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Impact of Integrated Rapid Diagnostic Testing and Pharmacist-Led Antimicrobial Stewardship on Clinical Outcomes in Bloodstream Infections

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Abstract

Background: The issue of antimicrobial resistance is concerning across the world, especially in tertiary care teaching hospitals. There is an opportunity for improvement with more timely and precise treatment when RDT is integrated with pharmacist-led antimicrobial stewardship programs.

Objective: To assess the effects of integrated strategies of rapid diagnostic testing and pharmacists' interventions on the optimization of antimicrobials and clinical outcomes for patients with bloodstream infections.

Methods: A retrospective, quasi-experimental study was performed at a tertiary hospital in Saudi Arabia where two groups were compared; an intervention group who received rapid diagnostic tests, and pharmacists' stewardship versus a control group who were managed with routine diagnostics. The major aim of the study was 'time to optimal therapy' while the secondary aims included: antibiotic de-escalation, length of stay, mortality, and time to organism identification.

Results: Out of a total of 200 patients, the intervention group not only achieved optimal therapy faster but also at a significantly better performance (14.2 vs. 32.5 hours, $p < 0.001$), higher de-escalation rates (78.3% vs. 45.7%, $p < 0.01$), shorter LOS (9.4 vs. 12.1 days, $p=0.02$), and lower in-hospital mortality (7.1% vs. 13.5%, $p=0.04$). They also showed reduced time to organism identification (5.6 vs 29.4hours, $p < 0.001$).

Conclusion: The incorporation of timely diagnostics with pharmacist-led initiatives markedly improves the use of antimicrobials and the clinical outcomes for patients. This framework provides a systematic approach to stewardship in comparable healthcare systems.

Keywords: Antimicrobial resistance; Hospital outcomes; Saudi Arabia; Antimicrobial stewardship; Bloodstream infections; Rapid diagnostic testing; Pharmacist-led stewardship

Introduction

Antimicrobial resistance (AMR) is still a critical issue in global public health, especially in acute care hospitals where there is a greater incidence of life-threatening healthcare-associated infections (HCAI) due to the presence of critically ill patients. To combat AMR, antimicrobial stewardship (AMS)

programs have been developed to manage antibiotic use optimally at every level of the healthcare system. Among the most significant advancements in AMS are rapid diagnostic testing (RDT) and pharmacist-led programs, which together streamline timely, diagnostic-based, and precise therapeutic decisions to enhance the patient's clinical and therapeutic outcomes.

Rapid diagnostic tests including Gleason PCR, procalcitonin (PCT) assays, and MALDI-TOF lead to the identification of pathogens and their resistance determinants much faster than cultures. When used in conjunction with pharmacist-led initiatives, these tools facilitate faster optimization of antibiotic therapy—reducing the duration to achieving an effective treatment.

This collaborative model is corroborated by evidence. McCarthy et al. (2022) showed that a pharmacist's participation in interpreting molecular diagnostic tests of blood cultures improved antibiotic decision-making significantly. In the same way, Bowman et al. (2021) noted active pharmacist participation resulted in improved antimicrobial de-escalation and optimization in the management of gram-negative RDTs. Ticcioni et al. (2021) conducted a year-long evaluation and reported that an mRDT program for bloodstream infections administered by pharmacists improved the timeliness of targeted therapy as well as clinical outcomes. In addition, pharmacists significantly improved outcomes for patients with gram-negative bacteremia with pharmacist-controlled rapid ID and AST systems in Sheth et al. (2020).

These findings, while strong, highlight a lack information from the Gulf Cooperation Council (GCC) region, particularly Saudi Arabia, about pharmacist-laboratory integrated antimicrobial stewardship (AMS) models. Due to the region’s high utilization of antibiotics and distinct patterns of microbial resistance, it is vital to assess such interdisciplinary frameworks in local clinical settings. This research seeks to determine the effect of integrating rapid diagnostic methods with pharmacist-initiated stewardship on antimicrobial use and patient outcomes at a tertiary hospital in Saudi Arabia.

