Original Article

An Antibiogram Study for Improving Infection Control and Antimicrobial Treatment in Misan Hospitals

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Abstract

Background: Infection control and effective antimicrobial treatment are essential in healthcare systems, especially within hospital settings. Misan Governorate, Iraq, faces unique challenges in managing infectious diseases due to its diverse population with distinct healthcare needs. **Objectives:** This study aimed to investigate the prevalence of bacterial infections and their antimicrobial resistance patterns in Misan, and to develop antibiograms to guide infection control and antimicrobial treatment strategies. **Materials and Methods:** A total of 160 specimens were collected from Al-Sadder Teaching Hospital and Misan Children and Maternity Hospital in Misan, south of Iraq, during the span of four months. Various sample types were obtained, including urine, blood, wound, sputum, ear swab, and cerebrospinal fluid. Bacterial identification was performed using the VITEK-2 system. Antimicrobial susceptibility testing was conducted using the Kirby-Bauer disc diffusion technique. **Results:** *Staphylococcus spp.* was the most prevalent pathogen, accounting for 53% of the isolates, followed by *Klebsiella pneumoniae* (14%) and *Escherichia coli* (10%). Tigecycline and vancomycin demonstrated the highest efficacy against *Staphylococcus spp*., while meropenem and imipenem showed excellent activity against *Klebsiella spp.* and *E. coli.* However, *Enterobacter spp.* exhibited low activity against carbapenems. *P*seudo*monas spp*. showed full susceptibility to meropenem, imipenem, amikacin, and gentamicin. **Conclusion:** This study emphasizes infection control and antimicrobial stewardship in Misan teaching hospitals. High *Staphylococcus spp.* prevalence calls for effective measures. Antibiograms aid therapy selection. Meropenem, imipenem, and amikacin remain effective against *K. pneumoniae* and *E. coli*, but *Enterobacter spp*. show carbapenem resistance, urging careful antibiotic use. Monitoring resistance trends is vital for improved Misan teaching hospital care.

Keywords: Antibiogram, antimicrobial treatment, hospital acquired infections, infection control

Introduction

Infection control and effective antimicrobial treatment are vital components of healthcare systems worldwide, particularly within hospital settings.[1] Hospitals play a critical role in diagnosing, treating, and preventing the spread of infectious diseases.[2,3] Therefore, recognizing and prioritizing the significance of infection control practices and the use of appropriate antimicrobial therapies are essential.[4] Misan Governorate, Iraq, emerges as a significant region to investigate, given its unique healthcare landscape and the challenges it faces in managing infectious diseases. Misan hosts a diverse population with distinct healthcare needs, making it imperative to study the prevalence of bacterial infections and their antimicrobial resistance patterns in this setting.

The appropriate use of antimicrobial agents is fundamental to successfully treating bacterial infections.[5] However, the emergence and spread of antimicrobial-resistant bacteria pose a significant threat to global public health.[6,7] Antimicrobial resistance occurs when bacteria develop mechanisms to withstand the effects of antibiotics, rendering them ineffective.[8,9] Misuse and overuse of antimicrobials contribute significantly to the development of resistance. Antimicrobial stewardship programs have

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Quick Response Code:	
	Website: https://journals.lww.com/mjby
	DOI: 10.4103/MJBL.MJBL_362_24

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Submission: 07-May-2024 **Accepted:** 06-Jun-2025 **Published:** 23-Jul-2025

How to cite this article: Mahmood AK, Hasan RA. An antibiogram study for improving infection control and antimicrobial treatment in Misan hospitals. Med J Babylon 2025;22:S24-9.

thus been established to promote the judicious use of antimicrobials, optimize treatment regimens, and combat antimicrobial resistance.[10] These programs emphasize accurate diagnosis, appropriate selection of antimicrobial agents, optimal dosing, and duration of therapy. Implementing antimicrobial stewardship programs enhances patient outcomes, minimizes the emergence of resistant organisms, and preserves the effectiveness of existing antibiotics.[11]

