalised CAP patients.[14–16] This practice has contributed to increasing resistance to first-line antimicrobials, including macrolides such as azithromycin and clarithromycin; fluoroquinolones such as levofloxacin and moxifloxacin.[17 18] These agents are categorised as Watch antibiotics in the WHO Essential Medicines List and Access, Watch and Reserve (AWaRe) classification and are recommended as first-line treatments only when clinically indicated for hospitalised CAP.[19] According to Torumkuney *et al*, resistance to these antibiotics remains high among CAP pathogens in Pakistan. The study also highlights limited susceptibility testing and poor adaptation of prescribing to local resistance patterns, emphasising the urgent need for improved antimicrobial stewardship (AMS) and context-specific treatment guidelines.[20] The absence of antimicrobial stewardship programmes (ASPs) and the suboptimal infection control practices further enhance the AMR burden, reducing the effectiveness of current antibiotic regimens.[21–23] Standardised treatment protocols and continuous monitoring of antibiotic use and resistance within ASPs are essential to optimise prescribing.[24–27]

Global guidelines such as the 2019 Infectious Diseases Society of America/American Thoracic Society (IDSA/ATS) recommendations and the WHO AWaRe classification provide structured approaches for the diagnosis and treatment of CAP. These guidelines emphasise the use of severity assessment tools, microbiological testing and timely empiric antibiotic therapy.[28 29] According to the WHO AWaRe guidance, antibiotics are categorised into AWaRe groups to inform stewardship efforts. For hospitalised CAP patients, Watch group antibiotics such as macrolides and fluoroquinolones are recommended as first-line empiric treatments when clinically indicated, especially in moderate to severe cases.[19 29] However, implementing these recommendations in resource-limited health systems such as those in Pakistan is often challenging due to diagnostic delays, shortages with antibiotics, cost barriers and existing high levels of AMR.[30 31] A recent systematic review by Khowaja and Karimi further highlighted that *Streptococcus pneumoniae*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* are the predominant pathogens responsible for adult CAP in Pakistan, many of which exhibit significant resistance to commonly prescribed empiric antibiotics such as ceftriaxone, levofloxacin, azithromycin and amoxicillin-clavulanate.[32] Consequently, physicians frequently rely on clinical acumen, local antibiogram trends and context-specific regimens to manage patients with infectious diseases including CAP in Pakistan, which may diverge from standardised global guidelines.[32 33]

The WHO and other international health bodies have emphasised the need to understand how such local adaptations affect rational antibiotic use, particularly in light of rising AMR rates among respiratory pathogens.[34 35] Although studies from LMICs, including Bangladesh, Ghana, India, Nigeria and Vietnam, have documented the CAP guideline adherence challenges, few have qualitatively examined these issues in Pakistan.[16 36–38] Prior research highlights a disconnect between evidence-based recommendations and their practical application in low-resource settings.[13] For instance, international guidelines continue to recommend Watch antibiotics macrolides and fluoroquinolones in certain CAP cases; however, their widespread use remains controversial in Pakistan due to documented resistance patterns and concerns about masking tuberculosis (TB), a major public health threat in the region.[12 18 39–43] To address such issues, the WHO, as mentioned, has published the AWaRe antibiotic book to enhance rational antibiotic use, with guidance tailored to country-specific contexts. The WHO AWaRe Book recommends ceftriaxone, cefotaxime or clarithromycin as first-line empiric treatment options for adult patients with moderate to severe CAP, with co-amoxiclav plus clarithromycin as a second-line option.[19 29] For the treatment of children with mild CAP, the WHO AWaRe book advises the use of Access group antibiotics such as oral penicillins (eg, amoxicillin) as the preferred choice.[19 29] These structured recommendations are designed to mitigate the utilisation of Watch antibiotics and promote Access antibiotics, aligning with United Nations General Assembly's recent target of achieving 70% Access antibiotics use to reduce AMR.[44]

