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Clinical and Microbiological Study of Intra-Abdominal Infections in a Tertiary Care Hospital

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Abstract

Intra-abdominal infections (IAIs) are one of the important contributors to sepsis in intensive care units. The emergence of antibiotic resistance and the diversification of etiological agents make it challenging to determine the optimal empirical therapy. This study attempts to know the etiological agents, their antibiotic susceptibility patterns, and the risk factors associated with IAIs in different settings. This prospective cross-sectional study was conducted in a tertiary care facility from January 2023 to June 2023. Adult and paediatric patients having primary IAI or developed infections during their hospital stay were included in this study. Specimen like peritoneal swabs or fluid from intra-abdominal drains placed for more than 24 hours were excluded. Matrix-assisted Laser Desorption/Ionization Time-Of-Flight was used to identify the etiological agents. VITEK®2 system was used to perform the antimicrobial susceptibility. Associated risk factors were documented. A total of 86 cases were analysed. The majority of the patients had complicated IAIs (95.3%), and 65.12 % acquired the infection in the community (CA-IAI). The vast number of cases presented with intra-abdominal abscesses (46.5%). Diabetes and hepatic disorders were the frequent underlying comorbid conditions associated with CA-IAIs. Prolonged hospital stay and the presence of concomitant conditions like malignancy and chronic renal failure significantly influenced the occurrence of hospital-acquired infections (HA-IAIs). *E. coli* was the frequently isolated Gram-negative pathogen both in the community and hospital settings. Whereas among Gram-positives, *Enterococcus* predominated and was commonly isolated from HA-IAIs. Enterobacterales were highly susceptible to meropenem and piperacillin-tazobactam. *E. coli* and *Klebsiella* were the frequent extended-spectrum beta-lactamase producers and showed the least susceptibility towards cephalosporins and fluoroquinolones. Multidrug-resistant organisms (MDROs) (p=.013), including carbapenem-resistant strains (p=.048), were significantly isolated from hospital-acquired IAIs. The high prevalence of IAIs with MDROs in hospital settings emphasizes the importance of developing hospital-based antibiotic policy, infection control measures, and judicious use of antibiotics.

Keywords: Intra-abdominal Infections, Multidrug-resistance, Community-acquired, Hospital-acquired, Risk Factors

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Abbreviations: IAI: Intra-abdominal infection, cIAI-Complicated intra-abdominal infection, CA-IAI- Community-acquired intra-abdominal infection, HA-IAI- Hospital-acquired intra-abdominal infection, MDRO-Multidrug-resistant organisms, ESBL-Extended-spectrum beta lactamases

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INTRODUCTION

A wide range of diseases are classified as intra-abdominal infections (IAIs). It encompasses several infectious processes, including abscess formation, diverticulitis, cholecystitis, pancreatitis, cholangitis, and local peritonitis to diffuse peritonitis. In addition to simple cases, they are the most significant cause of mortality and morbidity and the second most important contributor to sepsis in intensive care units after pneumonia.[1] Multidrug-resistant bacteria, anaerobes, and fungi are the main causative agents. The vast diversity makes this infection difficult and challenging to study. The management of IAIs remain a challenge. Successful management of IAIs require multiple factors. Early source control and prompt antibiotic therapy covering all potential causative pathogens are important in their successful management.[2] Empirical antimicrobial choices are based on knowledge of the causative microorganism, antimicrobial susceptibility data, the environment where infection arises, and the degree of infection.[3] However, the development of antibiotic resistance presents a challenge to clinicians in selecting the appropriate empirical antibiotic therapy. Guidelines are available to improve the diagnosis and treatment.[4,5] Despite this, we assume that the etiological agents and their resistance pattern vary from region to region and in different settings due to misuse and overuse of antimicrobials. Many patients may harbor carbapenemase-producing *Enterobacterales* in community settings. Therefore, this study was designed to know the prevalence of various IAIs, associated risk factors, and causative pathogens with their antibiotic sensitivity pattern in multiple settings. Based on the study findings, a hospital-based antibiotic policy can be developed, and the need for patient screening for multidrug-resistant organisms (MDROs) upon admission can be assessed.

PATIENTS AND METHODS

Study design and participants

A prospective cross-sectional study was conducted in a 2035-bed tertiary care hospital in south India. A total of 120 patient samples across all age groups were received for microbiological analysis from January to June 2023. Among these patients, those with a primary disease or developed an infection during the hospital course were included. A total of 86 cases were taken for the final analysis. This study did not evaluate peritoneal swabs or fluid from drain tubes left in place for more than 24 hours.

