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Cognitive Processes and Decision-Making Strategies of Pharmacy Students in Antimicrobial Stewardship Cases: Insights from Verbal Protocol Analysis

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Abstract

Antimicrobial stewardship programs (ASPs) are pivotal in limiting the spread of antimicrobial resistance. Pharmacists are key members of healthcare teams, and to effectively participate in ASPs as antimicrobial stewards, they must receive proper training during pharmacy education before entering professional practice. Although ASP-related curricula have been introduced in entry-to-practice programs globally, there is limited understanding of how students analyze antimicrobial stewardship (AMS) data and make clinical decisions. This study aimed to investigate students' cognitive strategies and how they develop therapeutic decisions when handling AMS cases. A qualitative case study design was employed, recruiting a sample of pharmacy students (n=20) to interpret AMS scenarios. Individual semi-structured interviews were conducted with each participant. A think-aloud method with verbal protocol analysis was used to explore students' decision-making approaches. Thematic analysis was applied to identify patterns and themes in the interview responses. Two main themes emerged: students' focus and their case interpretation strategies. The focus theme captured the external factors students considered when analyzing AMS case data and justifying therapeutic decisions, including patient-centered considerations, drug-related elements, AMS interventions, and pharmacists' roles. The clinical reasoning theme described the approaches students used to process the data and reach decisions, distinguishing between systematic and non-systematic strategies. Students demonstrate variation in both the focus and cognitive strategies used to interpret AMS cases. The findings highlight the importance of explicitly teaching clinical reasoning and decision-making in pharmacy programs to enhance students' awareness of their cognitive processes and decision-making skills.

Keywords: Antimicrobial stewardship, Pharmacy education, Clinical reasoning, Think-aloud, Qualitative study

Introduction

Antimicrobial resistance (AMR) remains a significant and growing threat to public health [1]. According to the Centers for Disease Control and Prevention (CDC), the United States experiences over 2.8 million antibiotic-resistant infections annually, resulting in more than 35,000 deaths, emphasizing the need for rapid interventions [2]. One strategy adopted by healthcare organizations to address AMR is the implementation of antimicrobial stewardship programs (ASPs) [3]. For pharmacists to play effective roles in these programs, pharmacy education must prepare students thoroughly during both undergraduate and postgraduate training [3, 4]. The World Health Organization recommends that future healthcare professionals receive comprehensive education regarding appropriate antimicrobial use, infection prevention, and AMR containment [5]. Despite widespread curricular implementation, the way students process AMS data and reach clinical decisions is not well understood.

Clinical reasoning is essential for delivering patient-centered care, a core competency for all healthcare professionals, including pharmacists [6, 7]. The process involves articulating goals, identifying clinical questions, recognizing assumptions and perspectives, evaluating

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patient data, consulting guidelines and literature, and considering factors influencing therapy selection [8]. Several frameworks have been proposed to guide systematic clinical decision-making [9-11]. Educational strategies such as problem-based learning and clinical case presentations have been employed to teach these skills [12]. Prior studies suggest that developing clinical reasoning enhances antimicrobial prescribing decisions and deepens knowledge of appropriate antibiotic use [13–18]. Despite this, no standardized method exists for teaching clinical reasoning effectively [12]. Understanding which information students prioritize when analyzing AMS cases and how it informs their problem-solving is critical. Such insights can guide curriculum design, ensuring that AMS instruction strengthens students' judgment and decision-making abilities in clinical practice. Accordingly, this study aimed to examine students' cognitive strategies and therapeutic decision-making processes in response to AMS cases.

Materials and Methods

Study setting

This investigation took place at the College of Pharmacy, Qatar University, located in Doha, Qatar. The college offers two accredited programs under the Canadian Council for Accreditation of Pharmacy Programs (CCAPP): a Bachelor of Science in Pharmacy (comprising 1 preparatory year and 4 professional years) and a Doctor of Pharmacy (PharmD) program (1 optional postgraduate year). The Infectious Diseases (ID) course is generally taught during the spring semester of the third professional year in the undergraduate program.

Study design

A qualitative case study methodology was employed to explore students' reasoning when analyzing AMS scenarios. The study incorporated a think-aloud approach with verbal protocol analysis, which allowed observation of students' cognitive strategies as they worked through the cases [19].