Therefore, implementing global guidance in Pakistan is complicated by diagnostic limitations, inconsistent stewardship implementation and local resistance patterns necessitating pragmatic prescribing adaptations. Consequently, in view of current concerns, this study sought to examine physician-reported practices related to the diagnosis, treatment and prevention of CAP in Pakistan, with a focus on how international guidelines are interpreted and adapted within a health system shaped by resource limitations, appreciable AMR and evolving stewardship priorities. It is anticipated that clinical practices would diverge from global recommendations due to contextual factors including limited access to diagnostics, especially with high patient co-payments in Pakistan, high AMR rates, medication availability including relevant antibiotics and financial constraints. The findings should offer valuable insight into pragmatic strategies employed by frontline physicians and provide an evidence base for designing context-specific approaches to CAP management and ASPs in low-resource settings where AMR is a high and growing burden.

MATERIALS AND METHODS

Study design and setting

This qualitative study employed semistructured in-depth interviews followed by a focus group discussion (FGD) to identify in-depth insights into current CAP management in Pakistan. This approach was chosen to explore the clinical decision-making processes of

physicians, their alignment to global guidelines, and the contextual challenges and implementation barriers influencing CAP treatment in the country. The study was conducted in major tertiary hospitals across urban regions, ensuring representation from both public and private sector institutions (see COREQ checklist online supplemental file S1).

Participant enrolment

The study included participants from various regions across Pakistan. Physicians registered with the Pakistan Medical and Dental Council (PMDC) were recruited using a purposive sampling technique. The PMDC is a statutory regulatory authority that maintains the official register of medical practitioners in Pakistan. The sample was a purposive, maximum variety sample of participants with particular knowledge, skills or experiences across Pakistan, representing major clinical departments, and comprised pulmonologists, infectious disease specialists and general medicine practitioners.

Instrument development

A semistructured interview guide was developed with the help of current literature evidence and ATS/IDSA recommendations[45] to facilitate a comparative analysis of prescribing practices for CAP in Pakistan. The guide covered key domains including diagnostic decision-making, empiric antibiotic prescribing practices, awareness of AMR and stewardship, and preventive strategies such as vaccination. The full interview guide is available in online supplemental table S2.

Data collection: interviews

Semistructured interviews were conducted using an interview guide. Interviews were conducted in English and lasted approximately 30–45 min. Detailed field notes were taken during each interview. In cases where audio recording was not feasible due to participant preference or logistical constraints, detailed written notes were expanded immediately post-interview.

Data collection-FGD

To complement and validate the interview findings, a single FGD was conducted with a subset of the same physician participants. All 33 interview participants were invited, but only 19 attended due to clinical and scheduling constraints. The FGD served as a reflective validation step, allowing participants to review preliminary themes and discuss barriers, facilitators and contextual adaptations in CAP management. This single FGD was conducted as a triangulation and validation exercise rather than primary data collection. Practical limitations, including scheduling and clinical commitments, restricted the possibility of multiple FGDs.

Prior to the session, participants received a summary of key interview findings and excerpts from international CAP guidelines to guide discussion. The FGD was moderated by two researchers; ZS (Ph.D.) as lead facilitator and EJ (Ph.D. scholar) as co-moderator to maintain focus and avoid off-topic dialogues. Field notes were taken during the session to support accurate interpretation and minimise post hoc bias.

The FGD session was conducted via Zoom and audio recorded using the platform's built-in feature for high quality transcription. The FGD lasted approximately 40–50 min. Discussions continued until data saturation was reached, defined a priori as the point at which no new codes or themes emerged across three consecutive interviews, consistent with established qualitative research practice.[46] Saturation was monitored throughout data collection by the primary moderator in consultation with the research team, ensuring the decision to stop recruitment was guided by this prespecified criterion rather than discretion alone. This saturation criterion indicated analytic sufficiency and methodological rigour. The FGD ultimately enhanced interpretive depth, validated the thematic structure from interviews and provided opportunities to assess consensus and divergence around CAP treatment practices and guideline applicability.

Analysis

Both interview and FGD data were analysed using a hybrid inductive and deductive thematic analysis approach.[47] Transcripts and field notes were manually coded, with initial codes drawn from the interview guide and refined through repeated review and team discussions. Emergent subthemes were organised into four cross-cutting themes capturing shared challenges and adaptive strategies across settings. FGD insights were integrated to validate and deepen the analysis, with data saturation reached when no new subthemes or perspectives emerged.

