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ORIGINAL RESEARCH

Feasibility Study on Risk Stratification for Multidrug-Resistant Organism Infections Among ICU Patients in the United Arab Emirates

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Video abstract

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Purpose: Global MDRO risk prediction tools are less applicable in UAE due to the variety in health profiles across all health sectors. Tools built using risk factors based on demographic structure of the country are more clinically applicable. This pilot retrospective case-control study aimed to identify potential risk factors associated with MDRO infections among critically ill patients in a UAE tertiary hospital and to assess the feasibility of conducting a larger-scale study for the future development of an empirical antibiotic selection tool.

Patients and Methods: Data were collected from a tertiary care academic hospital in Sharjah. Patients admitted to the ICU for more than 24 hours for a hospital-acquired infection between March to May 2022 were included. A total of 39 patients profiles were screened through random sampling. Potential risk factors for MDRO infections were identified. Student's *t*-test, Kruskal–Wallis test, and Chi-square test, all used wherever applicable at alpha = 0.05.

Results: Collected patient profiles were divided into three groups: MDRO (n = 11), Non-MDRO (n = 10), and no-growth (n = 18). Preliminary risk factors, such as history of bacterial growth was identified to put patients at 2.83 folds of risk of getting MDRO infection (*95% CI 1.489–5.39*). Patients who required enteral tube feeding had a 2.22 higher risk (95% CI 1.369–3.608). Moreover, the de-escalation of antibiotics was statistically significant ($p = <0.001$) and higher in the MDRO group versus non-MDRO with 81.8% (n = 9) and 60% (n = 6), respectively.

Conclusion: This study provides preliminary insights into potential risk factors for MDRO infections in ICU of UAE population, such as the need for tube feeding and tracheostomy. The study successfully demonstrated the feasibility of data collection and stratification of patients. The observed trends support the need for a larger, adequately powered study to validate these risk factors and to facilitate the development of a predictive risk assessment tool.

Keywords: antimicrobial resistance, risk assessment tool, epidemiological factors, critical care, antibiotic stewardship, UAE

Introduction

Antimicrobial resistance (AMR) poses a challenge to healthcare systems as it is considered a global threat to public health.[1] Hospital-acquired infections (HAI) caused by multidrug-resistant organisms (MDRO) increase the burden on health care, which is reflected in an increase in mortality, cost, and length of hospital stay.[2]

Hospital-acquired infections caused by MDRO could be identified by assessing patients for having certain risk factors, placing them at high risk of developing serious infections.[3] Although several risk factors for MDRO infections have been identified in studies conducted in countries such as the United States, Italy, Korea, and Switzerland, these

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findings are based on populations with distinct healthcare structures, antimicrobial stewardship practices, patient demographics, and patterns of antibiotic use.[4] In contrast, United Arab Emirates' (UAE) healthcare system is characterized by a unique blend of public and private sectors, high expatriate population diversity, and widespread empirical antibiotic use, which may contribute to different MDRO risk profiles. In the UAE, carbapenems-resistant *Pseudomonas aeruginosa* accounts for 14% of resistant isolates, and Enterobacterales of Extended-spectrum beta-lactamase (ESBL) accounts for 29.3% as outlined by the AMR surveillance report in 2023.[5] Reported risk factors related to the development of infections by these organisms in a UAE based-population is lacking. A meta-analysis of 21 represented articles identified history of antibiotic use as the most commonly reported risk factor for developing respiratory MDRO infection.[6] The presence of specific comorbidities, prior infection or colonization with particular bacteria, and previous hospitalization were considered other risk factors for the development of MDRO infection.[6] However, these risk factors were identified through studies conducted in countries with populations different from those in UAE. Distinctive risk factors for infections caused by Carbapenem-resistant Enterobacterales (CRE) such as surgical history have been reported in some countries but not others, highlighting the need for a risk assessment that is population-specific.[7] Consequently, the identification of MDRO risk factors for patients suspected to have HAI would surrogate high-risk ones from those with low risk; leading to the appropriate selection of empirical antimicrobials. This decision relies on clinical judgment, which may not be optimal in the absence of a risk stratification framework. Nevertheless, studies from the UAE population spot the light only on the resistance trends of MDR organisms focusing on surveillance data and resistance phenotypes. Most of these studies are considered descriptive in nature or performed at a molecular surveillance level.[8,9] As an example, Park S et al evaluated the effectiveness of tailored screening for MDRO upon ICU admission, identified common risk factors, and developed a prediction tool for MRSA and CRE *Acinetobacter baumannii* and Enterobacterales. However, despite it being a single-center study, the developed prediction tool was based on patient carriers of MDRO including colonization which has not been attributed to an infection.[7]

