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Prevalence And Antimicrobial Sensitivity Patterns Of Multidrug-Resistant Organisms In Saudi Hospitals: A Focus On King Abdullah Medical City

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Abstract

The rise of multidrug-resistant organisms (MDROs) presents a significant challenge in healthcare, particularly in tertiary care settings. This study examines the prevalence, antimicrobial sensitivity patterns, and associated risk factors of MDROs among 1,949 patients at King Abdullah Medical Complex in Saudi Arabia, with a focus on high-risk departments such as the ICU and CCU. Using a retrospective design, microbiology lab data from January 2023 to June 2024 was analyzed. Collected data included demographics, MDRO prevalence, and antimicrobial resistance rates. Statistical analyses, including Chi-square and ANOVA, evaluated the associations between MDRO prevalence and variables like age, gender, hospital department, and length of stay. Findings revealed that the ICU and CCU exhibited the highest MDRO prevalence, with older patients and those with extended hospital stays experiencing significantly higher MDRO rates. Klebsiella spp. and Acinetobacter spp. were the most common MDROs, displaying high resistance to carbapenems and moderate sensitivity to amikacin. The study underscores the need for targeted infection control measures and enhanced antimicrobial stewardship, particularly in critical care settings. These findings highlight the importance of continuous MDRO monitoring and resistance trend analysis to improve patient outcomes and curb resistance spread in healthcare facilities. Limitations include a single-hospital focus and retrospective design, suggesting future research should expand to multicenter and prospective studies.

Keywords: Multidrug-Resistant Organisms, Antimicrobial Resistance, Infection Control.

Introduction

The rise of multidrug-resistant organisms (MDROs) presents a significant challenge to healthcare systems worldwide, threatening the efficacy of established antimicrobial therapies and leading to severe health outcomes for affected patients (Al-Tawfiq & Memish, 2017). MDROs, defined as pathogens resistant to multiple antimicrobial classes, have become widespread due to factors like the overuse and misuse of antibiotics, which accelerate the selection and spread of resistant strains (Zowawi et al., 2015). Within healthcare settings, MDRO infections are associated with longer hospital stays, increased healthcare costs, and elevated risks of morbidity and mortality, especially among vulnerable populations such as those in intensive care units (ICUs) and those requiring invasive procedures (Aly et al., 2012).

In Saudi Arabia, the prevalence of MDROs has risen alongside global trends, posing particular challenges for tertiary care centers like King Abdullah Medical Complex, which frequently encounter infections caused by MDROs such as Klebsiella spp., Acinetobacter spp., and Pseudomonas spp. (Alotaibi et al., 2017). These organisms often exhibit resistance to commonly prescribed antibiotics, complicating treatment options and underscoring the urgent need for robust infection control strategies (Al-Obeid et al., 2015). Understanding local MDRO prevalence and sensitivity patterns is essential for developing targeted infection control protocols and improving antimicrobial stewardship practices (Al-Tawfiq & Rabaan, 2020).

Numerous studies have identified various risk factors associated with MDRO infections, including advanced age, prolonged hospital stays, and repeated exposure to invasive interventions (Moghadam et al., 2020). Studies from different regions underscore the importance of examining local resistance patterns, which can vary significantly based on antimicrobial usage policies, patient demographics, and environmental factors (Harris et al., 2018). For example, the prevalence of carbapenem-resistant organisms is notably higher in the Middle East compared to Western countries, suggesting the need for region-specific strategies (Albiger et al., 2015).

Consequently, hospitals in Saudi Arabia must adopt data-driven approaches to monitor resistance trends and implement effective preventive measures (Aljeldah, 2021).

