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Original Article

Prevalence of Multidrug Resistant Organisms (MDROs) and Antimicrobial Sensitivity Pattern from clinical samples of the patients in Riyadh Province of the Kingdom of Saudi Arabia

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ABSTRACT

Background: Multidrug-Resistant organisms (MDRO) pose a global health threat due to overuse of antibiotics and genetic transfer of resistance. The Middle East, including Saudi Arabia, faces unique challenges in combating MDROs, necessitating tailored interventions. **Objectives:** This research aims to inform evidence-based treatment and infection control measures. By understanding local epidemiology, we can optimize antimicrobial prescribing and minimize resistance emergence. Comprehensive surveillance in diverse healthcare settings is crucial given the escalating antimicrobial resistance. **Materials &Methods:** This study utilized a retrospective design. Data was collected from diverse healthcare facilities, including hospitals, clinics, and laboratories, from March 2022 to February 2023. Sample size was determined using OpenEpi Software, with 1500 participants needed. Data collection involved reviewing microbiological records and laboratory reports, with deidentification of personal information. Ethical approval was obtained from Shaqra University, Saudi Arabia. **Results:** The study reported that 37.3% of the 1500 patients were classified as MDRO, with a higher prevalence among males (64.3%) compared to females (35.7%). MDRO prevalence varied across age groups, with the highest prevalence observed in the 70–79 age group (14.3%). Multiple invasive procedures (P = 0.002), length of stay (LOS) (P = 0.01) were independent risk factors for MDRO infection. Antimicrobial resistance patterns showed significant proportions of MDRO among Klebsiella spp., Acinetobacter spp., and Pseudomonas spp., **Conclusion:** The study emphasizes the urgent need for policy interventions to tackle the alarming prevalence of MDROs and combat antimicrobial resistance (AMR). Healthcare providers must prioritize antimicrobial stewardship and implement rigorous infection prevention measures to curb MDRO transmission. Future research should evaluate the impact of stewardship, monitor resistance trends, and explore novel treatment strategies. Collaboration among stakeholders is vital for addressing AMR comprehensively through knowledge sharing and capacity building initiatives.

Keywords: Multidrug-Resistant organisms (MDROs), antimicrobial resistance (AMR), drug resistance, drug sensitivity patterns, ESBLs and Carbapenemases.

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INTRODUCTION

Multidrug-resistant organisms (MDROs) pose a significant concern to global public health, challenging the efficacy of antimicrobial therapies and complicating the management of infectious diseases[1]. As pathogens evolve and adapt, the emergence of resistance to multiple antimicrobial agents has become increasingly prevalent, necessitating vigilant surveillance and intervention strategies[2]. This rise is a consequence of several factors, including overuse and misuse of antibiotics in both human and veterinary medicine, as well as in agriculture. When bacteria are exposed to antibiotics frequently, they can evolve mechanisms to evade the drugs' effects, leading to the development of resistance. Additionally, the transfer of genetic material between bacteria can spread resistance genes rapidly within and between bacterial species[3].

Globally, the escalating prevalence of MDROs has garnered considerable attention from the scientific community and public health authorities[4]. The World Health Organization (WHO) identifies antimicrobial resistance (AMR) as one of the most pressing challenges of our time, with dire implications for patient outcomes, healthcare costs, and societal well-being[5]. Reports from various regions around the world underscore the urgent need for comprehensive surveillance programs and coordinated efforts to mitigate the spread of resistant pathogens[6].

The Middle East faces unique challenges in combating MDROs, with factors such as high antimicrobial usage, cross-border migration, and varying healthcare infrastructures contributing to the complexity of the situation[7]. In Saudi Arabia, where rapid economic development and extensive healthcare investments have transformed the landscape of medical services, the burden of MDROs presents a critical concern for healthcare providers and policymakers alike[8]. In Riyadh, understanding the prevalence and antimicrobial susceptibility profiles of MDROs is paramount for guiding evidence-based treatment protocols and infection control measures. By elucidating the epidemiological landscape of MDROs in this specific region, healthcare stakeholders can tailor interventions to address local challenges and optimize patient care[9].