Preliminary results or themes were subsequently shared with some of the original study participants who were available for follow-up discussions, to ascertain whether the findings reflected their views and experiences accurately. This highlighted that the participants' views were correctly interpreted and not misrepresented. Reflexivity was maintained throughout the analytic process to account for potential researcher bias and ensure transparent interpretation of the data. We used a thematic and discourse analysis of the data, with it being discussed by all authors. No qualitative data analysis software was used.

Grounded in a pragmatic qualitative framework, this study explored how clinicians make context-driven decisions and adapt evidence-based CAP guidelines to the constraints of routine practice in a low-resource setting.

RESULTS

33 physicians practising in varied clinical settings across Pakistan shared their experiences managing CAP, with a focus on diagnostic strategies, empirical prescribing, resistance challenges and preventive gaps. The demographic characteristics of the 33 physicians who

Table 1 Characteristics of study participants

Variable	Category	N (%)
Experience	1–5 years	6 (19.35)
	5–10 years	10 (32.26)
	10–15 years	6 (19.35)
	15–20 years	4 (12.90)
	More than 20 years	7 (22.58)
Sector	Public	26 (78.8)
	Private	7 (21.2)
Department	Pulmonology	25 (80.65)
	Infectious diseases	5 (16.13)
	General medicine	3 (9.68)
Designation	Assistant professor	11 (35.48)
	Professor	10 (32.26)
	Consultant	8 (25.81)
	General physician	3 (9.68)
	Associate professor	1 (3.23)

participated in the interviews, and of whom a subset also attended FGD, are presented in table 1. The majority were male (78.8%) and included a range of clinical experience levels and specialties.

Through inductive and deductive thematic hybrid analysis, four cross-cutting themes were identified, synthesising physicians' perspectives and revealing adaptations in CAP management and challenges in aligning global guidelines with local realities. Online supplemental table S3 presents these themes and subthemes, reflecting views on diagnosis, treatment adaptation, ASPs and preventive gaps in CAP management across clinical contexts in Pakistan.

Theme 1: navigating diagnostic limitations and clinical judgement

Participating physicians reported using a risk-stratified diagnostic approach for CAP based on severity, comorbidities and economic factors. While guidelines recommend severity-based testing, local practices emphasised selective resource use and clinical judgement over strict protocols. Routine Gram stains and cultures were avoided in low-risk outpatients but considered essential for hospitalised or multidrug-resistant organism (MDRO)-risk patients. Hospital antibiogram substituted for unavailable or delayed microbiology results. Blood cultures were used selectively due to low yield and cost, and tests for influenza or Legionella were ordered only when seasonally or clinically indicated (table 2).

Advanced diagnostics including multiplex PCR were inaccessible, especially in public sector hospitals. Biomarkers including C reactive protein (CRP) and procalcitonin, as well as chest imaging, were reserved for complicated cases. Both public and private sector physicians reported similar diagnostic approaches; however, private practitioners described relatively better access to advanced tests. Financial barriers, however, limited their routine use. Public sector physicians faced additional institutional limitations, including delayed cultures and restricted imaging availability. Despite these differences, clinical judgement emerged as the primary driver of diagnostic decisions, underscoring that systemic constraints rather than practice setting alone shaped CAP management practices in Pakistan. These differences are presented descriptively to highlight contextual variation in CAP management strategies across sectors, rather than as formal quantitative comparisons.

Table 2 Participant quotes on diagnostic practices

Diagnostic area	Quote	Participant
Gram stain and culture	"For low-risk CAP patients, I do not suggest Gram stains and cultures. However, for moderate to high-risk CAP patients or those with MDRO risk factors, I do recommend these tests."	P-24
Local antibiogram use	"Every hospital must have their antibiogram …so empirical therapy aligns with local resistance patterns."	P-14
Blood cultures	"For routine CAP cases, these tests do not add much value … I only suggest them for high-risk CAP patients."	P-31
Influenza testing	"Not routinely. Consider for patients with suspicion of influenza, particularly during flu season and in high-risk groups."	P-21
PCR testing	"Cost is prohibitive. Can be considered for severely ill patients requiring critical care admission."	P-24

CAP, community-acquired pneumonia; MDRO, multidrug-resistant organism.