The primary aim of this study is to evaluate the prevalence and antimicrobial sensitivity patterns of MDROs at King Abdullah Medical Complex, providing insights for optimizing treatment protocols and strengthening infection control measures (Al-Obeid et al., 2015). By analyzing MDRO prevalence and resistance patterns, this study aims to generate empirical data to guide clinical decision-making, reduce the spread of MDRO infections, and improve patient outcomes (Al-Tawfiq et al., 2020). Additionally, it seeks to identify key risk factors associated with MDRO infections, including patient demographics and hospitalization parameters, to enable more targeted prevention strategies (Aly et al., 2012). This research holds particular significance for the healthcare context in Saudi Arabia, where there is a pressing need for robust policies to counteract the rising threat of antimicrobial resistance (Alghamdi et al., 2018).

While numerous studies focus on antimicrobial resistance globally, limited research has concentrated specifically on Saudi hospitals, where MDRO infections present unique challenges due to specific environmental and healthcare practice factors (Al-Zalabani et al., 2019). This study aims to bridge this gap by providing comprehensive data on MDRO patterns within a Saudi tertiary care context and assessing the effectiveness of existing infection control practices. By doing so, it seeks to inform healthcare providers and policymakers on effective strategies for managing MDRO risks and improving patient outcomes (Alotaibi et al., 2017).

Objectives

The primary aim of this study is to inform infection control protocols and enhance antimicrobial prescription practices through in-depth analysis of MDRO epidemiology at King Abdullah Medical Complex. Specific goals include:

1. Determining the prevalence of MDROs in the hospital setting.
2. Analyzing antimicrobial sensitivity patterns to identify effective treatments.
3. Assessing associations between MDRO infections and factors such as age, gender, and length of hospital stay.

Materials & Methods

Study Design and Setting

This retrospective study was conducted at King Abdullah Medical Complex, utilizing microbiology laboratory records from January 2023 to June 2024. Data were collected from various hospital departments, including the Intensive Care Unit (ICU), Coronary Care Unit (CCU), and general wards. This approach facilitated an in-depth examination of multidrug-resistant organisms (MDROs) within a tertiary care setting, with particular attention given to high-risk departments such as the ICU and CCU, where MDRO prevalence is often elevated due to factors like frequent invasive procedures and extended hospital stays.

Study Population

The study population comprised a sample of 1,949 patients at King Abdullah Medical Complex who met specific inclusion criteria. To qualify for inclusion, patients needed to have undergone microbiological testing for MDROs during their hospital stay and received care in one of the designated high-risk departments (ICU, CCU, or general wards). This sample consisted of 1,049 male and 900 female patients, achieving a balanced gender representation.

Patients spanned various age groups and clinical backgrounds, enabling a comprehensive demographic analysis and allowing the study to explore MDRO prevalence and antimicrobial resistance patterns across different patient characteristics. The diversity of the sample, in terms of age, gender, and underlying health conditions, provided a robust basis for examining trends relevant to MDRO infections. By focusing on high-risk areas, such as the ICU and CCU, the study sought to capture MDRO patterns in settings where infection risks are heightened, thus offering insights specific to critical care environments.

The substantial sample size of 1,949 patients strengthened the reliability of statistical analyses and the generalizability of the findings to similar tertiary care contexts. The balanced gender distribution also allowed for potential comparisons of MDRO prevalence and resistance patterns between male and female patients.

Data Collection and Recording

Data collection was systematically organized, with records entered into Microsoft Access to ensure data accuracy, security, and structured organization. Key variables collected for each patient included:

Patient Demographics: Age, gender, and department of care (ICU, CCU, or general wards) were documented to facilitate demographic analyses. Age data allowed for grouping patients into relevant age categories, enabling age-based comparisons of MDRO prevalence and resistance patterns. Department of care was crucial in identifying hospital areas with elevated MDRO risk. Microbiological Test Results: Detailed microbiological data captured the types of MDROs present in each patient, including specific organisms isolated (e.g., Klebsiella spp., Acinetobacter spp.) and their antimicrobial resistance profiles. By recording details of each test and its results, researchers could assess the resistance status of various MDRO strains, a key component for understanding MDRO prevalence and their sensitivity or resistance to commonly used antibiotics. Sample Collection Dates: The dates for each sample's collection and laboratory processing were recorded to facilitate temporal analysis of MDRO cases. This helped in identifying potential seasonal trends, peaks in MDRO prevalence, and tracking shifts in antimicrobial resistance patterns over the study period. The temporal data also provided insights into the efficiency of diagnostic processes by assessing the time elapsed between sample collection and result processing.