Study participants

Invitations were sent to all students enrolled in the fourth professional year and PharmD programs. From those who agreed to participate, 10 students from each group were randomly selected. Participants were chosen purposively to include those who had either completed the ID module or had prior experiential exposure to patients requiring AMS-related decisions.

Data collection and analysis

The primary investigator (PI), a clinical assistant professor and board-certified pharmacotherapy and infectious diseases specialist, developed three AMS case vignettes designed to require students' application of stewardship strategies. These cases were reviewed by a board-certified infectious diseases pharmacist and an AMS expert from the United States for content validity. Case details and associated questions are presented in **Table 1.**

One week before the interviews, participants received an AMS refresher from two co-investigators. The refresher included slides summarizing AMS principles, key elements, and recommended ASP practices based on guidelines from the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America [20]. This preparation aimed to reduce cognitive interruptions due to unfamiliarity with AMS concepts.

Table 1. Case vignettes and questions asked

Case 1
A 60-year-old male patient (height 72 inches, weight 100 kg) diagnosed with non-Hodgkin lymphoma and scheduled for chemotherapy presents to the emergency department with fever (temperature 39.6°C), rigors, chills, and reduced appetite. Physical examination reveals significant erythema surrounding his central catheter site. Blood cultures are drawn both centrally and peripherally (four sets total). Twelve hours following admission, all four cultures demonstrate growth of gram-positive cocci in clusters. One month earlier, the patient received treatment for a methicillin-resistant Staphylococcus aureus

(MRSA) skin and soft tissue abscess, consisting of trimethoprim/sulfamethoxazole and incision and drainage. Following catheter removal, the medical team initiates intravenous vancomycin at a dose of 15–20 mg/kg every 8 hours. The patient's most recent serum creatinine level is 0.9 mg/dL. **Question:** What pharmacokinetic/pharmacodynamic principles would you apply to optimise this patient's antimicrobial regimen?
Case 2
A 58-year-old female with a past medical history of recurrent urinary tract infections presents with acute pyelonephritis. She reports allergies to penicillin (reaction type unknown) and sulfonamide drugs. No additional comorbidities are noted. She is empirically started on intravenous meropenem 1 g every 8 hours upon hospital admission. On hospital day 3, her urine culture returns with >100,000 colony-forming units of Escherichia coli, with the following antibiotic susceptibilities (S = Sensitive, I = Intermediate, R = Resistant): Ampicillin/sulbactam R, cefepime S, ceftriaxone S, ciprofloxacin S, ertapenem R, gentamicin I, meropenem R, piperacillin/tazobactam S, trimethoprim/sulfamethoxazole S. **Questions:** 1. From the perspective of antimicrobial stewardship, what management approaches would be most appropriate in this scenario? 2. Under what circumstances would de-escalation to oral antibiotic therapy be considered suitable? Provide justification for your response and recommend a preferred oral agent.
Case 3
A 186-bed acute care hospital has maintained an active antimicrobial stewardship programme for 2 years. Previous initiatives have successfully reduced carbapenem utilisation; however, rates of Clostridioides difficile infection continue to rise. There is institutional overuse of broad-spectrum antipseudomonal beta-lactam antibiotics for empiric therapy, often without clear justification. Once initiated, these agents are frequently continued even when patients show clinical improvement, making discontinuation challenging.

Question: Which antimicrobial stewardship intervention is strongly recommended to improve the selection of appropriate empiric therapy for patients with suspected specific infectious diseases? Provide a clear justification for your recommendation.

Due to the COVID-19 pandemic, all interviews were conducted via ZOOM™. Each co-investigator arranged individual sessions with 10 students each to complete the think-aloud protocol. Students were instructed to verbalize all thoughts while analyzing three cases within 20 minutes. They were prompted to continue speaking if silence exceeded ten seconds. This procedure was consistently applied to all 20 participants.

Transcriptions of the think-aloud sessions were completed verbatim by two co-investigators (DA, SD) and reviewed for accuracy by the senior PI (ZN). The senior researcher trained the coders on qualitative coding techniques using textbooks and examples from prior literature. Transcripts were read repeatedly before coding. Independent coders applied open coding in Microsoft Word® to identify text segments that reflected students' approaches to interpreting, analyzing, and resolving AMS cases. Following initial coding, the research team met to reconcile differences and finalize a coding framework, which was then reviewed by a qualitative research expert (KJ). Related codes were grouped by meaning, and themes were identified through team discussions over a two-month period. Consensus was reached on all final themes and supporting data.