Procedure

Gram staining was performed on all clinical specimens after they had been grown on 5% sheep blood agar, MacConkey agar, and brain heart infusion (BHI) broth. Pathogens were identified by matrix-assisted laser desorption ionization time-of-flight (MALDI-TOF) (Vitek MS, BioMerieux Inc., Marcy L'Etoile, France), an automated mass spectrometry microbial identification system. Cultures without growth were incubated for five days. Antibiotic susceptibility was performed using the VITEK® 2 system (BioMerieux, Inc. Durham, NC). Gram-negative bacteria were tested for amikacin, amoxicillin-clavulanic acid, ceftriaxone, cefuroxime, gentamicin, cotrimoxazole, ciprofloxacin, cefepime, meropenem/imipenem, piperacillin-tazobactam, ceftazidime, cefoperazone-sulbactam, and tigecycline. Penicillin, ampicillin, cefoxitin, oxacillin, erythromycin, clindamycin, tetracycline, levofloxacin, gentamicin, ciprofloxacin, linezolid, teicoplanin, and vancomycin were examined for Gram-positive bacteria.

Data collection

Demographic and clinical details, underlying comorbidity, ongoing treatment, and other laboratory findings such as procalcitonin, anaerobic culture, blood culture, and mycobacterial culture findings were recorded in the data collection form after obtaining informed consent from patients.

Statistical analysis

Categorical variables were expressed as percentages. Continuous data were evaluated in the median and interquartile range. Fisher's exact test was used to compare categorical data. Every statistical test was two-sided, and a p-value of less than 0.05 indicated statistical significance. The Statistical Package for Social Sciences (SPSS) version 23.0 (Chicago II, USA) was used to analyse the data.

Table 1. Comparative analysis of intra-abdominal infections acquired in the community vs. those related to healthcare

Intra-abdominal infections	Community-acquired (N = 56)	Hospital-acquired (N = 30)	Total (N = 86)	p-value*
Intra-abdominal abscesses	29 (51.8%)	11(36.7%)	40 (46.5%)	0.23
Primary peritonitis	07(12.5%)	4 (13.3%)	11 (12.8%)	1.0
Secondary & tertiary peritonitis	12 (21.4%)	13 (43.3%)	25 (29%)	0.059
Biliary tract infections	03 (5.4%)	01 (3.3%)	04 (4.7%)	0.57
Pancreatic necrosis	05 (8.9%)	01 (3.3%)	06 (6.9%)	0.50
Etiological agents				
Gram-negative bacteria	45 (80.36%)	23 (86.67%)	68 (79.07%)	0.52
Gram-positive bacteria	06 (10.71%)	07 (23.33%)	13 (15.12%)	0.37
E. coli (43)	27 (48.2%)	16 (53.3%)	43 (50%)	-
K. pneumoniae (16)	10 (17.8%)	06 (20%)	16 (18.6%)	-
Enterobacter cloacae (3)	03 (5.4%)	-	03 (3.4%)	-
Pseudomonas aeruginosa (4)	01 (1.8%)	03 (10%)	04 (4.6%)	-
E. faecium (6)	01 (1.8%)	05 (16.7%)	06 (6.9%)	-
E. faecalis (1)	-	01 (3.3%)	01(1.1%)	-
Streptococcus spp. (2)	02 (3.6%)	-	02 (2.3%)	-
Microbial resistance pattern				
Multidrug resistant bacteria	23 (41.02%)	23 (76.67%)	46 (53.49%)	0.013
ESBL producing Enterobacterales	23 (41.02%)	21 (70%)	44 (51.16%)	0.072
Carbapenem resistant GNBs	6 (10.71%)	9 (30%)	15 (17.44%)	0.048

*The p-value shows variations between patients with infections acquired in the community and those connected to healthcare.

Definition

Multidrug-resistant organisms: Organisms that showed resistance to at least one agent in three or more antimicrobial groups were classified as multidrug-resistant organisms.

Complicated intra-abdominal infection

An infection extends beyond the hollow viscus of origin into the peritoneal space.

Hospital-acquired infection

The infection developed after 48 hours of hospitalization and did not incubate at admission.