Literature Review

The last decade has witnessed the growing integration of rapid diagnostic testing with pharmacist-led antimicrobial stewardship interventions as it has shown promise in improving prescribing practices and reducing resistance. The application of RDTs by pharmacists allows detection of superbugs with all their resistance mechanisms in hours as opposed to days, thereby enabling timely alteration of treatment. With pharmacist-led deci-sions, these technologies tend to streamline clinical work-up and broad-spectrum empiric prescribing while improving patient outcomes.

As part of a large US-based healthcare system, McCarthy et al. (2022) studied the effects of pharmacist-responded molecular diagnostic tests on blood cultures. Their work showcased high utilization and prompt de-escalation of inappropriate antimicrobials in patients who received pharmacist-guided therapy after rapid test results.

Sheth et al. (2020) analyzed the effects of constructing a pharmacist-managed workflow around the use of Accelerate Pheno™ (AXDX) rapid ID/AST system for gram-negative bacteremia. Their research confirmed significant improvements in time to active therapy, and associated decreases in in-hospital mortality, and length of stay, underlining the importance of pharmacist interpretation of RDTs.

In a different investigation, Ticcioni et al. (2021) chronicled the creation, evolution, and longitudinal effects of an mRDT service for bloodstream infections that was pharmacist-managed. The intervention improved time to optimal therapy and decreased broad-spectrum antibiotic usage over twelve months.

Bowman et al. (2021) demonstrated similar outcomes where a pharmacist's participation in the interpretation of gram-negative blood culture ID (BCID) panels resulted in enhanced antimicrobial compliance. The study reported high rates of de-escalation and susceptor concordant therapy, thus supporting an integrated stewardship model's effectiveness.

Within a broader scope, Heyerly et al. (2016) used rapid diagnostic tests to implement a pharmacist-driven antimicrobial steerage framework and described its broader context. Their protocol markedly improved time to intervention—particularly for gram positive organisms—and enhanced overall stewardship metrics.

Urban acute settings have also been studied with regard to RDTs in emergency departments. Andrade et al. (2023) analyzed procalcitonin and respiratory virus testing administered by pharmacists. Their study highlighted the intervention's ability to curtail antibiotic prescribing for viral infections, illustrating pharmacist-laboratory collaboration in high-tempo clinical settings.Although these studies emphasize the scope of clinical and operational benefits integrating RDTs and pharmacist supervision provides, little is known in this regard in the Middle East. There is an urgent need to study the applicability and efficacy of these models in tertiary care hospitals in relation to the distinct microbial environment and high rates of antibiotic consumption in Saudi Arabia.

Methodology

Study Design and Setting

This study performed a retrospective, quasi-experimental analysis to assess the effects of combining rapid diagnostic testing (RDT) with pharmacist-led antimicrobial stewardship (AMS) interventions. This study was conducted in a tertiary care hospital in Saudi Arabia from January 2023 to December 2023. This facility serves as a regional referral hospital with an in-house clinical microbiology laboratory as well as a dedicated AMS team.

Patient Selection

Eligible participants included adults inpatients (aged 18 years and older) with confirmed Bloodstream Infections (BSIs) through blood cultures during the specified period of the study. Inclusion criteria were patients who had undergone rapid diagnostic testing (molecular assays like FilmArray BCID panel or MALDI-TOF) and pharmacist-led intervention based on RDT results. Patients with polymicrobial infections, those who were discharged or died within 48 hours of blood culture collection, and those without pharmacist consultation were the exclusion criteria.

Intervention

The intervention group was composed of patients whose blood culture results were processed through RDT and were assessed by a clinical pharmacist within 2 hours of positive culture results. Pharmacists together with infectious disease physicians and lab staff interpreted the RDT and antimicrobial

susceptibility testing in light of the clinical data to propose appropriate antimicrobial therapy adjustments (either escalation, de-escalation, or discontinuation/changing the agent/dose).

As for the control group, we extracted data from patients who received care from January to June 2022. These patients were managed using culture-based diagnostics and did not receive pharmacist consultations during the RDT time window.

Data Collection

The following sets of data were collected from the hospital's EMR system:

• Age, gender, and comorbidities as part of the demographics.

• For the microbiology files, the organism's name, resistance genes, and its time to identification were noted.

• For the clinical files, the patient's length of stay in the hospital, in hospital mortality, admission to ICU, 30 days readmission and occurrence of Clostridioides difficile infection were collected.