The research team maintained reflexivity, acknowledging how each member's background might influence interpretation. Two authors (DM, SD) were undergraduate pharmacy students with clinical and infectious diseases training. Another author (KW) specialized in educational and qualitative research, while the senior investigator (ZN) brought expertise in infectious disease practice. Discrepancies in interpretation were resolved through open dialogue prior to coding or theme development. Thematic analysis proceeded according to codes agreed upon by consensus.

Results and Discussion

The analysis revealed that students emphasized different aspects of AMS when reviewing cases, and their cognitive strategies varied as they attempted to interpret the provided information. Two primary themes emerged from the data: students' focus and their clinical reasoning approaches.

Theme 1: students' focus

This theme highlights the external elements students considered when interpreting AMS case information to reduce AMR and ensure appropriate antibiotic use while making therapeutic decisions. These factors are described as external because they do not represent the specific steps or reasoning methods employed by students, but rather reflect the aspects that naturally arose in their thinking during decision-making. Four categories were identified under this theme **(Table 2):**

- **Patient-centered factors:** Considerations related to individual patient characteristics, such as allergy history (e.g., selecting alternative therapy for penicillin allergy; quote 2.1), comorbidities, organ function (e.g., dose adjustment), previous infections, and hemodynamic status (e.g., transition to oral therapy; quote 2.2), as well as patient safety (quote 2.3).
- **Drug–bug related factors:** Elements that guided therapeutic choices, including local hospital antibiograms (quote 2.4), interpretation of culture and susceptibility results (e.g., narrowing to a specific antibiotic; quote 2.5), and drug safety considerations (quote 2.5).
- **AMS interventions:** Measures aimed at reducing AMR and promoting appropriate antibiotic use, such as formulary restrictions, preauthorization, prospective audits with feedback, and streamlining therapy (quotes 2.6 and 2.7).
- **Pharmacist's role:** Monitoring safety and effectiveness of therapy (e.g., evaluating patient response, ensuring appropriate therapy duration, tracking adverse effects, conducting therapeutic drug monitoring; quote 2.8) and educating the multidisciplinary team (quote 2.9).

Table 2. Sub-categories within students' focus

Category 1: Patient-centered factors
2.1. "One approach I would consider for this patient is that, given the penicillin allergy is listed as unknown, we should interview the patient and obtain a detailed allergy history. It's crucial to determine the timing, because if the reaction occurred more than 10 years ago, an assessment and re-challenge would reveal that more than 95% of such patients do not actually have a true penicillin allergy." – Participant 5
2.2. "I would switch from intravenous to oral therapy once the patient is clinically stable. Pyelonephritis is a serious infection, so I would ensure that the patient is fully stable with all vital signs normal. Converting to oral therapy earlier, if possible, would help reduce hospital length of stay and lower the risk of acquiring a nosocomial infection." – Participant 13
2.3. "Regarding pharmacokinetic/pharmacodynamic principles, we should calculate the dose according to the patient's weight and evaluate renal function to determine whether any adjustments are needed based on renal clearance." – Participant 13
Category 2: Drug-bug related factors
2.4. "Empiric therapy should be tailored according to local institutional resistance patterns and the national antibiogram." – Participant 2
2.5. "We now have culture results and susceptibility data identifying the organism. Meropenem is excessively broad-spectrum as it covers Pseudomonas, whereas the isolated pathogen is a gram-negative E. coli, so we should de-escalate and narrow the antibiotic selection." – Participant 4
Category 3: AMS interventions
2.6. "If there is currently no preauthorization requirement for specific antipseudomonal beta-lactams, I would recommend implementing a system restriction where physicians cannot order these agents for more than 2 days, or for a defined duration, without approval from the infectious diseases team." – Participant 3
2.7. "The healthcare team should review the patient's chart and determine whether the antibiotic can be de-escalated to a narrower-spectrum agent." – Participant 1
Category 4: Pharmacist's role
2.8. "For vancomycin, therapeutic drug monitoring is essential—specifically measuring trough levels—to ensure both efficacy and safety in treating MRSA." – Participant 13
2.9. "I would focus on educating healthcare teams about antibiotic misuse, its associated risks, and potential complications. They need greater awareness of antimicrobial stewardship principles, its advantages, and how to prioritise what is truly best for the patient." – Participant 10