Theme II: pragmatic prescribing: aligning guidelines with local realities

Physicians adopted a pragmatic antibiotic approach, aligning CAP guidelines with local AMR trends, drug access and costs. For low-risk patients without comorbidities, beta-lactams such as amoxicillin and co-amoxiclav were preferred, with limited macrolide use due to resistance. In stable patients with comorbidities, beta-lactams were combined with doxycycline or clarithromycin, while azithromycin was reserved for extensively drug-resistant (XDR) typhoid. Fluoroquinolones were largely avoided given resistance risk and interference with TB diagnosis.

Table 3 Participant quotes on pragmatic prescribing

Clinical context	Quote	Participant
Low-risk CAP	"In Pakistan, Amoxicillin/Clavulanic acid and Clarithromycin are preferable. They both are good enough for low-risk CAP."	P-4
Comorbid patient management	"Use Augmentin or Cefuroxime in combination with Clarithromycin or Doxycycline. Spare azithromycin for XDR Salmonella."	P-22
Moderate-risk (hospitalised)	"There should be combination of two or more antibiotics covering gram-positive, gram-negative, typical and atypical organisms, such as Co-Amoxiclav plus doxycycline or macrolides or alternatively fluoroquinolones."	P-15
ICU/high-risk CAP	"A combination of at least two antibiotics covering gram-positive, gram-negative, and atypical organisms is necessary for ICU patients."	P-13

CAP, community-acquired pneumonia; ICU, intensive care unit.

Table 4 Context-specific empiric treatment recommendations for CAP in Pakistan based on physician reports

CAP severity	Treatment recommendation
Low-risk (No comorbidities, OPD)	Amoxicillin 1 g PO q8h OR Clarithromycin 500 mg PO q12h OR Doxycycline 100 mg PO BID for 5 days
Low-risk (with comorbidities)	Co-amoxiclav 500/125 mg TID OR 875/125 mg BID OR Respiratory fluoroquinolone±macrolide
Moderate-risk (hospitalised)	Ceftriaxone IV 1–2 g daily OR Moxifloxacin/Levofloxacin IV+Azithromycin 500 mg daily OR Ampicillin-sulbactam IV
High-risk (ICU, no MDROs)	Non-pseudomonal beta-lactam+Levofloxacin OR Ceftriaxone+Azithromycin OR moxifloxacin IV
MDRO suspected (MRSA risk)	Vancomycin IV 15 mg/kg q12h OR Linezolid IV 600 mg q12h
MDRO suspected (ESBL risk)	Meropenem IV 1 g q8h+macrolide/fluoroquinolone OR ertapenem IV 1 g q24h
MDRO suspected (pseudomonas risk)	Piperacillin-Tazobactam IV 4.5 g q6h OR ceftazidime IV 2 g q8h OR meropenem IV 1 g q8h+macrolide
Aspiration pneumonia	Anaerobic coverage only with lung abscess/empyema
CAP with influenza	Oseltamivir for high-risk patients
Treatment duration	5 days if stable
De-escalation	Based on clinical/lab improvement

BID, two times per day; CAP, community-acquired pneumonia; ESBL, extended-spectrum beta-lactamase; ICU, intensive care unit; IV, intravenous; MDRO, multidrug-resistant organism; MRSA, methicillin-resistant *Staphylococcus aureus*; OPD, outpatient department; PO, per os (by mouth/orally); q8h, every 8 hours; q12h, every 12 hours; TID, three times daily.

For moderate-risk hospitalised cases, co-amoxiclav plus a macrolide or doxycycline was common, though some used respiratory fluoroquinolones for broader coverage. Intensive care unit (ICU) management involved broad-spectrum empiric regimens, typically third or fourth-generation cephalosporins, beta-lactamase inhibitors, macrolides and fluoroquinolones, reflecting higher patient acuity and MDRO risk (table 3).