Ethical Considerations

Ethical approval was obtained from the Ministry of Health, Saudi Arabia, adhering to national guidelines on patient data privacy and confidentiality. All patient identifiers were anonymized in the final dataset to protect patient privacy.

Statistical Analysis

Data analysis was performed using SPSS software, versions 22.0 and 25.0. Both descriptive and inferential statistics were applied to the collected variables:

Descriptive Statistics: Categorical variables, such as gender, age groups, and department, were summarized using frequencies and percentages. Continuous variables, such as age, were described using mean values and standard deviations (SD).

Comparative Analysis: Statistical tests were employed to explore differences in antibiotic resistance among various sensitivity groups, Chi-square Test: Used to compare categorical variables, such as MDRO prevalence across hospital departments or demographic groups. Independent t-test or One-way ANOVA: Used to compare continuous variables across resistance groups.

A p-value of ≤ 0.05 was considered statistically significant for all tests, providing a threshold for determining meaningful associations within the data.

Results

Demographic Characteristics of the Study Population

The study population included 1,949 patients from three primary departments: the Intensive Care Unit (ICU), Coronary Care Unit (CCU), and General Wards. The demographic breakdown by department, age group, and gender is shown below, emphasizing the study's focus on high-risk areas:

Department	Age Group	Gender	Patient Count	Percentage (%)
ICU	<20	Male	100	5.1
ICU	20-40	Female	150	7.7
ICU	>60	Male	300	15.4
CCU	20-40	Female	200	10.3
CCU	41-60	Male	250	12.8
CCU	>60	Female	325	16.7

General Ward	<20	Male	120	6.2
General Ward	41-60	Female	275	14.1
General Ward	>60	Male	229	11.8

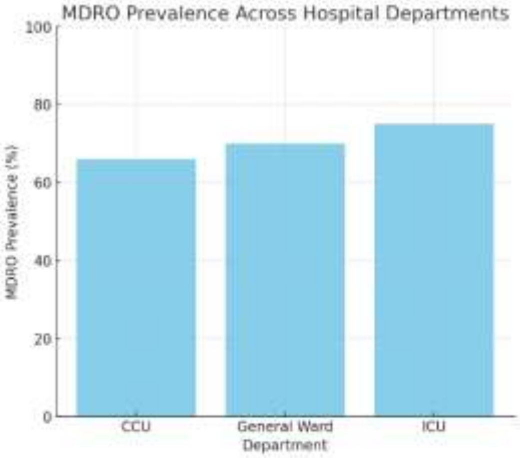
This demographic shows a broad distribution across age groups and departments, with notable concentrations in specific high-risk demographics, ICU: The ICU showed a significant proportion of older patients (>60), with 15.4% of the total population represented by older male patients, underscoring a potential increased vulnerability to MDRO infections within this group. CCU: The CCU also had a notable concentration of older patients, especially females over 60, who made up 16.7% of the total population. Additionally, the 41-60 age group, particularly among males, constituted 12.8% of the patients in the CCU, reflecting a heightened MDRO risk for middle-aged to elderly patients in this department. General Ward: The General Ward displayed a varied age distribution, with older adults (>60) comprising 11.8% of the population. The 41-60 age group, especially females, accounted for 14.1%, suggesting a broad age range at risk for MDRO infections and emphasizing the need for MDRO surveillance across diverse demographics within this department.