Antibiograms play a critical role in guiding effective treatment strategies. An antibiogram is a collection of antimicrobial susceptibility testing results for a specific group of bacterial isolates. It provides valuable information regarding the local resistance patterns of bacteria to different antibiotics.[12] Antibiograms enable healthcare providers to make evidence-based decisions when selecting appropriate empiric antimicrobial therapy. By considering local resistance patterns, healthcare professionals can prescribe the most effective antibiotics and tailor treatment regimens based on individual patient needs.[13] Furthermore, antibiograms help monitor trends in antimicrobial resistance, identify emerging resistance patterns, and guide the development of antimicrobial stewardship initiatives. The data collected from antibiograms are instrumental in updating treatment guidelines, enhancing empirical therapy protocols, and optimizing patient outcomes.[14,15]

Materials and Methods

Specimen collection

Specimen collection for the antibiogram study was conducted at two major hospitals in Misan, Iraq, Al-Sadder Teaching Hospital and Misan Children and Maternity Hospital, during the span of four months. The study obtained ethical approval from the Iraqi Ministry of Health. A total of 160 specimens were collected, representing various sample types. The largest proportion of specimens consisted of urine samples (*n* = 106, 66.3%), followed by samples obtained from wounds, burns, and skin lesions (*n* = 23, 14.4%). Blood samples accounted for 10.6% (*n* = 17) of the total, while sputum samples represented 4.4% (*n* = 7). Ear swabs constituted 3.8% (*n* = 6) of the specimens, and a single cerebrospinal fluid (CSF) sample was collected, accounting for 0.6% of the total. All samples were collected using appropriate techniques and were properly labeled to ensure accurate identification and traceability. The study adhered to the necessary ethical considerations and guidelines to ensure patient safety throughout the specimen collection process.

Isolation and identification of bacteria

The collected samples were streaked on MacConkey agar, blood agar, and eosin methylene blue agar, followed by incubation at 37°C for 24 h. Colonies were identified based on morphology, gram staining, and biochemical properties. The isolated macro-organisms included *Staphylococcus spp.* (*n* = 82), *Klebsiella pneumoniae* (*n* = 22), *Escherichia coli* (*n* = 16), *Enterobacter* (*n* = 13), *Pseudomonas spp.* (*n* = 13), *Proteus* (*n* = 3), *Streptococcus spp.* (*n* = 3), and *Salmonella spp.* (*n* = 2). Verification was done using the VITEK-2 system with bacterial isolates inoculated, cultured, and incubated at 37°C overnight. The suspension's turbidity was adjusted, and the bacterial suspension tubes were loaded into the VITEK-2 system for identification according to the manufacturer's instructions.

Antimicrobial susceptibility testing

Using the standardized Kirby-Bauer disc diffusion technique according to the criteria of the Clinical and Laboratory Standards Institute, an antimicrobial susceptibility pattern was conducted for all positive isolates. On the surface of Mueller-Hinton agar, antibiotic-impregnated discs of various antibiotics were placed. These included meropenem (0.20–0.25 μg), imipenem (0.25–0.37 μg), amikacin (1.25–2.13 μg), gentamycin (0.69–2.53 μg), trimethoprim (20 μg), ciprofloxacin (0.42–0.56 μg), vancomycin (0.80–0.88 μg), clindamycin (0.25 μg), moxifloxacin (0.32 μg), tigecycline (0.15–0.20 μg), and rifampin (0.56 μg). To ensure the quality of culture and as controls for antimicrobial susceptibility testing, standard strains of *Staphylococcus spp*., *Klebsiella spp*., *E. coli*, *Enterobacter spp*., and *Pseudomonas. spp*. were employed.

Results

In this study, a comprehensive antibiogram analysis was conducted to assess the antimicrobial susceptibility patterns of bacterial isolates obtained from 160 clinical samples collected from two major hospitals in Misan, south of Iraq, namely Al-Sadder Teaching Hospital and Misan Child and Maternity Hospital. The samples were derived from diverse sources, as depicted in Figure 1. Urine samples constituted the highest proportion of specimens, accounting for 66% of the total, followed by blood samples at 11%, wound and burn samples at 14%, sputum samples at 4%, and ear swab samples at 4%.

Among the isolated bacterial species, *Staphylococcus spp.* was the most prevalent, accounting for 51 isolates, followed by *Klebsiella spp.* with 14 isolates and *E. coli* with 10 isolates. The remaining bacterial species, including *Enterobacter spp*., *Pseudomonas spp*., *Proteus*, *Streptococcus spp*., and *Salmonella spp*., were observed in lower frequencies. Figure 2 displays the prevalence of isolated bacterial species across all analyzed samples.