In addition, physician-reported treatment patterns were summarised into context-specific empiric antibiotic recommendations across CAP severity levels (table 4). Table 4 reflects locally adapted prescribing approaches that aim to balance guideline alignment, resistance trends and patient-specific factors.

Theme III: stewardship under constraint: responding to AMR and MDRO risk

Physicians expressed uncertainty about local AMR patterns due to the lack of robust surveillance data but nonetheless sought to balance empiric therapy with AMS goals. For MDRO-risk cases (MRSA, ESBL, Pseudomonas), broad-spectrum combinations including fluoroquinolones, beta-lactams, carbapenems and vancomycin were commonly used to prevent treatment failure. Anaerobic coverage in aspiration pneumonia was applied selectively based on illness duration, presentation and aspiration risk. Most physicians practised de-escalation guided by clinical stability, culture results and local antibiograms, while non-responders were reassessed within 72 hours to exclude complications such as abscess or empyema (table 5).

This theme reflects the struggle to balance AMS principles with practical limitations, as physicians aim to make evidence-based decisions while navigating resource-constrained settings.

Theme IV: preventive gaps and missed opportunities

Physicians strongly supported pneumococcal and influenza vaccination but reported low uptake due to cost, poor awareness and lack of adult immunisation programmes.

Table 5 Participant quotes on ASP and MDRO risk

Topic	Quote	Participant
Empiric therapy for MDRO risk	"I prescribe combination of two or three, preferably carbapenem and vancomycin because these organisms are usually resistant to antibiotics."	P-32
Aspiration pneumonia	"Treatment not required. It should be given when there are risk factors for aspiration. It depends on the duration of illness; if more than five days and aspiration is suspected, empirical antibiotics should be started."	P-18
De-escalation practices	"De-escalation to targeted therapy is essential once cultures are obtained. Oral once tolerable."	P-22
Reassessment in non-responders	"Reassessment of the patient is required to rule out other diagnoses and confirm primary diagnosis, with evaluation for any complications of pneumonia."	P-8

ASP, antimicrobial stewardship programme; MDRO, multidrug-resistant organism.

> These vaccines are given to patients with comorbidities and should be done in high-risk patients after 60 years of age with COPD, asthma, allergic rhinitis, bronchiectasis, and heart failure. (P-12)

Despite consensus on their importance, vaccination practices varied; some advised post-recovery administration, others pre-emptive use in high-risk groups. All agreed that without public funding or policy support, vaccination would remain underused, representing a major missed opportunity in Pakistan's CAP response.

A thematic comparison of physician-reported CAP management practices with IDSA/ATS 2019 guidelines is provided in online supplemental table S4.[45] The table highlights areas of alignment and contextual divergence across diagnostic strategies, prescribing behaviours, stewardship efforts and preventive approaches.

DISCUSSION

We believe this qualitative study provides novel insights into how physicians in Pakistan pragmatically adapt CAP management amid limited diagnostics, rising AMR and variable ASP infrastructure. Through four themes, it illustrates how local realities intersect with global guideline awareness, informing prescribing across outpatient and hospital settings. Physicians reported risk-stratified diagnostics, selectively using microbiological tests, imaging and biomarkers based on disease severity, comorbidities and institutional capacity. While consistent with IDSA/ATS 2019 guidelines recommending advanced diagnostics for severe cases, implementation diverged due to cost, limited laboratory capacity and delayed results.[45] Participants highlighted hospital antibiograms as key tools for guiding empirical therapy reflecting pragmatic adaptation of global guidance to local resistance patterns and weak national frameworks in LMICs.[48]

In addition, observed differences between public and private sector providers highlight how institutional context and resources influence CAP management. Effective stewardship and guideline implementation must address public sector limitations while promoting affordable, rational use of advanced diagnostics in the private sector.[49] Most antibiotic use in Pakistan occurs in unregulated community settings, private clinics and retail pharmacies in peri-urban and rural areas, remaining largely outside stewardship oversight.[50]