The significance of this research lies in its potential to inform clinical practice, public health policies, and

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antimicrobial stewardship initiatives. By elucidating the prevalence and antimicrobial susceptibility patterns of MDROs in Riyadh, Saudi Arabia, this study seeks to contribute valuable insights to the global discourse on antimicrobial resistance and facilitate the development of targeted interventions to combat this growing threat. Through a comprehensive understanding of the local epidemiology of MDROs, healthcare providers can optimize antimicrobial prescribing practices, minimize the emergence of resistance, and ultimately safeguard the effectiveness of antimicrobial therapies. This aim of the study is to investigate the prevalence of MDROs and discern the antimicrobial sensitivity patterns among clinical samples obtained from patients in the Riyadh Province of the Kingdom of Saudi Arabia.Given the increasing antimicrobial resistance and its implications for patient care, there is an imperative to conduct surveillance of MDROs in diverse healthcare settings.

OBJECTIVES

- To assess the prevalence of MDROs among patients presenting to healthcare facilities in Riyadh Province.
- To investigate the antimicrobial resistance patterns of identified pathogens, including Klebsiella spp., Acinetobacter spp., Pseudomonas spp., Escherichia coli, and others, to guide empiric treatment decisions and infection control strategies.
- To identify risk factors associated with the acquisition and transmission of MDROs within the local healthcare environment, including demographic factors, comorbidities, and previous antimicrobial usage.

MATERIALS AND METHODS

Study Design

This study employed a retrospective design to assess the prevalence of MDROs and characterize antimicrobial sensitivity patterns among clinical samples obtained from patients in Riyadh, Saudi Arabia. Cross-sectional data collection will enable a snapshot of the epidemiology of MDROs within the study population.

Study Sit

The study was conducted in healthcare facilities across the Riyadh Province, including hospitals, clinics, and diagnostic laboratories. Facilities were selected to ensure representation from diverse healthcare settings, including tertiary care hospitals, community hospitals, and primary care clinics. The data in the study were collected from March 2022 till February 2023. Ethical approval was obtained from Shaqra University, Saudi Arabia. (Approval No: ERC_SU_F_202300017).

Study Participants

The study includes patients of all ages presenting to healthcare facilities within the Riyadh Province of the Kingdom of Saudi Arabia. Participants were selected based on the availability of clinical samples collected as part of routine diagnostic procedures for suspected infections.

Eligibility Criteria

Inclusion criteria:

- Patients of all ages presenting with clinical suspicion of infection.
- Clinical samples collected for microbiological analysis.
- Patients who provide informed consent for participation in the study.
- Patients enrolled in Riyadh Health Institute from March 2022 till February 2023 were included

Exclusion criteria

- Patients not able to understand English and Arabic Languge.
- Clinical samples collected from non-human sources.
- Samples with inadequate quantity or quality for microbiological analysis.

Sample Size

The sample size was determined using OpenEpi Software based on the prevalence of MDROs reported in previous studies conducted in similar healthcare settings within the Riyadh Province. A power analysis was conducted to ensure that the study has sufficient statistical power to detect significant associations and trends. A power of 80% with 5% level was significance was considered for calculating sample size. After adjusting for non-response, a sample size of 1500 is required.

Data Collection Tool

Data collection involved the review of microbiological records and laboratory reports to identify clinical samples positive for MDROs. Information collected include patient demographics, clinical diagnosis, specimen type, microbiological findings (including identified pathogens and antimicrobial susceptibility profiles), and any documented risk factors for antimicrobial resistance. All the personal information was de-identified before analysis. The ethical approval was taken from Ethical Review Approval Shaqra University, Saudi Arabia.

Statistical Analysis

Descriptive statistics is used to summarize the demographic characteristics and the prevalence of MDROs. Antimicrobial sensitivity patterns were analyzed using standard microbiological methods, and the results will be presented as percentages of susceptibility or resistance to individual antimicrobial agents. Bivariate and multivariate analyses was conducted to identify factors associated with the acquisition and transmission of MDROs. Statistical significance was assessed using T tests, with p-values < 0.05 considered significant. Data analysis was performed using statistical software SPSS.