Ethical approval

The Institutional Ethics Committee approved this study. All participants were explained about the study and were ensured confidentiality of the data. Written informed consent was obtained from each study participant.

RESULTS

Types of intra-abdominal infections & risk factors

The median age of the patients was 45.50 years, with 72.1% (62/86) being male. The male-to-female ratio was 2.6 to 1. Most of them had complicated intra-abdominal infections (82,95.3%). Only 4.7% of them had uncomplicated infections (4/86). Infections were acquired in two different settings: in the community (CA-IAI), where they affected 56 patients (65.12%), and in the hospital (HA-IAI), where they affected 30 patients (34.88%). The most common type of infection was intra-abdominal abscess (40/86; 46.5%), followed by secondary peritonitis (24/86, 27.90%) due to visceral perforation. Intra-abdominal abscesses were more prevalent in community settings. At the same time, cases of secondary peritonitis were acquired in the hospital.

Table 2. Risk factors for intra-abdominal infection based on the infection acquisition scenario

Patient Characteristic	Community-acquired Infection (n=56)	Healthcare-associated infection (n=30)	Total (n=86)	p-value*
Demographic features				
Age in years (median)	44 (29-60)	52 (39-67)	45.50	0.042
Median hospital days	8 (6-11)	11 (7-15)	9 (6-12)	0.04
Underlying Conditions				
Patients with single comorbidity	32 (57.14%)	25 (83.33%)	57 (66.27%)	0.032
Patients with two comorbid conditions	13 (23.21%)	11 (36.67%)	24 (27.90%)	
Diabetes	15 (26.79%)	09 (30%)	24 (27.91%)	0.804
Hypertension	07 (12.5%)	09 (30%)	16 (18.60%)	0.652
Hypothyroidism	01 (1.79%)	01 (3.33%)	02 (2.33%)	0.655
Malignancy	03 (5.36%)	12 (40%)	15 (17.44%)	0.001
Liver disorder	11 (19.64%)	01 (3.33%)	12 (13.95%)	0.074
Chronic kidney disease	-	04 (13.33%)	04 (4.65%)	0.013
Chronic lung disease	02 (3.57%)	-	02 (2.33%)	0.540
Cardiac diseases	02 (3.57%)	02 (6.67%)	04 (4.65%)	0.522
Crohn's disease	02 (3.57%)	-	02 (2.33%)	0.540

*The p-value shows variations between patients with infections acquired in the community and those connected to healthcare

Familiar sources of secondary peritonitis were small bowel (7/24, 29.17%), stomach (5/24, 20.83%), pancreas (5/24, 20.83%), gallbladder and biliary tract (3/24; 12.5%), appendix (2/24; 8.33%) and colon (2/24; 8.33%). The most common site of visceral abscess formation was the appendix (10/40, 25%), followed by the gallbladder (7/40, 17.5%), liver (6/40; 16%), kidney (5/40, 12.5%) and spleen (3/40, 7.5%). A total of 22.5% of cases presented with post-operative intraperitoneal abscess. Primary bacterial peritonitis (11/86; 12.79%), biliary tract infections (4/86, 4.7%), and pancreatic diseases (6/86; 7%) were less frequent. A single case of tertiary peritonitis was documented during the study period. IAIs lead to sepsis in 34.9% of patients. Different types of intra-abdominal infections in various settings are described in Table 1.

Overall, 94.1% of patients had underlying comorbidity. Diabetes mellitus was the most common associated risk factor (27.19%). In the community settings, in addition to diabetes, hypertension, and hepatic disorders were the other possible risk factors. Malignancy of intra-abdominal organs and renal dysfunction were found to be significant risk factors for HA-IAI. The median hospital stay for HA-IAI was more compared to CA-IAI (p=0.04). Table 2 describes the risk factors associated with intra-abdominal infections.

Microbiological analysis

A total of 92 samples were obtained from 86 patients. Different types of samples, such as intraoperative pus (45.6%, 42), peritoneal fluid (36.9%, 34), tissue (4.3%, 4), bile (6.5%, 6), and abdominal drain fluid (6.5%, 6) were received. Out of 86 cases, 56 (65.11%) had monomicrobial intra-abdominal infections, and 13 (15.11%) had polymicrobial infections. The aerobic cultures were sterile for 17 (19.76%) patients after five days of incubation. Coinfection with aerobic and anaerobic bacteria was observed in 4 cases (4.65%). Blood cultures were received in 50% (43/86) of the patients. Of 43 patients, 34.88% (15) had intraabdominal bacteremia. Hospital-acquired infections led to sepsis at a higher rate (60%). Mycobacteriology workup was asked for 30 patients (34.88%) on suspicion. Only two patients had coinfection with *Mycobacterium tuberculosis*.