The prevalence of isolated bacterial species within specific sample sources is illustrated in Figure 3. Among urine samples [Figure 3A], *Staphylococcus spp*. and *Klebsiella spp*. were the predominant pathogens. In blood samples [Figure 3B], *Staphylococcus spp*. and *Enterobacter spp*. were the main isolates. Meanwhile, *Staphylococcus spp*.

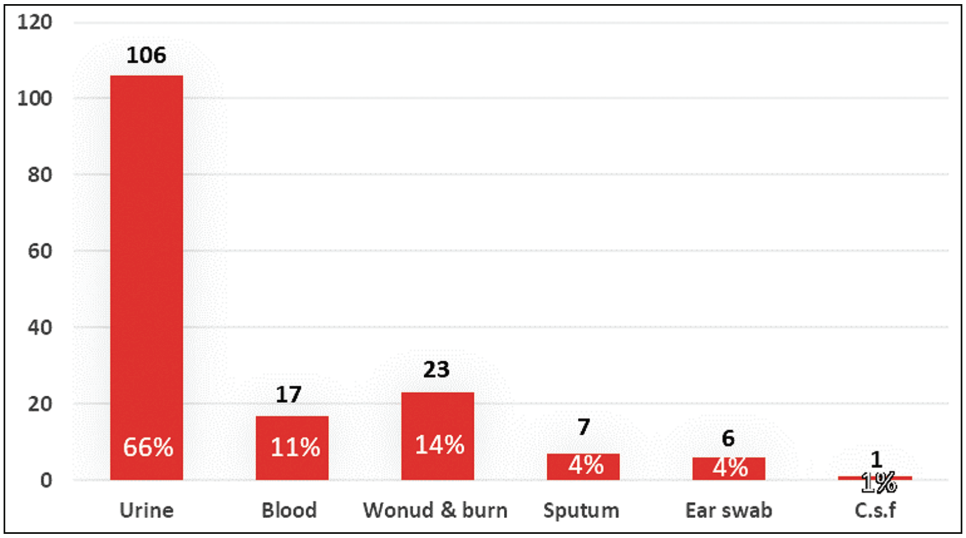

Figure 1: The proportions of collected specimens

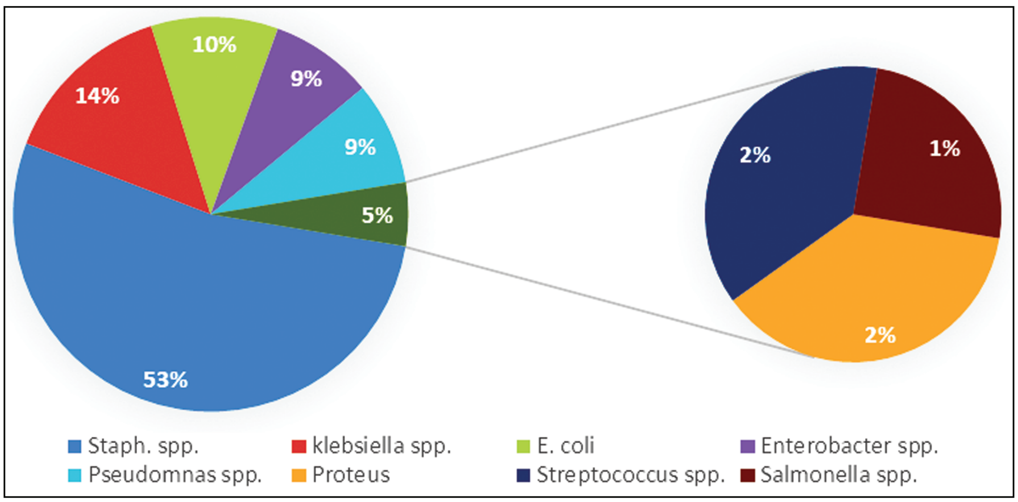

Figure 2: Prevalence of isolated pathogens included

dominated the wound and burn samples [Figure 3C]. The sputum samples [Figure 3D] displayed a diverse range of bacterial isolates, including *Pseudomonas spp*. and *E. coli*. Lastly, in ear swab samples [Figure 3E], *Staphylococcus spp*. and *Pseudomonas spp*. were identified as the prevalent bacterial species.