Despite the global and local urgency in tackling MDROs, data related to MDRO risk factors identification from UAE is limited, highlighting the need for region-specific studies to guide risk prediction in ICU settings. To our knowledge, no locally derived tool exists to identify risk factors and predict the likelihood of MDRO infections among ICU patients is available from UAE population, thereby limiting the ability to guide empirical antibiotic use effectively.

The aim of this pilot retrospective case-control study is to explore potential risk factors associated with MDRO infections among critically ill patients of UAE population. Additionally, the study sought to assess the feasibility of conducting a larger-scale investigation to support the future development of a risk prediction tool that could guide the selection of empirical antibiotic therapy and enhance antimicrobial stewardship efforts.

Materials and Methods

Study Design and Setting

This is a pilot retrospective case-control study conducted at the medical ICU of a tertiary care hospital in the United Arab Emirates after obtaining the necessary ethical approval. The study was designed to evaluate data accessibility, patient categorization feasibility, and to explore preliminary trends in risk factors associated with MDRO infections. Due to the exploratory nature and small sample size, this study did not perform matching for age, gender or comorbidities which might be considered as confounding factors, however controls and cases were selected from the same source population admitted during the period of March–May 2022 to reduce selection bias. A waiver of informed consent under applicable ethical guidelines was requested from the ethics committee at the hospital, due to the retrospective nature of the study, as no direct intervention to patients was done.

Study Population and Grouping

Eligible patients were adults admitted to the ICU during the study period who had clinical suspicion of infection and corresponding microbiological culture results. Patients were divided into three groups based on culture outcomes:

MDRO group (n = 11): Patients with confirmed infections caused by multidrug-resistant gram negative organisms.

Non-MDRO group (n = 10): Patients with infections caused by gram-negative non-resistant pathogens. Reports of microbiological cultures showed growth in sputum, urine, and blood cultures.

No-growth group (n = 18): Patients with clinical suspicion of infection but negative culture results after 48–72 hours of incubation, attributed to the use of antimicrobials prior ICU admission.

Cases were defined as patients with culture-confirmed infections caused by MDROs, while controls were those with culture-confirmed infections not caused by MDROs.

The identified MDROs in this study were Extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae that is known to be resistant to Ceftriaxone, carbapenem-resistant Enterobacteriaceae (CRE), and carbapenem-resistant *Pseudomonas aeruginosa,* and organisms of resistant strains such as AmpC β-lactamase (Class C cephalosporinase) (ampC), *Klebsiella pneumoniae* carbapenemase (KPC), Oxacillinase-48–type carbapenemase (OXA-48).

Inclusion Criteria

Patients admitted to the ICU for more than 24 hours for a hospital-acquired infection, including but not limited to sepsis, lower respiratory infection, urinary tract infection, etc. At least one culture report is to be available for both cases and controls.

Exclusion Criteria

Patients admitted to ICU for less than 24 hours, those who were admitted for community-acquired infection, or those who have no culture report available for both cases and controls.

Sample Size and Sampling Method

The sample size calculation for the intended full-scale study was conducted using Epi Info™ and OpenEpi (Open Source Epidemiologic Statistics for Public Health). Based on an anticipated effect size, a power of 80%, and a two-sided significance level ($\alpha = 0.05$), the required total sample size was estimated to be 294 patients.

However, as this was a pilot study primarily intended to assess feasibility and inform the design of a larger investigation, a sample representing approximately 10–15% of the calculated size (i.e., 30 to 44 patients) was deemed sufficient.[10] This range aligns with commonly accepted thresholds for pilot studies aimed at refining data collection procedures and evaluating logistical considerations. A convenience sampling approach was employed to identify eligible patients from the electronic medical records during the study period.