Table 3. Etiological agents associated with intra-abdominal infections

Etiological agents	Type of IAIs (n=86)						Total
	IA Abscess N (%)	Primary peritonitis N (%)	Secondary peritonitis N (%)	Tertiary peritonitis N (%)	Pancreatic necrosis N (%)	Cholangitis N (%)	
E. coli	20 (23.25%)	3 (3.48%)	13 (15.12%)	1 (1.12%)	4 (4.65%)	2 (2.33%)	43 (50%)
K. pneumoniae	5 (5.81%)	1 (1.12%)	7 (8.14%)	_	2 (2.33%)	1 (1.12%)	16 (18.6%)
E. cloacae	2 (2.33%)	_	_	_	_	1(1.12%)	3 (3.48%)
P. aeruginosa	3 (3.48%)	1 (1.12%)	_	_	_	_	4 (4.65%)
Enterococcus spp.	1 (1.12%)	2 (2.33%)	2 (2.33%)	1 (1.12%)	_	1 (1.12%)	7 (8.1%)
S. aureus	4 (4.65%)	_	_	_	_	_	4 (4.65%)
Streptococcus spp.	2 (2.33%)	_	_	_	_	_	2 (2.33%)

Etiological agents

In both community and hospital settings, Gram-negative bacteria accounted for 79% (68/86) of the isolates. *Escherichia coli* was the most frequently isolated pathogen (50%, 43/86) (Table 3). It was the most common etiology for intra-abdominal abscesses (23.26%, 20/86) and secondary bacterial peritonitis (15.12%, 13/86). It remains the important cause of spontaneous bacterial peritonitis (3/86) and pancreatic infection (4.65%, 4/86). Besides *E. coli, K. pneumoniae* was the significant pathogen that caused secondary peritonitis (8.14%; 7/86) and abscesses (5.81%; 5/86). Infection with Gram-positive bacteria such as *Enterococcus* and *S. aureus* was observed more in HA-IAIs compared to CA-IAIs. Gram-positive cocci were recovered in 15.12% of the patients (13/86), with Enterococci being the most prevalent bacteria (8.1%, 7/86) that produce peritonitis (5), abscesses (1), and cholangitis (1). However, *S. aureus* (4.65%; 4/86) outnumbered *Enterococcus* in abscess formation. Table 3 describes the common etiological agents isolated from IAIs.

Pseudomonas aeruginosa and *Acinetobacter baumannii* were recovered from patients with PD peritonitis. Furthermore, anaerobic bacteria and fungi were found in 4.65% (4/86) and 1.1% (1/86) of the patients, respectively. The commonly isolated anaerobic bacteria were *Bacteroides fragilis* (3) and *Prevotella* spp. (1). *Candida albicans* was the only identified fungal agent.

Antimicrobial susceptibility pattern

E. coli was the most common extended-spectrum beta-lactamases (ESBL) producer, accounting for 83.7% (36/43) of all isolates. Out of 43 isolates, only 11.6% and 16.3% of them were susceptible to cefuroxime and ceftriaxone, respectively. Another *Enterobacterale, K. pneumoniae*, was the second critical ESBL-producing bacteria (8/16; 50%). Fourth-generation cephalosporins were only effective against 34.9% of *E. coli* and 50% of *Klebsiella*. Both showed higher resistance to fluoroquinolones (86.1% and 50%). Among aminoglycosides, *E. coli* showed a higher susceptibility to amikacin (88.7%) than gentamicin (76.7%). Susceptibility to trimethoprim-sulfamethoxazole was the least for *E. coli* (39.5%) among *Enterobacterales*. The resistance rate for carbapenem was higher (37.5%) for *Klebsiella* compared to *E. coli* (27.3%). *Klebsiella* and *E. coli* also showed resistance to tigecycline (18.7% and 14%). *Enterobacter* and *Pseudomonas* were 100% sensitive to every antibiotic tested except for ciprofloxacin.