The results of the antibiogram study revealed diverse susceptibility patterns and minimum inhibitory concentration (MIC) values among the isolated bacterial species as tabulated in Table 1. Among the *Staphylococcus spp.* isolates (82 in total), high susceptibility was observed for meropenem (90% with MIC < 0.20) and imipenem (90% with MIC < 0.25). However, no isolates showed susceptibility to ciprofloxacin. Notably, a significant proportion of *Staphylococcus spp*. isolates exhibited resistance to clindamycin (34% with MIC = 0.25) and moxifloxacin (44.9% with MIC = 0.32).

Among the *Klebsiella spp.* isolates (22 in total), meropenem and imipenem demonstrated notable efficacy, with 90% of isolates showing susceptibility (MIC < 0.20 and MIC < 0.25, respectively). However, a considerable proportion of *Klebsiella spp.* isolates displayed susceptibility to amikacin (80% resistant). The susceptibility rate for ciprofloxacin was moderate, with 53% of isolates being susceptible (MIC < 0.56).

E. coli isolates (16 in total) exhibited high susceptibility rates to meropenem (100% with MIC < 0.25), imipenem (100% with MIC < 0.25), and amikacin (100% with MIC < 2.36). However, a notable proportion of *E. coli* isolates displayed resistance to gentamicin (63.6% with MIC > 1.20) and trimethoprim (43.4% with MIC > 20.00) which highlights the emergence of resistance among *E. coli* strains and emphasizes the importance of judicious use of antibiotics to maintain their effectiveness. Figure 4 illustrates the antibiogram analysis for different bacterial species.