Improving access to diagnostic tests is essential to support guideline-concordant care, reduce misdiagnosis and restrict unnecessary prescribing. Overdiagnosis of pneumonia and other infections contributes to AMR,[51] emphasising the need in LMICs to balance pragmatic guideline adaptation with expanding diagnostic capacity. In this context, diagnostic stewardship, the systematic promotion of appropriate microbiological testing and interpretation, represents an important complement to AMS, helping to ensure timely, accurate diagnosis and reduce inappropriate therapy.[52 53] However, barriers such as high cost, weak infrastructure, personnel shortages and reporting delays hinder alignment with international standards.[53 54] Physicians in this study relied on empirical treatment as a pragmatic response, underscoring the need to sustain adaptive practices while addressing barriers to best practice. Tackling these barriers is vital for effective, context-sensitive stewardship interventions.

Similar challenges have been observed in other LMICs, including Bangladesh, India, Nigeria and Vietnam, where limited diagnostic use is often driven by inadequate infrastructure and clinicians' doubts about the usefulness of available tests.[16 55–60] In Pakistan, routine microbiological testing is largely reserved for moderate to severe CAP cases to optimise resources, given the financial burden of laboratory tests on both hospitals and patients, personnel issues and potential delays in initiating antibiotics.[61–64] As testing is predominantly performed in more severe cases, this selective sampling may introduce bias and overestimate AMR patterns when applied to the wider CAP population.[31 65] Similar to other LMICs, empirical treatment remains the dominant approach.[55 64 66 67] However, this reliance on empirical therapy without microbiological confirmation raises concerns about inappropriate antibiotic use and contributes to the growing problem of AMR in the region.[26 67 68]

To analyse these findings, we used a hybrid inductive-deductive thematic analysis to examine how physician

practices aligned or diverged from IDSA/ATS and WHO AWaRe guidelines (deductive) while allowing new insights on locally adapted practices shaped by resource and AMR pressures (inductive).[19 45] Following Proudfoot, this approach offered structure and flexibility, situating findings within established theory while generating context-specific knowledge relevant to LMICs.[47]

Antibiotic prescribing reflected deliberate alignment with international guidance while adapting to local resistance and stewardship priorities. Consistent with the WHO AWaRe framework, beta-lactams, especially Access group agents like amoxicillin and co-amoxiclav, were preferred for low-risk CAP due to efficacy, safety and low resistance risk.[19 29] Similar patterns in other LMICs support beta-lactam use for outpatient and non-severe CAP within AMS priorities.[30 67] While macrolides are guideline-recommended where pneumococcal resistance is below 25%, Pakistan's higher rates led physicians to use them cautiously, reserving them for specific indications or when alternatives like amoxicillin or doxycycline were unsuitable. Fluoroquinolones, though guideline supported in some cases, were largely restricted due to rising resistance and their potential risk to mask multidrug-resistant (MDR) TB.[12 18 39–43] These prescribing patterns, aligned with national AMR data, underscore physicians' awareness of local epidemiology, stewardship goals and drug safety. Overall, they illustrate pragmatic adaptation of global recommendations to local realities amid persistent concerns about inappropriate antibiotic use in Pakistan's hospitals.

In hospitalised and ICU patients, physicians opted for broader empiric coverage with dual or triple regimens to preempt MDROs. The inclusion of tailored empiric recommendations by severity, as detailed in table 4, illustrates how clinicians synthesise guideline principles with local treatment realities.

The theme III highlights the gap between the principles of ASPs and the practical realities of clinical care in resource-constrained settings. Physicians supported de-escalation, reassessment after 72 hours and transitioning to oral agents where feasible. However, these practices were often hindered by delayed lab reports, patient instability and the absence of ASP support teams. Similar constraints such as weak diagnostics, limited training and poor regulatory oversight have been reported across LMICs.[55 66 69] Nonetheless, participants employed informal yet systematic AMS practices, guided by local epidemiology and risk stratification. These adaptations suggest stewardship is present but contextually modified, an encouraging finding given ongoing concerns about ASP awareness and implementation among clinicians in Pakistan.[70]

Preventive strategies were recognised as essential yet persistently neglected in CAP management. Although physicians supported pneumococcal and influenza vaccination for high-risk groups, implementation was hindered by financial constraints, lack of government-funded programmes, patient hesitancy and absence of routine adult immunisation infrastructure. This gap between physician advocacy and system capacity mirrors trends in other LMICs, including Pakistan, where adult vaccine uptake remains low despite proven benefits in reducing disease burden and antibiotic use.[71–73] Strengthening preventive care through vaccination counselling at discharge, public insurance coverage and educational efforts to counter hesitancy are key priorities to reduce CAP incidence and recurrence in Pakistan.