Data Extraction

A data extraction was performed by JM using a patient profile form to collect data from medical records retrospectively. Information of 2–3 patient profiles were randomly verified by another person in the field, to validate the data provided. Collected data variables includes demographics data such as age and gender, infective parameters including first-day levels of CRP, PCT, and WBC were collected. Potential factors attributed to the risk of MDRO as previously reported in the literature, including a history of antibiotic use, a history of infections and positive cultures in previous 90 days, a history of hospitalization, and the use of medical device, were collected. All the collected data were anonymized and de-identified where possible. Secure data storage and limited access protocols are in place as privacy and confidentiality protections.

Statistical Analysis

The statistical analysis was done using IBM SPSS version 28. After data cleaning and coding, appropriate tests were selected accordingly. Normality testing was first performed to assess the population distribution of the data using the Shapiro–Wilk test of normality. Then, based on the type of data, the Student's *t*-test was used for parametric variables, Kruskal-Walis for non-parametric variables, and Chi-square test for nominal variables, all used wherever applicable. Tests of significance were 2-tailed. A *p-value* of < 0.05 was considered significant. Risk analysis of 2×2 cells was used to determine the presence of an association between MDRO and all other variables.

Results

Patient Demographics and Clinical Data

A total of 39 patient cases were retrieved from the medical records, of which 61.5% of all the cases were represented by females with an overall mean age of 80.26 years (± 12.49 SD). Table 1 shows the baseline characteristics of the selected

Table 1 Patient Baseline Characteristics

Characteristic	No Growth (n = 18)	MDRO Cases (n = 11)	Non-MDRO (n = 10)	*P* Value
Age (mean± SD)*	76.44 ± 14.41	85.55 ± 10.53	81.30 ± 8.88	0.157
Females◊	12(50%)	7 (29.2%)	5 (20.8%)	0.676
Creatinine Level at admission umol/l [Median (IQR)]*	174 (216)	122 (92)	168 (212)	0.089
Comorbidities◊				
Diabetes Mellitus	61.1%	81.8%	70%	0.502
Hypertension	88.9%	81.8%	80.8%	0.782
Chronic Kidny Disease	55.6%	36.4%	40%	0.544
Atrial fibrillation	27.8%	18.2%	20%	0.808
Heart Failure	11.1%	9.1%	10%	0.985
Ischemic Heart Disease	22.2%	36.4%	30%	0.706
Dyslipidemia	38.9%	18.2%	10%	0.196
Malignancy	11.1%	18.2%	20%	0.786
Hepatic Dysfunction	16.7%	9.%	10%	0.800
Asthma	5.6%	9.1%	0	0.637
Neurological disease	22.2%	54.5%	40%	0.202
Others	22.2%	36.4%	50%	0.317
Reported bacterial growth in previous 90 days◊	55.6%	100%	60%	0.032 (for cases VS non-cases: 0.0.035)
Route to ICU Admission◊				
Transfer from Ward of Same Hospital	88.9%	100%	80%	0.316
Transfer from Other Hospital	11.1%	0%	20%	
Use of Antibiotic in the past◊				
None	11.1%	0	10%	0.817
Monotherapy	11.1%	18.2%	10%	0.593
Combination	77.8%	81.8%	80%	0.916
CRP Level at admission [Median (IQ)]*	54 (141)	109 (147)	82 (178)	0.771
PCT Level at admission (mean± SD)!	1.80±2.59	6.26±15	1.74 ±1.88	0.572
WBC Level at admission (mean± SD)!	23.29 ± 30.21	15.05 ± 6.90	23.49 ± 29.83	0.904
Absolute Neutrophils Level at admission (mean± SD)!	15.21±20.57	11.53 ± 6.43	23.04 ± 29.59	0.579
RBG Level at admission (mean± SD)*	9.43 ± 3.31	9.21±4.85	9.22 ± 1.82	0.982
Death cases◊	17 (47.2%)	9 (25%)	10 (27.8%)	0.265
LOS in ICU [Median (IQR)]*	11 (17)	43 (53)	22 (36)	0.074
Recurrent infection within 90 days◊	33.3%	63.6%	80%	0.045 (for cases VS non-cases: 0.635)