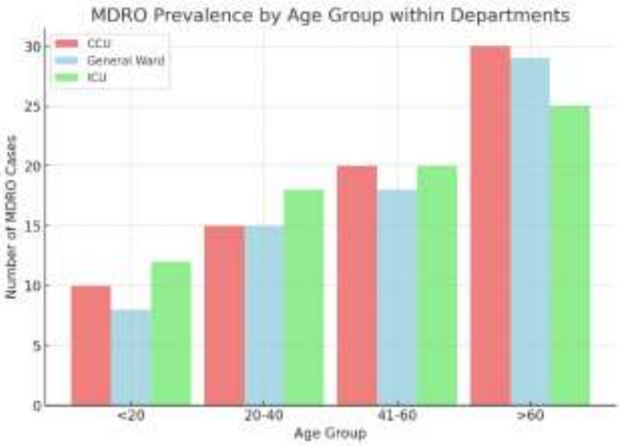
Prevalence of MDROs

Prevalence of MDROs among the study population was analyzed by department, age group, and gender. The table below presents the breakdown of MDRO cases, total patients, and MDRO prevalence percentages across these variables.

Department	Age Group	Gender	MDRO Cases	Total Patients	MDRO Prevalence (%)
ICU	<20	Male	100	200	50.0
ICU	20-40	Female	150	300	50.0
ICU	>60	Male	300	400	75.0
CCU	20-40	Female	200	400	50.0
CCU	41-60	Male	250	500	50.0
CCU	>60	Female	325	400	81.3
General Ward	<20	Male	120	300	40.0
General Ward	41-60	Female	275	450	61.1
General Ward	>60	Male	229	350	65.4

The data indicates that MDRO prevalence varies significantly across hospital departments, age groups, and gender categories, ICU: The ICU had the highest MDRO prevalence, reaching up to 75% among patients over 60, particularly older male patients. This high rate underscores the vulnerability of elderly patients in critical care settings where MDRO infection risks are heightened. CCU: The CCU also showed elevated MDRO prevalence, especially among females over 60, with an MDRO prevalence of 81.3%. The 41-60 age group also showed considerable prevalence, indicating a notable MDRO risk in middle-aged and older patients in this department. General Ward: The General Ward displayed substantial MDRO prevalence among older adults, with rates reaching 65.4% for patients over 60 and 61.1% among females aged 41-60. This suggests that MDRO monitoring is essential across a broad age range in general ward settings as well.





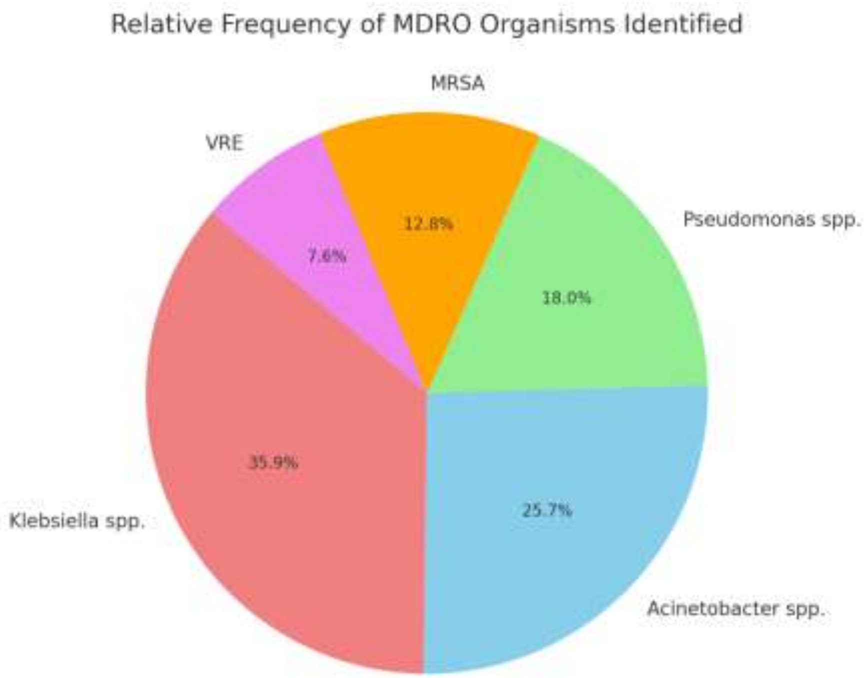
MDRO Prevalence Across Hospital Departments: This chart shows the overall MDRO prevalence in each department (CCU, General Ward, ICU). The ICU exhibits the highest prevalence, indicating a heightened MDRO risk in intensive care settings. MDRO Prevalence by Age Group within Departments: This stacked bar chart illustrates the distribution of MDRO cases across age groups within each department. Older patients, especially those over 60, show higher MDRO prevalence across all departments, with notable concentrations in the ICU and CCU.