RESULTS

The study shows that among the 1500 patients included in the study, 37.3% were classified as multidrug-resistant organisms (MDROs). Gender-wise distribution revealed that among female patients (n=600), 200 (35.7%) were classified as MDRO, while among male patients (n=900), 360 (64.3%) were MDRO. Furthermore, MDRO prevalence varied across different age groups, with patients aged below 10 years accounting for 50 (3.3%) of the total, among which 10 (1.8%) were MDRO. The highest prevalence of MDROs was observed in the age group of 70–79 years, where 80 (14.3%) patients were classified as MDRO (Table 1).

Table 2 outlines the antimicrobial resistance patterns among different pathogens identified in the clinical specimens. Klebsiella spp., Acinetobacter spp., and Pseudomonas spp. exhibited multidrug resistance (MDR) in significant proportions, with 44.97%, 89.88%, and 81.09% of isolates demonstrating resistance, respectively. Additionally, a considerable proportion of Klebsiella spp. isolates (60.05%) exhibited both extended-spectrum β-lactamase (ESBL) and carbapenemase production. E. coli also showed high rates of MDR (48.19%) and ESBL/carbapenems production (59.9%). It provides insights into specific resistance mechanisms observed among different pathogens. ESBL production was prevalent among Proteus spp. (10.9%) and Enterobacter spp. (6.5%), while carbapenems production was common among Klebsiella spp. (60.05%) and E. coli (59.9%). Methicillin-resistant Staphylococcus aureus (MRSA) was detected in 40.87%

Table 1: Distribution of MDR in Relation to Sociodemographic data of the patients.

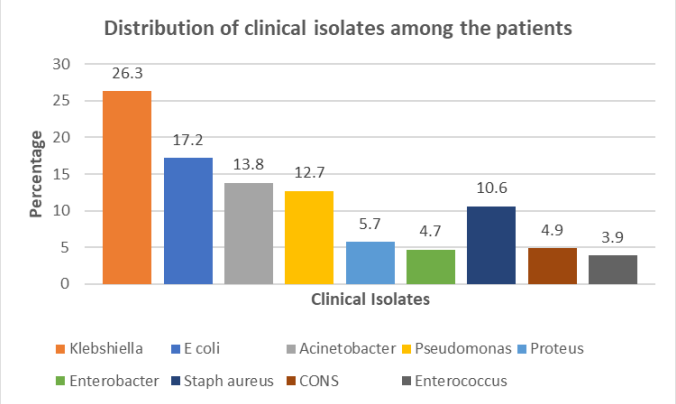
	Non-MDR n (%)	MDR n (%)	Total n (%)
	940 (62.7)	560 (37.3)	1500 (100)
Gender			
Female	400 (42.6)	200 (35.7)	600(40)
Male	540 (57.4)	360 (64.3)	900 (60)
Age			
<10	40 (4.3)	10 (1.8)	50 (3.3)
>10	74 (7.9)	23 (4.1)	97 (6.5)
10–19	61(6.5)	35 (6.3)	96 (6.4)
20–29	157 (16.7)	84 (15)	241 (16.1)
30–39	133(14.1)	61 (10.9)	194 (12.9)
40–49	89 (9.5)	26 (4.6)	115 (7.7)
50–59	97 (10.3)	70 (12.5)	167 (11.1)
60–69	109 (11.6)	72 (12.9)	181 (12.1)
70–79	67 (7.1)	80 (14.3)	147 (9.8)
80–89	72 (7.7)	65 (11.6)	137 (9.1)
≤90	41 (4.3)	34(6)	75 (5)
Location			
ICU	195 (20.7)	117 (20.9)	300 (20)
IN-PATIENT	412 (43.8)	194 (34.6)	606 (40.4)
OUT PATIENT	127 (13.5)	71 (12.7)	198 (13.2)
OTHERS (Dialysis, Burns unit)	206 (21.9)	178 (31.8)	396 (26.4)
Previous History of Hospitalization in the past 3 months			
Yes	265 (28.1)	380 (67.9)	
No	675 (71.9)	180 (32.1)	
Empirical Usage of third generation Cephalosporins			
Yes	240 (25.5)	375 (67)	
No	700 (74.5)	185 (33)	

Table 2: Distribution of pathogens and different resistance mechanisms from patients among various Hospitals in Riyadh Province March 2022–February 2023.