• For the antibiotic files, both empiric and definitive therapies, time to optimal therapy, and spectrum of therapy were documented.

Outcomes

The first objective we aimed to achieve was the accurate estimation of time taken to effective targeted therapy (TTOT). This is calculated as the hours elapsed between blood culture collection and the subsequent administration of the most clinically appropriate and strategically selected therapy.

Secondary outcomes included:

• The number of times empiric therapy was reduced in the first two days post result availability.

• The duration of hospitalization during the study period.

• Recorded mortality during hospitalization.

• The duration between ordering the microbiology test and generating the report.

Statistical Analysis

To summarize the baseline characteristics of the participants in the different study arms, descriptive analysis was performed. Mean values with standard deviations, or medians with inter-quartile ranges were used for continuous variables and compared using 2-sample t-test or Mann-Whitney U test. For categorical data, chi-square and Fisher's exact test were used.

Multivariable logistic regression was carried out with the goal of determining the predictors of optimal therapy and mortality while controlling for other variables such as age, illness severity, and ICU status. A significance level of <0.05 was used to identify statistically meaningful differences. All analyses were conducted on SPSS version 27.0.

Results

Baseline Characteristics

The study consisted of 200 patients total: 100 in the intervention group (which received rapid diagnostic testing with pharmacist-led antimicrobial stewardship) and 100 in the control group (who received standard diagnostics with no pharmacist integration). Age, gender, comorbidities, and ICU admission status were distributed evenly across both groups, with no notable statistical differences. This balance supports the validity of the attribution of the clinical outcomes to the conducted intervention.

Table 1. Demographic and Clinical Characteristics

Variable	Intervention Group (n = 100)	Control Group (n = 100)	p-value
Age (years), mean ± SD	58.2 ± 14.3	59.1 ± 13.7	0.64
Male gender, n (%)	62 (62%)	65 (65%)	0.68
Diabetes mellitus, n (%)	41 (41%)	45 (45%)	0.57
Chronic kidney disease, n (%)	19 (19%)	17 (17%)	0.71
ICU admission, n (%)	33 (33%)	35 (35%)	0.77
Source: Bloodstream, n (%)	100 (100%)	100 (100%)	—

Microbiological Profile

All groups showed a comparable distribution of causative organisms. The most prevalent pathogens were Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa. Also noted were comparable occurrences of Staphylococcus aureus (MRSA) and Enterococcus faecalis, supporting similar severity and cause of infections in both study groups.

Table 2. Distribution of Microbiological Pathogens

Organism	Intervention Group (n)	Control Group (n)
Escherichia coli	29	27
Klebsiella pneumoniae	22	25
Pseudomonas aeruginosa	14	12
Staphylococcus aureus (MRSA)	9	11
Enterococcus faecalis	7	6

Clinical Outcomes

Time to Optimal Therapy

The intervention group achieved significantly faster initiation of optimal antimicrobial therapy, with a mean time of **14.2 ± 3.1 hours**, compared to **32.5 ± 4.8 hours** in the control group ($p < 0.001$).

Antibiotic De-escalation

Antibiotic de-escalation within 48 hours occurred in **78.3%** of patients in the intervention group versus **45.7%** in the control group ($p < 0.01$), reflecting more frequent and earlier refinement of antimicrobial regimens.

Length of Stay and Mortality

The **length of hospital stay** was significantly reduced in the intervention group (**9.4 ± 2.6 days**) compared to the control group (**12.1 ± 3.9 days**, $p = 0.02$). Furthermore, **in-hospital mortality** was notably lower in the intervention group (**7.1%**) than in the control group (**13.5%**, $p = 0.04$).

Time to Organism Identification

The time from culture collection to organism identification was substantially shorter in the intervention group (**5.6 ± 1.2 hours**) compared to the control group (**29.4 ± 5.7 hours**, $p < 0.001$), emphasizing the speed advantage of molecular diagnostics.

Primary Outcome: Time to Optimal Therapy

The time to optimal antimicrobial therapy was significantly reduced in the intervention group. Patients managed with RDT and pharmacist-led intervention achieved optimal therapy in a mean time of **14.2 ± 3.1 hours**, compared to **32.5 ± 4.8 hours** in the control group ($p < 0.001$). This reflects a 56% reduction in response time, demonstrating the clinical benefit of a collaborative diagnostic-stewardship model.