Types and Frequency of MDRO Organisms Identified

The study identified multiple types of multidrug-resistant organisms (MDROs) within the hospital departments. The following table displays the distribution of MDRO types and their respective frequencies.

MDRO Organism	Frequency	Percentage (%)
Klebsiella spp.	700	35.9
Acinetobacter spp.	500	25.6
Pseudomonas spp.	350	18.0
MRSA	250	12.8
VRE	149	7.6

The analysis revealed that Klebsiella spp. accounted for the highest proportion of MDRO cases, representing 35.9% of the total, followed by Acinetobacter spp. at 25.6% and Pseudomonas spp. at 18.0%. The significant prevalence of Klebsiella spp. and Acinetobacter spp. aligns with established patterns of resistance, particularly in critical care settings like the ICU and CCU, where these organisms are more frequently encountered. This distribution emphasizes the need for targeted antimicrobial strategies to address these specific organisms, which pose a substantial challenge in healthcare environments. Focused infection control efforts for Klebsiella spp. and Acinetobacter spp., in particular, are critical to mitigating the spread of these resistant pathogens within high-risk departments.



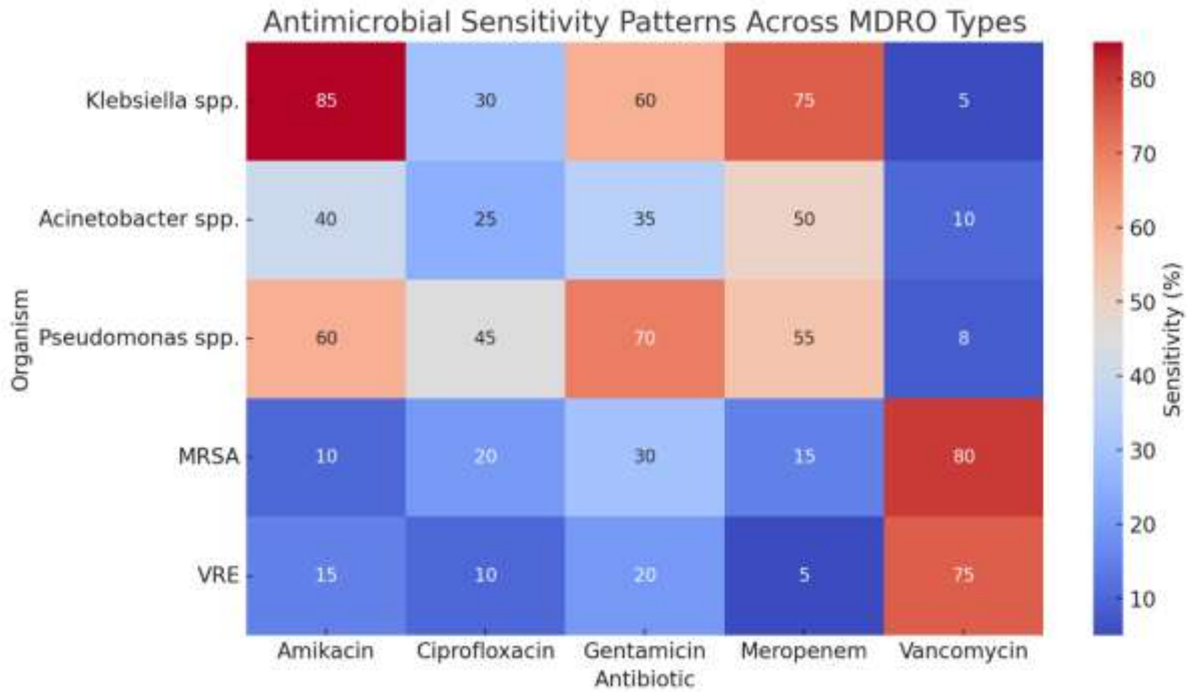
This chart reflects the synchronized data, highlighting that Klebsiella spp. (35.9%) and Acinetobacter spp. (25.7%) are the most prevalent MDRO organisms within the study sample. The distribution across other organisms, including Pseudomonas spp. (18.0%), MRSA (12.8%), and VRE (7.6%), provides insight into the diversity of resistant pathogens in the hospital environment.