Pathogen type (n) and pattern of resistance	Resistance, n (%)
Klebsiella spp. (338)	
ESBL & Carbapenamase production	203 (60.05)
Multidrug resistance	152 (44.97)
Acinetobacter spp. (178)	
Multidrug resistance	160 (89.88)
Pseudomonas spp. (164)	
Multidrug resistance	133 (81.09)
Escherichia coli (222)	
ESBL & Carbapenamase production	133 (59.9)
Multidrug resistance	107 (48.19)
Proteus spp.(73)	
ESBL production	8 (10.9)
Enterobacter spp. (61)	
ESBL production	4 (6.5)
Staphylococcus aureus (137)	
MRSA	56 (40.87)
Coagulase-negative staphylococci (63)	
MR-CONS	38 (60.31)
Enterococcus spp. (51)	
VRE*	NIL

ESBL= extended-spectrum β-lactamase, MRSA= methicillin-resistant S aureus, VRE= vancomycin-resistant Enterococcus
*Vancomycin resistance was confirmed by Vitek 2C

of Staphylococcus aureus isolates, while MR-coagulase-negative staphylococci (MR-CONS) were found in 60.31% of coagulase-negative staphylococci (CONS) isolates.



Among the co-morbidities assessed, diabetes was the most prevalent, with 25% of patients having this condition. However, the prevalence of diabetes was slightly lower among patients with MDROs (21.6%) compared to non-MDRO patients (27%). Other significant associations were observed with chronic lung disease, leukemia, chronic renal disease, autoimmune disease, malignant tumor, septic shock, shock from other causes, cardiovascular and cerebrovascular diseases, combined with other infections, and multiple invasive procedures. MDRO patients had higher percentages of these co-morbidities compared to non-MDRO patients (Table 3).

Table 4 shows the alarming levels of resistance to key antibiotics. Acinetobacter spp. and Pseudomonas spp. Was notably high resistance rates to amikacin, with 85.95% and 48.78% resistance. Acinetobacter spp. (93.8%) and Klebsiella spp. (81.65%) showed resistance to cefepime, while widespread resistance to ceftriaxone was observed across Klebsiella spp. (90.23%) and Enterobacter spp. (90.16%). Levofloxacin resistance was prominent in Klebsiella spp. (68.34%) and E. coli spp. (53.60%). Among gram-positive pathogens, Staphylococcus aureus, coagulase-negative staphylococci, and Enterococcus spp. demonstrated concerning resistance patterns. High rates of penicillin resistance were observed in Staphylococcus aureus (94.16%) and coagulase-negative staphylococci (95.23%), while erythromycin resistance was notable in Staphylococcus aureus (60.58%) and coagulase-negative staphylococci (79.36%). Levofloxacin resistance was prominent in Staphylococcus aureus (21.16%) and Enterococcus spp. (92.15%)

DISCUSSION

The present study offers valuable insights into the prevalence of multidrug-resistant organisms (MDROs) and their antimicrobial resistance patterns among patients in Riyadh, Saudi Arabia. With an observed MDRO prevalence of 37.3%, this study shows the significant burden of antimicrobial resistance in the Riyadh, Saudia Arabia, aligning with global trends in the escalating rates of MDROs[10]. Gender disparities were notable, with a higher proportion of male patients classified as MDRO compared to females (64.3% vs. 35.7%), suggesting potential differences in healthcare-seeking behavior, antimicrobial usage patterns, or underlying biological factors[11].Further analysis revealed varying MDRO prevalence across different age groups, with the elderly population exhibiting the highest rates of MDRO colonization or infection. This finding corroborates existing literature highlighting advanced age as a significant risk factor for MDRO acquisition, attributed to factors such as comorbidities, healthcare exposure, and

Table 3: Significance of co-morbidities associated with MDROs among the patients among various Hospitals in Riyadh Province.