Note: *One Way ANOVA. ◊Chi-Square. !Kruskal-Wallis.
Abbreviations: MDRO, Multi-Drug Resistant Organism; SD, Standard deviation; ICU, Intensive Care Unit; IQR, Interquartile Range; LOS, Length of Stay; RBG, Random Blood Glucose; CRP, C-Reactive Protein; PCT, Procalcitonin; WBC, White blood count; CRRT, Continuous renal replacement therapy.

sample. Hospital acquired pneumonia, sepsis and urinary tract infection were the only reported infections among the collected data. Ten cases with MDRO (such as ESBL *E.coli*, XDRO *Klebsiella pneumonia*, and CRE *Pseudomonas aeruginosa*) and 11 unmatched non-cases of MDRO (such as *E.coli, Klebsiella pneumonia*, and *pseudomonas aeruginosa*) were identified during the pilot phase; the remaining 18 cases had no bacterial growth in culture.

No significant differences were found in baseline characteristics among the groups. Recurrent infection was found to be higher in MDRO and non-MDRO groups when compared to the no-growth group ($p = 0.045$), however no statistically

significant difference between cases (MDRO) and controls (non-MDRO) (p = 0.635). No difference was found in the objective data of infection, such as CRP and procalcitonin, among all groups at the baseline level.

Relationship Between Factors and MDRO Infection

Upon comparison between cases and controls to identify the association between projected factors and MDRO infection, it was found that previously reported bacterial growth within 90 days prior to ICU admission would put patients at 2.83-fold risk of getting MDRO infection (95% CI 1.489–5.39), as shown in Table 2. Enteral tube feeding puts patients at 2.22 folds of risk getting an MDRO infection (95% CI 1.369–3.608), a similar risk was identified in those requiring central venous catheters. Moreover, the control group had significantly lower odds of requiring tracheostomy when compared to the cases (OR = 0.056, CI at 95% (0.006–0.491)). The association between the potential risk factors and MDRO infection is shown in Figure 1

Pattern of Empirical Antimicrobial Use

Looking into the pattern of antibiotic use in both groups, a similar average number of antimicrobials, and similar duration of therapy was identified. The MDRO group had a higher duration of therapy with days more than 14; however, 33.3% of patients in the control group had an average of 7 to 14 days of therapy. Ceftazidime/Avibactam was mostly used in MDRO group against ESBL *E.coli* and XDRO *Klebsiella pneumonia*. One of the highlighted findings in this study is the need for de-escalation of antimicrobials during the ICU stay, which was higher (81.8%) in MDRO cases compared to the control group (60%). Whereas, the empirical selection with appropriate sensitivity towards the resistant organism accounted for 18.2% in the MDRO group. This highlights the need for more selective empirical treatment at the start of therapy upon identifying patients with a high risk of MDRO infection. Patients transferred to the ICU within the same facility were at double the risk of getting an MDRO infection when compared to the control group (95% CI 1.402–4.024). Table 3

Table 2 Association Between Factors and MDRO Infection

Independent Variable	Dependent Variables		Odds Ratio	95% Confidence Interval (CI)
	MDRO (n = 10)	Non-MDRO (n = 11)		
Gender (Female)	7 (29.2%)	5 (20.8%)	1.75	0.306–10.02
Requiring Tracheostomy	81.8%	20%	0.056	0.006–0.491
Requiring Endotracheal Intubation	81.8%	80%	0.889	0.101–7.85
Requiring CRRT	45.5%	60%	1.800	0.318–10.20
Previous exposure to combination antibiotic therapy	81.8%	80%	0.889	0.101–7.85
Previous exposure to antibiotic Monotherapy	18.2%	10%	0.500	0.038–6.54
Presence of a Foley catheter	100%	100%	0.890	0.103–6.83
Requiring enteral feed	100%	90%	2.222	1.369–3.608
Requiring central line	100%	90%	2.222	1.369–3.608
Reported bacterial growth in previous 90 days	100%	60%	2.83	1.489–5.39
Transfer from the Same hospital, different ward	100%	80%	2.375	1.402–4.024

Abbreviations: MDRO, Multi-Drug Resistant Organism; CRRT, Continuous renal replacement therapy.