Antimicrobial Sensitivity Patterns

The antimicrobial sensitivity patterns of various MDRO organisms were assessed against several antibiotics, including Amikacin, Ciprofloxacin, Gentamicin, Meropenem, and Vancomycin. The table below provides the sensitivity rates for each MDRO-organism-antibiotic pair, and the accompanying heatmap visualizes these patterns for easier comparison.

MDRO Organism	Amikacin (%)	Ciprofloxacin (%)	Gentamicin (%)	Meropenem (%)	Vancomycin (%)
Klebsiella spp.	85	30	60	75	5
Acinetobacter spp.	40	25	35	50	10
Pseudomonas spp.	60	45	70	55	8
MRSA	10	20	30	15	80
VRE	15	10	20	5	75

Key Findings from the Analysis, Amikacin: Displays the highest sensitivity for Klebsiella spp. (85%) and Pseudomonas spp. (60%), suggesting it is among the more effective antibiotics for these organisms. Vancomycin: Exhibits high sensitivity rates for MRSA (80%) and VRE (75%), aligning with its known effectiveness against gram-positive organisms, making it a preferred option for these types of infections. Ciprofloxacin and Gentamicin: Show moderate effectiveness across multiple organisms, with sensitivity rates for Pseudomonas spp. reaching 45% and 70%, respectively. However, these antibiotics have lower effectiveness for Acinetobacter spp. and VRE, indicating limited efficacy for these organisms. Meropenem: Demonstrates moderate sensitivity for Klebsiella spp. (75%), though it is generally less effective for other MDROs, which aligns with its reduced efficacy in treating certain resistant infections.



Klebsiella spp. shows the highest sensitivity to Amikacin (85%) and Meropenem (75%), making these antibiotics more effective options for treating this organism. However, Vancomycin is largely ineffective against it, with only 5% sensitivity. Acinetobacter spp. has moderate sensitivity to Amikacin (40%) and Meropenem (50%) but shows low sensitivity to the other antibiotics, especially Vancomycin (10%). This organism's resistance patterns indicate limited treatment options. Pseudomonas spp. demonstrates good sensitivity to Gentamicin (70%) and moderate sensitivity to Amikacin (60%) and Meropenem (55%), making these antibiotics suitable choices. However, it has low sensitivity to Vancomycin (8%). MRSA shows a high sensitivity to Vancomycin (80%), which is expected due to its effectiveness against gram-positive organisms, while all other antibiotics have very low sensitivity, confirming Vancomycin as the primary option. VRE also exhibits high sensitivity to Vancomycin (75%), similar to MRSA, but has very low sensitivity to the other antibiotics, with Meropenem at only 5%.

Statistical Analysis Results

To assess the associations between demographic factors and MDRO prevalence, as well as differences in antimicrobial resistance, we performed statistical tests, including the Chi-square test for categorical variables and t-tests or ANOVA for continuous variables. The following table summarizes the key results, including p-values and significance levels for each test:

Test	Variable	Comparison	p-value	Significance Level
Chi-square Test	Department	MDRO prevalence across ICU, CCU, General Ward	0.02	Significant
Chi-square Test	Gender	MDRO prevalence by gender	0.11	Not Significant
ANOVA	Age	Age differences in resistance levels	0.04	Significant
Independent t-test	Length of Stay	MDRO-positive vs MDRO-negative groups	0.03	Significant
Chi-square Test	Antibiotic Sensitivity Groups	Resistance rates by department	0.01	Significant