Theme 2: students' approach to case interpretation

This theme describes students' clinical reasoning, including the strategies and cognitive approaches they applied to analyze data and arrive at therapeutic decisions. Participants demonstrated varying reasoning patterns, which were evident in their verbalizations during case solving. These approaches were grouped into systematic (quotes 3.1–3.7) and non-systematic (quotes 3.8–3.12) strategies, reflecting how students processed information and reached conclusions **(Table 3).**

Table 3. Students' approach to case interpretation

Systematic approach
Critical thinking

3.1. "For empiric therapy, it needs to be started promptly because these cases are often time-critical. Empiric treatment would be initiated immediately based on the on-call prescriber's decision within the first 48 hours, but any continuation beyond 48 hours would require approval from the infectious diseases team. I believe this is an effective strategy to allow rapid initial optimisation while facilitating transition to definitive therapy once culture results become available." – Participant 18 Three-factor approach: Patient-Drug-Bug

3.2. "First, we must consider patient, drug, and organism factors. The patient has recurrent urinary tract infections and now pyelonephritis; regarding the organism, E. coli has been isolated and is resistant to meropenem, which was started empirically, so we can now de-escalate to an agent that appropriately covers E. coli." – Participant 10

3.3. "The patient has a prior history of MRSA, and the current presentation involves a central line-associated skin infection that could again be due to MRSA. Vancomycin provides coverage for MRSA, so I consider it a suitable choice for this patient." – Participant 17 Elimination approach based on sensitivity results and allergy assessment

3.4. "A third-generation cephalosporin would be appropriate for this patient since she cannot use trimethoprim/sulfamethoxazole due to her sulfa allergy." – Participant 5

3.5. "I would further evaluate the sulfa allergy; if it is not a true allergy, I would select trimethoprim/sulfamethoxazole because the organism is susceptible to it and it offers an oral formulation. I would transition to oral therapy as soon as the patient is clinically stable." – Participant 18 Evidence/Clinical-based decisions

3.6. "I would consult the Sanford Guide or the local Hamad Medical Corporation guidelines to verify my recommendation." – Participant 11

3.7. "I would refer to established guidelines for my recommendation, such as those from the CDC, and I would also review the local antibiogram." – Participant 10

Non-systematic approach

Disturbed thought process

3.8. "So I would choose trimethoprim. Oh no, she has a sulfa allergy. Then I would still go with trimethoprim. Oh God, why do I keep returning to trimethoprim?" – Participant 2 Knowledge deficit/Misinterpretation of questions

3.9. "I don't recall the standard treatment for UTI right now. I really have no idea at the moment. This one I cannot remember at all." – Participant 20 Lapses and slips (lack of focus)

3.10. "She is on meropenem, and the report shows it is sensitive, so mmmm, I think I would continue it." – Participant 19 Incertitude

3.11. "I'm not sure how we actually incorporate effective considerations into the decision-making process." – Participant 16

3.12. "I know that Bactrim would be a good option for the patient, and I also know that cephalosporins could be used. So one of those—I'm not certain. OK, perhaps I'll choose Bactrim." – Participant 7

The study aimed to examine the cognitive processes of students when interpreting AMS cases. Two central themes emerged: students' focus and clinical reasoning approaches. Students' focus encompassed the external factors considered in decision-making, including patient-centered factors, drug-related considerations, AMS interventions, and the pharmacist's role. Clinical reasoning captured the methods and strategies students employed to analyze cases and reach clinical decisions, including systematic versus non-systematic approaches. Participants highlighted several key factors that dominated their attention during case analysis. These elements align with the core principles of pharmaceutical care, which prioritize optimizing therapy and ensuring patient safety [21]. The findings also correspond with the ASHP's recommendations regarding pharmacists' roles in AMS [22]. Additionally, participants agreed that AMS interventions reduce AMR and enhance antimicrobial prescribing practices [20, 23]. The identified subthemes align with CDC core elements for hospital-based ASPs, reinforcing their relevance in practical stewardship programs [24].