The frequency of Methicillin resistance *S. aureus* was 50%. Teicoplanin, linezolid, and vancomycin were all effective against MRSA isolates. *Streptococcus* spp. showed a 100% susceptibility in general. A higher number of *Enterococcus* spp. showed resistance to multiple drugs (57.14%).

An overall total of 53.49% (46/86) of the isolates were multidrug resistant. They significantly contributed to healthcare-associated IAIs (76.67%, p = 0.013). For MDR Gram-negative bacteria, *E. coli* was responsible for 40.74% of all cases (33/81). Tables 4 and 5 show the antibiotic susceptibility trends for Gram-positive and Gram-negative bacteria.

Table 4. Antibiotic susceptibility of Gram-negative bacteria

Gram-negative bacteria (N)	N (%) Susceptibility												
	Amikacin (%)	Gentamycin (%)	Cotrimoxazole (%)	Ciprofloxacin (%)	Amoxiclav (%)	Cefuroxime (%)	Ceftriaxone (%)	Ceftazidime (%)	Cefo-sulbactam (%)	Cefepime (%)	Pip-tazo (%)	Meropenem (%)	Tigecycline (%)
E. coli (43)	38 (88.7)	33 (76.7)	17 (39.5)	6 (13.9)	15 (34.9)	5 (11.6)	7 (16.3)	NT*	25 (58.1)	15 (34.9)	22 (51.2)	33 (76.7)	37 (86)
Klebsiella (16)	11 (68.8)	11 (68.8)	10 (62.5)	8 (50)	8 (50)	8 (50)	8 (50)	NT	9 (56.3)	8 (50)	8 (50)	10 (62.5)	13 (81.3)
Enterobacter (3)	3 (100)	3 (100)	3 (100)	2 (66.7)	0	0	3 (100)	NT	3 (100)	3 (100)	3 (100)	3 (100)	3 (100)
Pseudomonas (4)	4 (100)	4 (100)	NT	3 (75)	NT	NT	NT	3(75)	4 (100)	4 (100)	4 (100)	4 (100)	NT

Abbreviations NT: not tested; Pip-tazo: Piperacillin/tazobzctam; cefo-sulbactam: cefeperazone/sulbactam; Amoxiclav: Amoxycillin/Clavulanic acid

Table 5. Antibiotic susceptibility of Gram-positive bacteria

Gram positive cocci (N)	N (%) Susceptibility												
	Penicillin (%)	Ampicillin (%)	Cloxacillin (%)	Ceftriaxone (%)	Ciprofloxacin (%)	Gentamycin (%)	Cotrimoxazole (%)	Erythromycin (%)	Doxycycline (%)	Clindamycin (%)	Linezolid (%)	Teicoplanin (%)	Vancomycin (%)
E. faecium (6)	1 (16.7)	NT#	NT	NT	1 (16.7)	2 (33.3)	NT	01 (16.7)	NT	6	(100)	6 (100)	6 (100)
E. faecalis (1)	1 (100)	NT	NT	NT	0	1 (100)	NT	0	0	NT	1 (100)	1 (100)	1 (100)
Streptococcus spp. (2)	2 (100)	2 (100)	NT	2 (100)	NT	NT	NT	NT	NT	2 (100)	NT	NT	NT
S. aureus (4)	0	NT	2 (50)	NT	0	4 (100)	4 (100)	3 (75)	4 (100)	4 (100)	4 (100)	4 (100)	4 (100)

#NT: Not tested

DISCUSSION

Intra-abdominal infections are frequent surgical emergencies and pose several clinical challenges in the intensive care unit. It is clinically heterogeneous, and many pathogens cause this infection. The incidence of various intra-abdominal infections, their causative agents, the infection acquisition scenario, associated risk factors, and the antibiotic susceptibility profile of the causative agents are all described in this study.

The main reason for admission to our hospital was a complex intra-abdominal infection, accounting for 95.3% of cases. Intra-abdominal abscesses accounted for 46.5% of patient admissions. In contrast to this study, other authors reported perforation peritonitis as the predominant IAI in tertiary care hospitals.[6,7] Secondary peritonitis, following visceral perforation, constitutes 27.90 % of the total cases. Underlying pathologies such as peptic ulcer disease or malignancy of the internal organs were the common reasons for visceral perforation in our cases, and the small intestine was the common site (29.17%). At the same time, anastomosis leakage and trauma were the frequently mentioned reasons for perforation in the literature.[7]

The appendix and gallbladder were the common sites of abscess formation. Similar results were also noticed by F. Mechai et al.[8] Compared to wealthy countries, liver abscess is still a common concern in poor countries. *E. coli* and *Klebsiella* are the common causative agents of liver abscess in India.[9] We also observed 15% of cases of pyogenic liver abscess.