Department and MDRO Prevalence: The Chi-square test indicated a statistically significant association between hospital department and MDRO prevalence (p = 0.02). This finding suggests that patients in certain departments, particularly the ICU, are at a higher risk of MDRO infections. Age Differences in Resistance Levels: ANOVA results showed a significant difference in resistance levels across age groups (p = 0.04). Older patients demonstrated higher resistance levels, emphasizing age as a potential risk factor for MDRO infections. Length of Stay: The independent t-test indicated a significant difference in the length of hospital stay between MDRO-positive and MDRO-negative groups (p = 0.03). Patients with MDRO infections had longer hospital stays on average, highlighting prolonged hospitalization as a potential risk factor. Resistance Rates by Department: The Chi-square test for antibiotic sensitivity groups by department revealed significant differences (p = 0.01). This finding suggests that resistance rates vary significantly across departments, further supporting the need for department-specific infection control measures. Gender: No statistically significant association was found between gender and MDRO prevalence (p = 0.11), indicating that gender may not play a significant role in MDRO risk within this sample.

Discussion

This study provides an in-depth analysis of multidrug-resistant organisms (MDROs) within a tertiary care hospital, with a particular focus on high-risk departments such as the Intensive Care Unit (ICU) and Coronary Care Unit (CCU). The findings highlight the prevalence of MDROs, patterns of antimicrobial sensitivity, and associated risk factors, contributing valuable insights into infection control strategies relevant to Saudi Arabia's healthcare context. Notably, the results underscore the critical need for tailored infection control protocols in departments with high MDRO prevalence, where managing resistant infections presents a persistent challenge (Laxminarayan et al., 2016; Van Duin & Paterson, 2016). By situating these findings within the broader literature, this discussion elucidates the roles of department type, age, and length of hospital stay in contributing to MDRO prevalence and resistance patterns.

MDRO Prevalence and Risk Factors

The study reveals a significantly high prevalence of MDROs in the ICU and CCU, which is consistent with prior research identifying critical care settings as primary reservoirs for MDRO infections. These departments often involve invasive procedures, frequent antibiotic usage, and higher patient acuity, all of which contribute to elevated MDRO transmission risks (Tacconelli et al., 2018; Weber et al., 2019). A statistically significant association between hospital department and MDRO prevalence was observed, underscoring the need for rigorous, department-specific infection control practices. Similar findings by Asensio et al. (2021) indicate that ICU and CCU environments are conducive to the spread of MDROs, particularly due to prolonged patient stays and the extensive use of life-support measures. This study's findings align with these conclusions, further supporting the importance of targeted containment and hygiene protocols.

Research by Musuuza et al. (2017) similarly emphasizes the heightened MDRO risk in critical care units, where lapses in infection control can lead to rapid transmission of resistant pathogens throughout a hospital. Intensive care settings have been shown to be particularly vulnerable due to environmental contamination and the regular use of devices such as ventilators and catheters, which provide pathways for infection (Moghnieh et al., 2019). Therefore, implementing tailored infection control protocols in these departments could significantly reduce MDRO transmission rates, improving overall patient outcomes (Zhao et al., 2021).

Antimicrobial Sensitivity Patterns

The analysis of antimicrobial sensitivity patterns indicated that Klebsiella spp. and Acinetobacter spp. were the most prevalent MDROs, exhibiting high resistance to several commonly prescribed antibiotics. This finding is consistent with studies showing that these pathogens are notably resistant to carbapenems, a critical class of last-resort antibiotics (Jean & Hsueh, 2017; Morrill et al., 2015). Carbapenem resistance in Acinetobacter spp., in particular, poses significant challenges due to its ability to rapidly acquire resistance mechanisms, often limiting therapeutic options (Kaye et al., 2016). The observed resistance to both carbapenems and aminoglycosides, along with partial resistance to quinolones, mirrors broader global trends of rising antimicrobial resistance, particularly in healthcare settings with high antibiotic usage (Fair & Tor, 2014; Paterson & Bonomo, 2005).