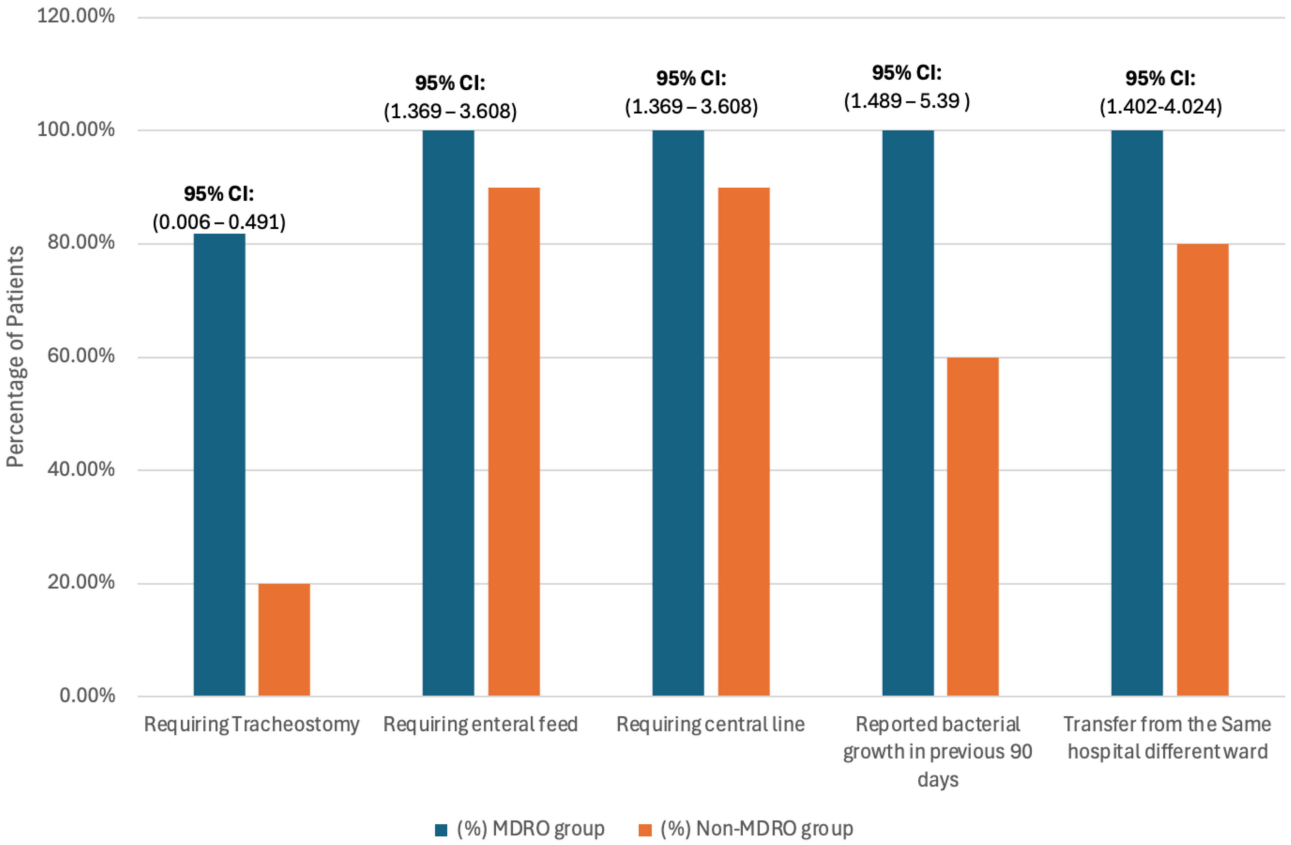

Figure 1 Association between potential risk factors and MDRO Infection.

Discussion

This pilot study offers preliminary insights into potential risk factors associated with MDRO infections among critically ill patients in a UAE tertiary hospital. It confirms the feasibility of conducting a larger-scale investigation in this setting. Patients were stratified into three groups—MDRO, non-MDRO, and no-growth—based on the results of microbiological cultures.

Table 3 Pattern of Empirical Antimicrobial Use in Suspected Patients with MDRO Infections

Parameter	MDRO Cases (n = 11)	Non-MDRO Controls (n = 10)	*P* Value
Average number of antibiotics used – [Median (IQR)]^	3 (6)	3.5 (3)	0.082
Type of Antimicrobial#			
Piperacillin-tazobactam	3	7	0.050
Ceftriaxone	1	1	0.476
Cefepime	2	2	0.916
Fluroquinolones	4	1	0.157
Carbapenems	7	4	0.279
Ceftazidime/avibactam	4	0	0.034
Colistin	1	1	0.943

(*Continued*)

Table 3 (Continued).