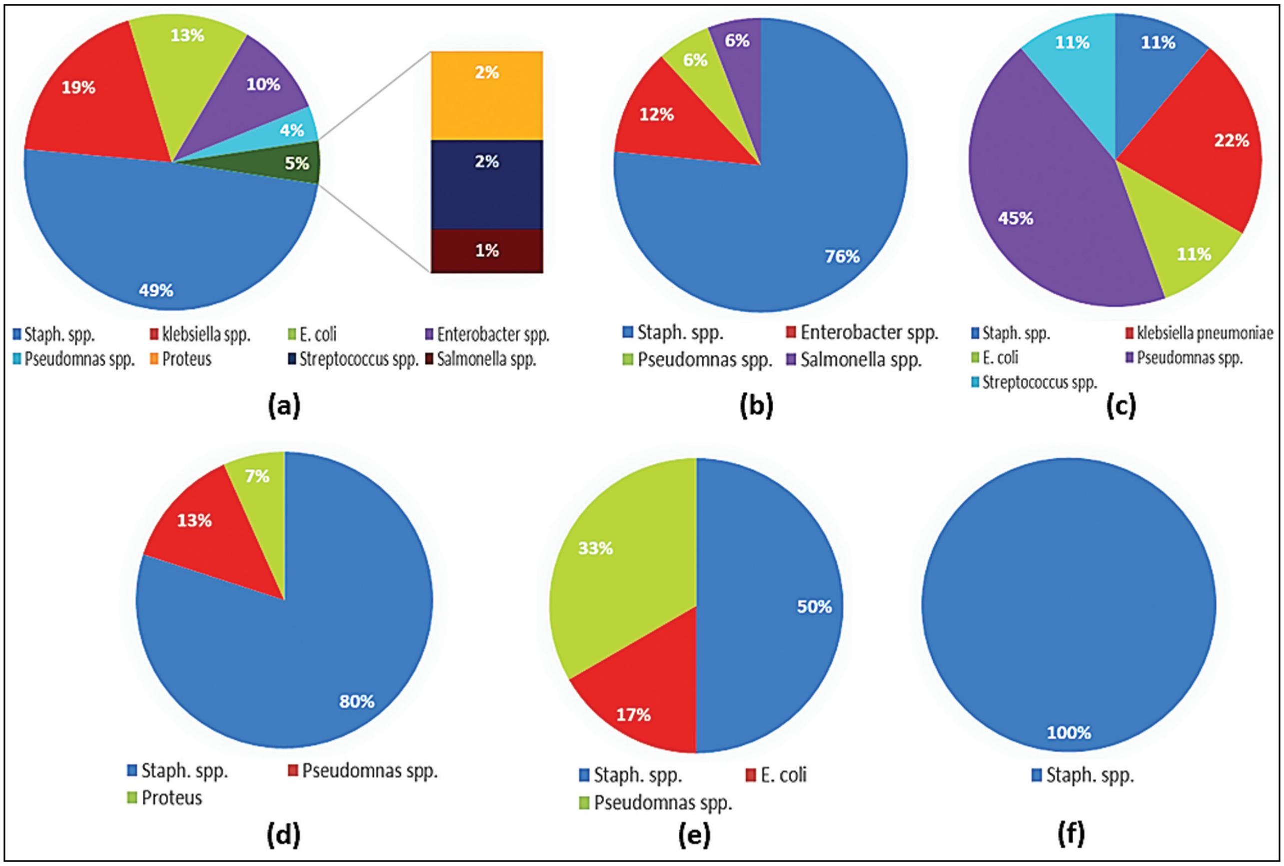

Figure 3: Prevalence of isolated bacterial species in (a) urine, (b) blood, (c) sputum, (d) wound and skin, (e) ear swab, and (f) CSF samples

Table 1: The patterns of antimicrobial susceptibility of selected isolated pathogens and minimum inhibitory concentration of some antibiotics

Pathogen		MER	IMI	AMI	GEN	TRI	CIP	VAN	CLI	MOX	TIG	RIF
Staphylococcus spp.	S%	Na	Na	Na	45%	61%	Na	77%	34%	45%	79%	61%
	MIC	Na	Na	Na	<0.69	>20	Na	<0.80	0.25	0.32	0.20	<0.56
Klebsiella spp.	S%	90%	90%	80%	60%	Na	53%	Na	Na	Na	Na	Na
	MIC	<0.20	<0.25	<1.25	>1.20	Na	<0.56	Na	Na	Na	Na	Na
E. coli	S%	100%	100%	100%	63%	43%	Na	Na	Na	Na	Na	Na
	MIC	<0.25	<0.25	<2.36	<1.04	>20	Na	Na	Na	Na	Na	Na
Enterobacter spp.	S%	27%	27%	Na	Na	Na	54%	54%	Na	Na	100%	Na
	MIC	<0.25	<0.25	Na	Na	Na	0.42	0.88	Na	Na	<0.15	Na
Pseudomonas spp.	S%	100%	100%	100%	100%	Na	Na	Na	Na	Na	Na	Na
	MIC	<2.15	<0.37	<2.13	<2.53	Na	Na	Na	Na	Na	Na	Na

Key: MER: meropenem, IMI: imipenem, AMI: amikacin, GEN: gentamicin, TRI: trimethoprim, CIP: ciprofloxacin, VAN: vancomycin, CLI: clindamycin, MOX: moxifloxacin, TIG: tigecycline, RIF: rifampin, S%: susceptibility percentage, MIC: minimum inhibitory concentration

Discussion

The findings from this study revealed that *Staphylococcus spp.* was the predominant pathogen responsible for infections in Misan hospitals, constituting 53% of the isolates from various sources such as urine, blood, wounds, and ear swab samples. These results were in agreement with a study conducted in Diwaniyah city, in the middle of Iraq, particularly concerning urine samples,[16] as well as with another study that isolated *Staphylococcus spp*. from blood samples of pediatric patients in Iraqi hospitals.[17] However, these findings contradicted studies from Duhok, north of Iraq, which identified *E. coli* as the most common pathogen associated with both community and hospital infections,[18] and a study from Zakho, north of Iraq, which found *K. pneumoniae* to be the most common cause of urinary tract infections.[19] These discrepancies might be attributed to variations in local epidemiology, patient populations, infection control practices, and antibiotic usage among different regions.