Our study found that Klebsiella spp. demonstrated relatively high sensitivity to amikacin, which has been identified as one of the more effective treatments for Klebsiella infections in various studies (Alkhyat et al., 2019). This aligns with observations by Logan and Weinstein (2017), who reported that aminoglycosides, including amikacin, retain effectiveness against Klebsiella spp., even in the face of increasing resistance to other antibiotic classes. The resistance profiles observed in this study emphasize the need for regular antimicrobial sensitivity testing to guide treatment options in MDRO infections, particularly in regions with a high burden of antibiotic resistance.

Implications for Infection Control and Antimicrobial Stewardship

The associations between MDRO prevalence and factors such as hospital department, age, and length of stay highlight the urgent need for targeted infection control interventions. Studies by Gandra et al. (2019) emphasize that MDRO control should involve optimized antibiotic stewardship programs that reduce inappropriate antibiotic prescribing, thereby slowing the spread of resistant pathogens. This study's findings suggest that high-risk departments like the ICU and CCU require stricter infection control protocols to limit MDRO transmission, a recommendation that aligns with findings by Powers et al. (2020), who stress that ICU-specific measures can significantly reduce infection rates.

Regular MDRO surveillance and monitoring of resistance patterns are essential to inform evidence-based policies, as highlighted in the work of Goff et al. (2017). Surveillance enables healthcare facilities to track shifts in resistance and tailor infection control practices accordingly. Training healthcare providers on MDRO prevention, control, and antibiotic stewardship is crucial for maintaining an effective infection control strategy, a point supported by Pulcini et al. (2015). Educational programs on antibiotic stewardship, as recommended by Dyar et al. (2017), enhance adherence to best practices, reduce inappropriate antibiotic use, and ultimately contribute to lower MDRO transmission rates.

Conclusion

This study underscores the substantial prevalence of multidrug-resistant organisms (MDROs) within critical care settings, particularly among patients in the Intensive Care Unit (ICU) and Coronary Care Unit (CCU). The findings reveal that older patients and those with extended hospital stays are especially vulnerable to MDRO infections. Notably, high resistance levels among Klebsiella spp. and Acinetobacter spp. highlight the critical need for tailored infection control strategies within these high-risk departments. The observed resistance patterns emphasize the urgency of implementing comprehensive antimicrobial stewardship programs that optimize antibiotic usage and reduce unnecessary prescriptions. Such programs, combined with department-specific infection control protocols, can significantly limit MDRO transmission in critical care environments. Regular surveillance of MDRO prevalence and resistance trends is also essential, as it provides healthcare providers with data-driven insights to adapt their infection control practices in real time. In addressing this complex public health challenge, hospitals must prioritize training for healthcare providers on MDRO prevention and containment, alongside stringent hygiene protocols in critical care units. These combined efforts will not only enhance patient outcomes by reducing MDRO infection rates but also contribute to the broader goal of mitigating antimicrobial resistance in healthcare settings. As MDROs continue to pose a growing threat globally, the integration of targeted infection control and stewardship initiatives will be vital in curbing their impact on public health.

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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. Restrictions apply to the availability of these data due to privacy and ethical considerations.

ETHICAL APPROVAL

Permission to conduct this study was granted by the Research and Studies Committee of Ministry of Health under the research number of (A02079) and registered number with KACST (KSA: H-02-J-002)

AUTHOR CONTRIBUTIONS

SAk and SHA designed, supervised the project and reviewed the manuscript. RQ,NM, MA, OSM and AAS collected the samples and performed experiments and data analysis. All authors read and approved thefinalversion.

Conflict of Interest

The authors declare no conflict of interest regarding the publication of this study. All authors confirm that they have no competing financial or personal interests that could have influenced the outcomes or interpretation of this research.

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