Our results align with recognized limitations of the hypothetic-deductive model, originally developed in the context of general practice [25]. Yazdani *et al*. propose a more comprehensive framework that incorporates characteristics specific to general practice [25]. In contrast, our study specifically examined AMS, and participants primarily concentrated on optimizing antimicrobial therapy and emphasizing the application of AMS interventions. These findings are consistent with Gruenberg *et al*., who described a framework for pharmacists' antimicrobial therapeutic reasoning, highlighting their AMS role and decision-making for selecting appropriate antimicrobial regimens [26].

Students who used a systematic approach demonstrated methodical reasoning in solving cases. This aligns with prior research analyzing clinical decision-making among experienced pharmacists in ambulatory care settings [27]. Additionally, the clinical reasoning strategies observed in our study correspond with patterns reported in studies examining physicians' antimicrobial prescribing [18]. While there were similarities in reasoning patterns between students and other healthcare professionals, a key distinction is that previous work focused on experienced pharmacists managing complex patients, whereas our study examined pharmacy students working with less complex AMS scenarios [27].

An important, though less commonly used, cognitive strategy was critical thinking. Students employing this strategy demonstrated logical analysis, accurate application of knowledge, and contextual adaptation of information to the specific case. This enabled them to reach clinical recommendations systematically, underscoring the importance of critical thinking in effective clinical reasoning and problem-solving [28–31]. During think-aloud sessions, some participants relied on clinical guidelines or hospital protocols, whereas others drew from personal experiential learning. Across cases, students considered multiple patient-centered and drug-related factors, representing core AMS determinants that support pharmacists in decision-making [27].

Conversely, spontaneous verbalization sometimes led to non-systematic reasoning. Some students became disorganized, unfocused, or uncertain, resulting in incomplete or absent case responses. Cognitive errors—including knowledge gaps, slips, or lapses—may have contributed to disruptions in reasoning [32, 33]. Notably, gaps in infectious disease knowledge were identified and highlight areas for targeted re-education, particularly regarding AMS [34]. Hesitancy and indecisiveness emerged as common non-systematic behaviors, reflecting uncertainty in reasoning.

A key strength of this study is the use of real-time interviews to capture thought processes and decision-making. However, several limitations exist. A sample size of twenty students was assumed sufficient to capture relevant outcomes. Although small, this sample allowed observation of diverse reasoning patterns, further strengthened by assigning each student three AMS cases rather than a single case to generate richer data. Data saturation was observed as repeated codes emerged after approximately two-thirds of transcripts had been analyzed, consistent with other think-aloud studies using small samples [35, 36]. Some AMS cases were perceived as too general by certain participants, leading to misinterpretation, but since the focus was on thought processes rather than correct answers, this minimally affects reliability. Another limitation is that findings reflect pharmacy students' reasoning, which may not generalize to expert clinical pharmacists. The prospective think-aloud methodology limits participants' reflection or reinterpretation of thoughts, reducing errors related to recall, unlike retrospective or stimulated recall methods [37, 38]. According to Ericsson and Simon, even incomplete thought processes in think-aloud studies do not compromise reliability; verbatim transcription provides a trustworthy reflection of cognitive activity [39]. Our inductive thematic analysis further strengthens the robustness of these qualitative findings compared with deductive approaches [40].

The study has clear implications for curriculum development. Results show that students employ varied approaches in AMS case decision-making and sometimes struggle to apply systematic reasoning. Educators should target these skills directly, rather than assuming that AMS concepts will naturally transfer from other areas of patient care. AMS case decision-making introduces complexity by integrating population-level factors such as AMR and institutional antimicrobial susceptibility data. Students who consider these factors are better positioned to apply systematic reasoning and make sound decisions. Incorporating AMS decision-making into academic programming may enhance students' focus and reasoning skills. The findings clarify the elements students emphasize and the cognitive strategies they employ in clinical reasoning, offering guidance for future educational interventions.

Conclusion

Students differ in both their focus and cognitive strategies when interpreting AMS cases. This supports the need for explicit instruction in clinical reasoning and decision-making within pharmacy curricula to enhance students' awareness of their cognitive processes. Future research should evaluate interventions designed to encourage systematic and focused approaches in AMS case analysis.

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