These findings reaffirm that while Pakistani physicians are aware of international guidelines, constrained health system realities necessitate contextual adaptation. Diagnostic gaps, limited antibiotic options, AMR patterns and economic barriers contribute to a form of informed pragmatism. This concept describes the clinician's ability to align with best practices when possible but make flexible, locally rational decisions when ideal conditions are lacking.

To advance the quality of CAP care in Pakistan and reduce inappropriate antibiotic use, national efforts will ultimately need to strengthen locally adapted CAP management protocols based on robust guidelines, including the WHO AWaRe antibiotic book and the 2019 IDSA/ATS guidelines for CAP.[19 28] However, our findings are exploratory and theory-generating, underscoring the need for further research and broader data before definitive best practices can be developed and implemented.

Future strategies should integrate regional antibiogram data, AMS principles and severity-based diagnostic and treatment pathways. Strengthening laboratory capacity, ASP hospital teams and adult vaccination programmes is essential. International CAP and AMR guidelines should allow adaptable frameworks that recognise the realities of resource-constrained health systems, enabling evidence-informed flexibility rather than strict protocol adherence. Recent studies emphasise tailoring AMS strategies to local resistance, diagnostics and infrastructure in LMICs, including Pakistan,[27 74 75] reflecting a shift towards adaptive, quality improvement systems aligned with global AMR goals. Overall, this analysis enhances understanding of how global guidance can be locally applied and highlights the importance of front-line clinician perspectives for successful implementation.

We are aware this study has several limitations. Findings were based on self-reported practices, which may be influenced by recall or social desirability bias. Although diverse settings were included, participants may not represent CAP management nationwide, especially in rural or under-resourced areas. Reliance on field notes instead of full recordings for some interviews may have limited analytic depth.

Additionally, preliminary findings were shared with only a subset of participants, introducing possible selective bias despite enhancing interpretive rigour. As a qualitative study, results are not statistically generalisable but provide valuable contextual insights. Lastly, while thematic analysis offered rich exploratory findings, it cannot yield confirmatory conclusions; results should be

viewed as theory-generating and context-specific, guiding future hypothesis-driven or mixed-methods research.

CONCLUSIONS

In conclusion, this study provides an in-depth view of how physicians in Pakistan manage CAP amid rising AMR, limited diagnostics and inconsistent preventive access. While treatment regimens often align with ATS/IDSA 2019 guidelines, local adaptations reflect resource constraints. Most physicians were unaware of the exact prevalence of causative pathogens and their resistance patterns in Pakistan. However, they generally agreed that international guidelines should be adapted to local realities, taking into account resistance trends, limited diagnostic capacity and resource constraints. Physicians also emphasised prioritising beta-lactam use while restricting moxifloxacin and azithromycin to curb the growing resistance associated with MDR TB and XDR typhoid in Pakistan. Despite these limitations, physicians endeavoured to uphold AMS principles, balancing clinical judgement with systemic constraints.

Findings highlight the tension between global standards and local realities. Rather than new guidelines, there is a need for adherence to existing standards while adapting stewardship to local barriers through education, awareness and use of antibiogram data. Pragmatic, locally responsive strategies may enhance stewardship alignment, though this exploratory study requires confirmatory research to assess effects on AMR and outcomes. Strengthening ASP capacity, diagnostics and provider training is essential to align empiric therapy with resistance trends. These theory-generating insights can inform national and global efforts to improve CAP care and reduce AMR in LMICs, though findings should be interpreted cautiously given potential sampling bias toward better-resourced institutions.

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