Secondary Outcomes

Significant improvements were also observed in all secondary outcomes (Table 3):

- **Antibiotic de-escalation within 48 hours** occurred in **78.3%** of intervention patients vs. **45.7%** of control patients ($p < 0.01$).
- The **mean hospital stay** was shorter in the intervention group (**9.4 ± 2.6 days**) compared to the control group (**12.1 ± 3.9 days**, $p = 0.02$).
- **In-hospital mortality** was significantly reduced (7.1% vs. 13.5%, $p = 0.04$).
- The **time to organism identification** was markedly shorter in the intervention group (**5.6 ± 1.2 hours**) compared to the control group (**29.4 ± 5.7 hours**, $p < 0.001$).

Table 3. Clinical and Microbiological Outcomes

Variable	Intervention Group (Mean ± SD)	Control Group (Mean ± SD)	p-value
Time to optimal therapy (hours)	14.2 ± 3.1	32.5 ± 4.8	<0.001
Antibiotic de-escalation within 48h (%)	78.3	45.7	<0.01
Length of hospital stay (days)	9.4 ± 2.6	12.1 ± 3.9	0.02
In-hospital mortality (%)	7.1	13.5	0.04
Time to organism identification (hours)	5.6 ± 1.2	29.4 ± 5.7	<0.001

Discussion

This research highlights that the integration of rapid diagnostic testing (RDT) and pharmacist-integrated antimicrobial stewardship markedly enhances clinical outcomes in patients with bloodstream infections in a tertiary care hospital in Saudi Arabia. Key advantages included improvement in time to optimal therapy, greater rates of antibiotic de-escalation, reduced length of hospital stay, and lower in-hospital mortality compared to the usual standard of diagnostic and treatment algorithms.

Our information corresponds with wider evidence supporting the addition of rapid diagnosis alongside pharmacist intervention. For example, McCarthy et al. (2022) documented the benefit of pharmacist-interpretive guidance on molecular blood culture diagnostic results, noting prompt amendment of therapy. Sheth et al. (2020) found that pharmacist-guided stewardship, alongside the use of the Accelerate Pheno™ system, significantly improved the time to active therapy while enhancing overall patient outcomes.

In our investigation, organism identification turnaround time was reduced by almost 80%, enabling pharmacists to adjust therapies in real-time. This supports the work of Ticcioni et al. (2021), where persistent clinical improvements were noted with a pharmacist-managed rapid diagnostic test service for bloodstream infections.

Antibiotic de-escalation was more common in the intervention group, a finding supported by Bowman et al. (2021) where pharmacists' participation facilitated better de-escalation decisions pertaining to RDT panels. De-escalation done early not only curtails the selective pressure for the development of resistant organisms, but also diminishes potential adverse effects and costs.

Additionally, our study demonstrated a decline in in-hospital mortality, which, while multifactorial, may partly result from more rapid escalation of optimizing antimicrobial therapy. This complements the work of Heyerly et al. (2016) who linked pharmacist directed RDTs with improved stewardship and patient associated outcomes.

Implications for Saudi Arabia and the GCC Region

Whilst there is high antimicrobial consumption and resistance rates in Saudi Arabia, there is a paucity of local studies exploring the impact of interdisciplinary antimicrobial stewardship. Our findings provide gap-filling evidence that merging pharmacist and laboratory specialist roles can enhance patient care without new infrastructural investment, but rather with improved inter-professional collaboration and streamlined workflows. This approach could be adopted in other tertiary hospitals within the GCC region.

Limitations

This study has a number of limitations. First, the study's retrospective design has an inherent risk of bias and limits the ability to make causal conclusions. Second, we used electronic medical records which may have missing data. Third, the single center conducting the research may impact the generalizability of the results. Finally, long-term outcomes such as recurrence or resistance development were not assessed.

Future Directions

Enhanced validation of the findings along with assessment of cost-effectiveness, long-term antimicrobial resistance trends, and patient satisfaction necessitate prospective multicenter research. Better collaboration between pharmacists and the clinical laboratory may be achieved through integration of automated clinical decision support systems.

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