Co-morbidities	Total (n=1500)	MDR (n=560)	Non-MDR (n=940)	p
Diabetes	375 (25)	121 (21.6)	254 (27)	0.39
Leukemia	30 (2)	24 (4.29)	6 (0.64)	0.28
Chronic renal disease	105 (7)	53 (9.5)	52 (5.5)	0.52
Chronic lung disease	49(3.3)	37(6.6)	12(5.36)	0.54
Autoimmune disease	8(2.88)	6(3.61)	2(1.79)	0.60
Malignant tumor	49(17.63)	34(20.48)	15(13.39)	0.17
Septic shock	120(43.17)	77(46.39)	43(38.39)	0.23
Shock from other causes	74(26.62)	47(28.31)	27(24.11)	0.55
Cardiovascular and cerebrovascular diseases	66(23.77)	36(21.69)	30(26.79)	0.40
Combined with other infections	238(85.61)	147(88.55)	91(81.25)	0.13
Multiple invasive procedures	810 (54)	347(62)	395(42)	0.002
LOS	26 (10–45)	28 (14–50)	19.5(10–38)	0.01
In-hospital mortality	225 (15)	100 (18)	9 (10)	0.15
Bloodstream infection	360 (24)	157 (28)	188 (20)	0.70

ICU= intensive care unit; LOS= length of stay

Significant at p<0.05

Table 4: Antibiotic resistance pattern of the prevalent gram-negative pathogens isolated from patients in various Hospitals of Riyadh Province. Resistant isolates, n (%)

Antibiotic	Acinetobacter spp. (n = 178)	Klebsiella spp (n = 338)	E.coli spp. (n =222)	Pseudomonas spp. (n = 164)	Proteus spp. (n = 73)	Enterobacter spp. (n =61)	Total, n/N(%) (N =1036)	p value
Amikacin	153 (85.95)	268 (79)	107(48.19)	80 (48.78)	28 (38.35)	10 (16.39)	646/1036 (62.35)	p <0.001*
Amoxicillin/clavulanate	**NA	284 (84.02)	156 (70.27)	**NA	37 (50.68)	17 (27.86)	494/650 (76)	p < 0.001 *
Ampicillin/sulbactam	150 (84.27)	290 (85.79)	193 (86.94)	**NA	44 (60.27)	21 (34.42)	698/750 (93.06)	p < 0.001*
Cefepime	167 (93.8)	276 (81.65)	157 (70.72)	120 (73.17)	22 (30.13)	43 (70.49)	785/850 (92.35)	p < 0.001 *
Cefotaxime	174 (97.75)	305 (90.23)	192 (86.48)	**NA	55(75.34)	50 (81.96)	776/850 (91.29)	p < 0.001 *
Cefoxitin	**NA	291 (86.09)	133 (59.91)	**NA	22 (30.13)	55 (90.16)	501/750 (66.8)	p < 0.001 *
Cefpodoxime	**NA	331 (97.93)	207 (93.24)	**NA	32 (43.84)	50 (81.96)	620/650 (95.38)	p < 0.001 *
Ceftazidime	160 (89.89)	135 (39.94)	78 (35.13)	92 (56.1)	26 (35.62)	55 (90.16)	546/1036 (52.70)	p < 0.001 *
Ceftriaxone	178 (100)	305 (90.23)	193 (86.94)	**NA	37 (50.68)	55 (90.16)	768/1036 (74.13)	p < 0.001 *
Ciprofloxacin	150 (84.27)	284(84.02)	133 (59.91)	150 (93.75)	44(60.27)	30 (49.18)	791/850 (93.05)	p < 0.001 *
Doxycycline	174 (97.75)	305 (90.23)	156 (70.27)	**NA	61 (83.5)	50 (81.96)	746/850 * (87.76)	p < 0.001
Gentamicin	160 (89.89)	284 (84.02)	78 (35.13)	120 (73.17)	32 (43.84)	33 (54.09)	707/850 (83.17)	p < 0.001 *
Imipenem	101 (56.74)	10 (2.95)	10 (4.50)	20 (12.19)	4 (5.47)	1 (1.6)	120/850 (14.09)	p <0.001 *
Levofloxacin	150 (84.27)	231 (68.34)	119 (53.60)	80 (48.78)	8 (10.95)	5 (8.19)	593/1036 (57.23)	p<0.001*
Meropenem	125 (70.22)	7 (2.07)	5 (2.25)	20 (12.19)	4 (5.47)	1 (1.6)	162/1036 (15.63)	p <0.001 *
Piperacillin/ tazobactam	107 (60.11)	108 (31.95)	21 (9.45)	12 (7.31)	4 (5.47)	1 (1.6)	253/1036 (24.42)	p <0.001 *
Tetracycline	174 (97.75)	284 (84.02)	156 (70.27)	**NA	32 (43.84)	55 (90.16)	701/850 (82.47)	p <0.001 *
Tobramycin	107 (60.11)	231 (68.34)	119 (53.60)	120 (73.17)	8 (10.95)	5 (8.19)	590/850 (69.41)	p < 0.001*
Trimethoprim/ sulfamethoxazole	150 (84.27)	142 (42)	133 (59.91)	**NA	16 (21.9)	3 (4.8)	444/850 (52.23)	p <0.001 *
Colistin	0	**NA	**NA	0	**NA	**NA	**NA	–
Nitrofurantoin	NA	276 (81.65)	78 (35.13)	**NA	**NA	0 (0)	354/650 (54.46)	p < 0.001*