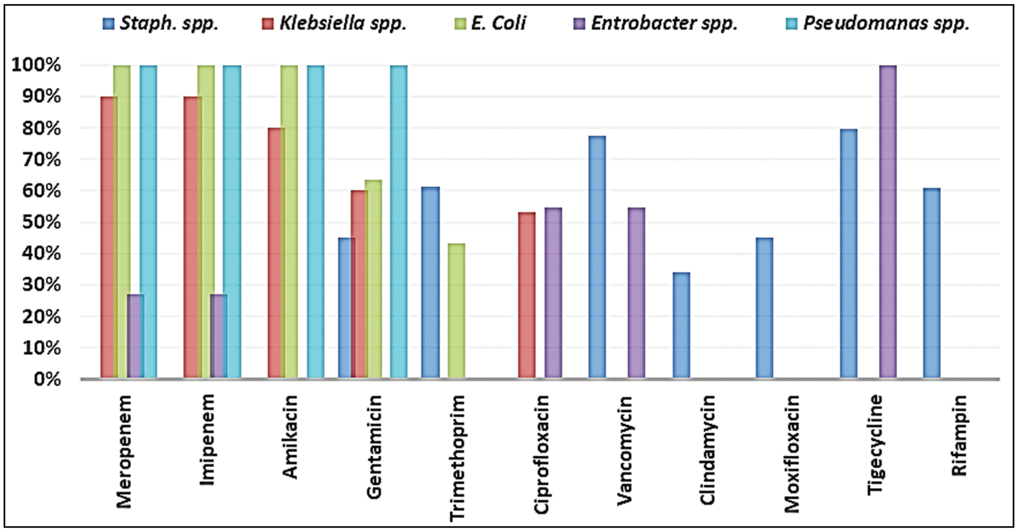

Figure 4: Antibiotic sensitivities of the isolated pathogens

The explanation for the observed pathogen distribution in this study (*Staphylococcus spp.* – 53%, *K. pneumoniae* – 14%, *E. coli* – 10%, *Enterobacter* – 9%, *Pseudomonas spp*. – 9%, *Proteus* – 2%, *Streptococcus spp*. – 2%, *Salmonella spp*. – 1%) compared to other studies could be linked to differences in patient demographics, antimicrobial stewardship, and infection control measures in Maysan hospitals. Furthermore, studies by Al-Jawad *et al.* and de León-Rosales *et al.*[20,21] showed different distributions of pathogens, highlighting the need for a comprehensive understanding of local factors influencing bacterial infections.

Regarding antibiotic susceptibility, this study found tigecycline to be the most effective against *Staphylococcus spp.* (80%, MIC = 0.2), followed by vancomycin (78%, MIC = 0.8). These results were consistent with other studies reporting tigecycline's high activity against *Staphylococcus spp.,*[22] while there have been concerns about the reduced susceptibility to vancomycin globally.[23] These variations in susceptibility might be due to differences in antibiotic usage, resistance mechanisms, and bacterial evolution in response to selective pressure.

In the case of *Klebsiella spp.*, both meropenem and imipenem showed very high susceptibility rates (90%) in this study, which were consistent with another study that reported a 93% inhibition of tested isolates by these antibiotics.[24] These results suggest that meropenem and imipenem remain effective treatment options for *Klebsiella* infections, and their continued use may help maintain their efficacy.

For *E. coli*, this study demonstrated 100% susceptibility to meropenem, imipenem, and amikacin. These findings align with other studies that consider meropenem and imipenem as primary treatments for *E. coli* infections,[25] while amikacin remains highly active.[20,26,27] However, some studies have reported high resistance of *E. coli* to first-line antibiotics, including gentamicin,[28,29] which could be attributed to the frequent use of these antibiotics in Maysan hospitals.

Enterobacter spp. exhibited full susceptibility (100%) to tigecycline in this study, which was in line with the findings.[28] However, the study also revealed low activity against the carbapenem antibiotics (meropenem and imipenem), which is a concerning trend reported in many studies as carbapenem-resistant *Enterobacter*.[30] This resistance could be attributed to the overuse or misuse of carbapenems and the dissemination of resistance genes among *Enterobacter* isolates.

Pseudomonas spp. showed a full susceptibility rate (100%) to meropenem, imipenem, amikacin, and gentamicin in this study. These results were consistent with other studies that found amikacin and gentamicin to be effective against *Pseudomonas spp*.[20] infections, and carbapenems were identified as valuable treatment options.[31] These findings emphasize the importance of using appropriate antibiotics to combat *Pseudomonas* infections effectively.

Conclusion

This study provided an antibiogram analysis that revealed diverse susceptibility patterns among the isolated bacterial pathogens in Misan teaching hospitals. The observed variations in pathogen distribution and antibiotic susceptibility compared to other studies can be attributed to regional differences in epidemiology, antimicrobial usage, and infection control practices. The findings underscore the importance of continuous surveillance of bacterial infections and antimicrobial resistance to inform evidence-based treatment strategies and infection control measures in healthcare settings.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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