Parameter	MDRO Cases (n = 11)	Non-MDRO Controls (n = 10)	*P* Value
Duration of Antibiotic therapy#			
• 1–6 days	9.1%	20%	
• 7–14 days	0%	33.3%	
• >14 days	90.9%	25%	
• Mean days ± (SD)	14.72 ± 4.64	10.30 ± 6.16	0.279
De-escalation to narrower spectrum antibiotic#			<0.001
Yes	81.8%	60%	
No	-	10%	
Not needed, first antibiotic appeared to be sensitive	18.2%	30%	

Note: ^Mann–Whitney Test. #Chi-Square Test.
Abbreviations: MDRO, Multi-Drug Resistant Organism; SD, Standard deviation; IQR, Interquartile Range.

The practice of using antimicrobials in the ICU is subjected to the status of the patient if hemodynamically unstable. Surviving sepsis campaign recommends the use of empirical antimicrobials within one hour of early recognition of sepsis; however, the selection of an agent is left to practitioners. In our study, the utilization pattern of piperacillin-tazobactam was higher in the control group, ceftazidime-avibactam was higher in the cases group, which correlated with the presence of resistant strains like ESBL *E.coli* and KPC *Klebsiella pneumonia*, and carbapenems were used in both.[11] Multiple factors influence the use of empirical antibiotics in different infections, and identifying specific factors that put patients at risk of developing an MDRO infection by either an ESBL or CRE is crucial at the time of admission to ICU.[12] Identification of risk factors varies based on specific epidemiological factors in each region. Isabelle Vock et al reported a history of colonization or infection as the most predictive independent risk factor for ESBL-producing *Enterobacterales* in Switzerland.[13] This finding is consistent with the results of this pilot study, which revealed that a history of bacterial growth increased the risk of infection caused by MDRO by 2.83-fold.

Previous use of antimicrobials was reported by Tumbarello et al, as an independent risk factor for ESBL infection in a population of Italy, and recent use of beta-lactam and fluroquinolones was reported by Jonson et al in the USA, however in this pilot study it was not found as similar which might be due to the small sample size.[14,15]

Another noteworthy finding was the increased risk of MDRO infection in patients receiving enteral tube feeding, who demonstrated a 2.22-fold higher risk (95% CI: 1.369–3.608). This supports existing evidence linking invasive interventions to increased MDRO acquisition. Feeding through the enteral tube is also considered a risk factor for carbapenem-resistant gram-negative bacterial infection as described by Kiddee et al, in Thailand, likely due to compromised barriers and prolonged exposure to the healthcare environment.[16]

Recurrent infections were significantly more prevalent in patients with positive culture results compared to those with no growth ($p = 0.045$), suggesting that a history of infection may be a useful clinical indicator for heightened diagnostic and therapeutic vigilance. Importantly, the presence of a previously documented bacterial infection within the preceding 90 days was associated with a 2.83-fold increased risk of developing an MDRO infection (95% CI: 1.489–5.39). This finding aligns with global literature that identifies recent healthcare exposure and prior colonization as key predictors of antimicrobial resistance. However, these associations must be interpreted cautiously due to the small sample size and exploratory nature of the analysis.

Another study done in Saudi Arabia by Alwazzeh, M.J et al, showed that among bacterial infections associated with central-line, 47% were of multi-drug resistant organisms.[17] Similarly, those who had a central line were at 2.22 times higher odds of developing an infection by MDRO (95% CI of 1.369–3.608), in our study. In addition to these factors, Song JY et al reported in the Korean population that patients who developed infection caused by carbapenem-producing *pseudomonas aeruginosa* had higher admission rates from wards of the same hospital. This finding is coherent with our

findings in terms of the route of admission to the ICU, as we found patients transferred from wards had a 2.375-fold higher risk of developing MDRO infection when compared to the non-MDRO group.[18]