**NA = not applicable
* significant at p<0.05

immunosenescence[12]. The analysis using p value in Table:3 clearly explains that multiple invasive procedures and increase in the length of hospital stay are the major risk factors leading to increased drug resistance which correlates with the finding by Cuiyun Wu et al.[13]

In the present study, gram-negative isolates exhibited high resistance to almost all the used antibiotic classes with the least frequency recorded against amikacin (62.35%), followed by imipenem (14.09%) and meropenem (15.63%). Antimicrobial resistance patterns among identified pathogens decrease the complex interplay between bacterial genetics, antimicrobial selective pressures, and local epidemiological factors. High rates of multidrug resistance observed in Klebsiella spp., Acinetobacter spp., and Pseudomonas spp. mirror global trends, emphasizing the urgent need for robust infection control measures and antimicrobial stewardship interventions[14].

The literature further supports the study's findings, with consistent documentation of escalating MDRO prevalence globally. Gender disparities and age-related variations in MDRO prevalence have been well-documented, reflecting universal trends across diverse populations. The observed antimicrobial resistance patterns align with global reports, highlighting the urgent need for coordinated surveillance efforts and antimicrobial stewardship initiatives to combat the spread of resistant pathogens.[15]

In Saudi Arabia, addressing the challenge of antimicrobial resistance requires a multifaceted approach. Strengthening antimicrobial stewardship programs, enhancing infection control practices, and promoting antimicrobial surveillance initiatives are imperative to combatting MDROs effectively. Investments in laboratory capacity, antimicrobial susceptibility testing, and surveillance infrastructure are crucial for monitoring resistance trends and informing policy development[16]. Promoting antimicrobial stewardship education and awareness campaigns among healthcare professionals, patients, and the public can enhance antimicrobial prescribing practices and foster a culture of responsible antimicrobial use.[17]

The Strengths of this study include its multicenter approach, which allowed for the assessment of antimicrobial resistance patterns across diverse healthcare settings within Riyadh Province. Additionally, the comprehensive analysis of resistance mechanisms provides valuable insights into the underlying drivers of AMR among clinical pathogens.

However, this study has several limitations. Firstly, the retrospective nature of the study limits the ability to establish causality between antibiotic use and resistance patterns. Secondly, the study may be subject to selection bias, as it only includes patients from healthcare facilities within Riyadh Province. Lastly, the study did not assess the impact of antibiotic stewardship interventions on AMR prevalence, warranting further research in this area.

CONCLUSION

The study highlights the alarming prevalence of MDROs and underscores the urgent need for policy interventions to combat antimicrobial resistance (AMR). Policy makers must enact antimicrobial stewardship policies, enforce surveillance programs, and foster inter-facility collaborations to address this growing threat effectively. Healthcare providers should prioritize antimicrobial stewardship, implement rigorous infection prevention measures, and enforce patient isolation protocols to curb MDRO transmission. Future research should evaluate the impact of antimicrobial stewardship, monitor resistance trends longitudinally, and explore novel treatment strategies. Collaboration among stakeholders is essential for addressing AMR comprehensively through knowledge sharing platforms, research collaboration, and capacity building initiatives globally.

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CONFLICTS OF INTEREST

None.

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