Overall, most intra-abdominal infections were monomicrobial, with the *Enterobacterales* family accounting for 79%. Unlike others, the predominance of abscesses over perforation peritonitis could be the reason for monomicrobial infection here.[6] The bacteria most often isolated were *E. coli* (50%) and *K. pneumoniae* (18.6%) from intra-abdominal abscesses and subsequent bacterial peritonitis. Among Gram-positive bacteria, *Enterococcus* (8.1%) was the common pathogen for perforation peritonitis and *S. aureus* for abscesses. These findings are consistent with previous studies in India and Asia.[10,11] The contribution of anaerobes to the pathogenesis of abscess formation was observed in only 4.65% of the total cases. The low incidence might have been due to the frequent use of metronidazole as an empirical therapy.[3] However, few studies reported a similar proportion of anaerobes in the literature.[10,11]

IAIs were also characterized according to their origin. The common pathogens among the 65.12% of patients who contracted infection in community were *E. coli*, *Klebsiella pneumoniae*, and *Enterococcus* species. *Pseudomonas aeruginosa, Acinetobacter*, and *Candida* spp. were also isolated along with *Enterobacterales* from hospital-acquired infections. These findings are similar to previous studies.[12] They established themselves probably through translocation or cross-infection. Prolonged hospitalization ($p = 0.04$) and the presence of two or more comorbid diseases ($p = 0.032$) were significant risk factors for HAIs. In agreement with others, older ages, malignancies of intra-abdominal organs, and chronic kidney disorders were found to be important risk factors for IAIs acquired in hospital settings.[6] IAIs acquired from the hospital significantly contributed to sepsis (60%; $p = 0.048$). Hyperglycaemia is associated with increased susceptibility to bacterial infection, so it was found to be a common risk factor overall.

For mild to moderate community-acquired infections, the World Society of Emergency Surgery advises ceftriaxone, ciprofloxacin, and metronidazole. Cefepime combined with piperacillin-tazobactam or metronidazole, on the other hand, has been recommended for high-risk IAIs.[13] However, in the current study, we discovered that *E. coli* exhibited an exceptionally low susceptibility to ceftriaxone (16.3%), cefepime (34.9%), piperacillin-tazobactam (51.2%), and ciprofloxacin (13.9%). A similar susceptibility pattern was also observed for *Klebsiella*. The susceptibility rate for meropenem, amikacin, gentamicin, and tigecycline was more than 60% for both *E. coli* and *Klebsiella*. Carbapenem, amikacin, and tigecycline could be considered an alternative therapy for ESBL producers. However, multidrug resistant (76.67%; $p = .013$), including carbapenem-resistant pathogens (30%), was also significantly isolated from hospital settings. Tigecycline could be selected as an alternative option for these isolates.

CONCLUSION

This study highlighted that complicated intra-abdominal infections were more prevalent in our settings. Frequently encountered complicated IAIs were community-onset intra-abdominal abscesses. Secondary bacterial peritonitis was the most common hospital-acquired IAI and an important contributor to sepsis. In community settings, the ESBL-producing *E. coli* was the predominant pathogen. On the contrary, carbapenem-resistant *Klebsiella pneumoniae* and *E. coli* were more prevalent in hospital settings. Prolonged hospitalization, old age, malignancy, and chronic kidney disorders were risk factors for HAIs caused by multidrug-resistant pathogens. *Enterobacterales* showed low susceptibility towards commonly used drugs for IAIs, such as cefepime, piperacillin-tazobactam, and ciprofloxacin. Around 20% of them also showed resistance to tigecycline. These findings underscored the necessity of developing a hospital-based antibiotic policy for better patient care. It also emphasizes the importance of infection control practices and the prudent use of restricted antibiotics to prevent the spread of MDR strains.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

FUNDING

None.

DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

ETHICS STATEMENT

This study was approved by the Institutional Ethics Committee, Kasturba Medical College and Kasturba Hospital, Manipal, Karnataka, India (IEC2:425/2022).

INFORMED CONSENT

Written informed consent was obtained from the participants before enrolling in the study.

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