Furthermore, tracheostomy was found to be associated with the development of an MDRO infection and was lower in those who had infections unrelated to MDRO in our study. These results are consistent with one study done in UAE by Park S et al, at a single center in a northern emirate, which indicated that patients who had tracheostomy or endotracheal tube have positive screening for MDRO carrier, yet not necessarily an infection.[7] Different findings were reported in a systemic review and meta-analysis including studies performed on patients with lower-respiratory tract infections caused by MDRO. Factors such as recent hospitalization, previous antibiotic treatment, and previous tracheostomy were not defined consistently across all studies included.[6] In Saudi Arabia, the independent risk factors identified for patients who developed nosocomial infection caused by MDRO were related to the use of TPN, a history of carbapenem use, concurrent use of antifungals, a longer duration of antibiotics (>10 days) and the presence liver disease.[19] The only factor consistent with our study is the history of antibiotic use, while others are deemed different pertaining to the Saudi population.

Antibiotic de-escalation, often used as a marker for effective antimicrobial stewardship, was significantly more common in the MDRO group (81.8%) than in the non-MDRO group (60%) ($p< 0.001$). While this may initially appear counterintuitive, it could reflect clinicians' efforts to tailor therapy once resistance patterns were identified or when targeted treatment was possible after microbiological confirmation. Alternatively, it may reflect delayed initiation of appropriate therapy, necessitating eventual streamlining once susceptibility results became available.

The feasibility of this study was confirmed by the ability to retrieve key clinical data, stratify patients based on culture results, and identify measurable risk variables. The results highlight observable trends and support the need for a larger, more robustly powered study to validate these findings and to develop a locally relevant risk prediction tool.

The differences in populations could justify the variances in reported risk factors through multiple studies, depending on the epidemiological factors concerning each country. This highlights the need for individualized risk stratification by each region, taking into consideration disparities in the country's population. The challenge in selecting the appropriate antimicrobial upon admission to the ICU arises from the inability to precisely identify patients requiring the use of broader or narrower spectrum antibiotics. Hence, the use of a risk prediction model is essential to classify patients at risk or not. However, the application of published prediction models in healthcare institutions other than those in which they were originally developed may lead to substantial patient misclassification. This misclassification can result in inappropriate identification of individuals at risk, which in turn may cause the improper allocation of antibiotic therapies. Such discrepancies not only compromise individual patient outcomes but may also contribute to increased antimicrobial resistance rates at a broader institutional or population level over time.

Limitations

Limitations of the study include the small sample size, which restricts statistical power and generalizability. Moreover, the retrospective design and use of convenience sampling may introduce selection bias. Nonetheless, these limitations are inherent in pilot studies and do not detract from the study's utility in informing future research design.

Implications for Future Research

The association between MDRO infection and the five potential risk factors were observed within a subset comprising approximately 10% of the estimated sample size required for a full-scale study. It is anticipated that additional relevant variables will emerge upon recruitment of the full sample representing the target population. While the identification of risk factors is essential, it is not sufficient in isolation. The integration of these factors into a validated risk prediction model or assessment tool is critical for translating this knowledge into clinical decision-making.

Based on these findings, we recommend conducting a larger, multicenter study encompassing hospitals across different cities in the United Arab Emirates. Furthermore, based on insights gained during this pilot, the patient data collection form has been revised to enhance the comprehensiveness and accuracy of future data.

Modifications include capturing five-days trends in infection-related biomarkers, documenting corticosteroid use within the preceding 90 days, and specifying the resistant strain of the MDRO (eg, ESBL or CRE). These enhancements aim to improve variable identification and strengthen the foundation for a robust predictive model.

Conclusion

The use of tracheostomy, central line, enteral tube feeding and previously documented bacterial growth, are potential risk factors for MDRO infection in UAE population. Identifying these risk factors at bed site is a step towards the appropriate choice of empirical antibiotics which in turn strengthens antimicrobial stewardship efforts and positively impacts the trends of antimicrobial resistance in UAE. The exploratory findings of this study provide insights to perform larger, adequately powered, multicenter study, able to internally and externally validate these risk factors and to facilitate the development of a predictive risk stratification tool. Such a tool could play a crucial role in optimizing empirical antibiotic therapy and advancing antimicrobial stewardship efforts in the region.

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Disclosure

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