Scientific Research Publishing

Open Journal of Medical Microbiology, 2023, 13, 263-275
https://www.scirp.org/journal/ojmm
ISSN Online: 2165-3380
ISSN Print: 2165-3372

Risk Factors Associated with MDR and CR *Acinetobacter baumannii* Carriage among ICU Patients Hospitalized at MOI Teaching and Referral Hospital, Kenya

Fred Kipsang[1*], Abednego M. Musyoki[2], Nelson C. Menza[2]

[1]Department of Biomedical Sciences, Kabarak University, Kabarak, Kenya
[2]Department of Medical Laboratory Sciences, Kenyatta University, Nairobi, Kenya
Email: *menza.nelson@ku.ac.ke

How to cite this paper: Kipsang, F., Musyoki, A.M. and Menza, N.C. (2023) Risk Factors Associated with MDR and CR *Acinetobacter baumannii* Carriage among ICU Patients Hospitalized at MOI Teaching and Referral Hospital, Kenya. *Open Journal of Medical Microbiology*, **13**, 263-275.
https://doi.org/10.4236/ojmm.2023.134021

Received: September 15, 2023
Accepted: December 22, 2023
Published: December 25, 2023

Abstract

Background: Multi-drug resistant and Carbapenem-Resistant *Acinetobacter baumannii* (CRAB) infections present a significant challenge in hospital ICU settings worldwide and the threat posed is worse in developing countries including Kenya. Despite the limited treatment options, there is inadequate comprehensive data on factors associated with MDR and CR *Acinetobacter baumannii* carriage among ICU patients hospitalized at hospitals. This study therefore aimed to address this gap and determined risk factors associated with MDR and CR *Acinetobacter baumannii carriage* among ICU patients hospitalized at MOI Teaching and Referral Hospital, Kenya. **Methods**: Through cross-sectional study design, a total of 132 ICU admitted patients were purposively enrolled in this study between July 2019 and July 2020. Demographic and risk factors associated with MDR and CR *Acinobacter baumannii* were collected using structured questionnaire. Descriptive statistics and bivalent analysis were used for data analysis obtained. Level of statistical significance was 95% confidence interval (CI) for all analysis. **Results:** Bivariable analysis showed that employed participants were 3.4 times more likely to have *A. baumannii* compared to the unemployed (cOR = 3.38, 95%, CI: 1.09 - 10.43, p = 0.035). Patients who were having high BMI were likely to be infected by *A. baumannii* compared to those who had normal/low BMI (aOR = 11.2, 95%, CI: 3.57 - 21.11, p = 0.004). Those who were aged ≥ 50 years were 21 times more likely to be carbapenem-resistant *Acinetobacter baumannii*, COR = 21.0, 95% CI: 1.83 - 240.52, p = 0.011. Those who stayed in ICU for more than 30 days were 16 times more likely to be carbapenem-resistant *Acinetobacter baumannii* compared to those who had been

admitted (COR = 16.0, 95% CI: 1.45 - 176.45, p = 0.019). **Conclusion:** Increased length of hospital stay, obesity and marital status were the factors found to be significantly associated with *A. baumannii* infections among ICU admitted patients. On the other hand, gender, age, level of education, occupation, referral status and presence of infection were found to have no significant association with *A. baumannii* infections among ICU admitted patients. All patients admitted to the intensive care units should be screened for colonization with *A. baumannii*, owing to the poor treatment outcomes associated with carriage of this multidrug resistant pathogen. Proper infection control in the ICU settings should be upheld to mitigate the spread of *A. baumannii* in the intensive care units.

Keywords

MDR, Carbapenem Resistant *Acinetobacter baumannii*, ICU

1. Introduction

In many African countries, *Acinetobacter baumannii* has emerged as a concerning and significant cause of healthcare-associated infections, particularly in intensive care units (ICUs) and other healthcare settings. Its ability to thrive in healthcare facilities and persist on various surfaces contributes to its reputation as a troublesome nosocomial pathogen. However, the lack of standardized surveillance systems and inconsistent data reporting practices across different African countries may result in underestimation or variability in reported prevalence rates. As a result, obtaining accurate and comprehensive epidemiological data on *Acinetobacter baumannii* prevalence in Africa becomes an ongoing challenge, hindering the development of targeted interventions and infection control measures. Despite these challenges, available data suggests a notable rise in *Acinetobacter baumannii* infections in African healthcare settings. For example, a study done in a major tertiary hospital in West Africa reported that *Acinetobacter baumannii* was the common ubiquitous pathogen in majority of the specimens from clinical setups, accounting for approximately 40% of all gram-negative bacteria [1]. In another study from East Africa, conducted in a referral hospital's ICU, the prevalence of *Acinetobacter baumannii* infection was found to be 24.5%, with a considerable proportion of the isolates showing resistance to multiple antibiotics, including carbapenems [2].

In Kenya, as in many other regions, the major risk factor associated with the emergence of drug-resistant *Acinetobacter baumannii* (*Ab*) variants is prior exposure to antibiotics. Patients with a history of carbapenem exposure have a higher likelihood of acquiring strains of *Ab* that are resistant to multiple drugs. Moreover, the constant exposure of *Ab* to antimicrobial drugs within the hospital environment creates a breeding ground for the development of mutant forms, leading to infections that pose serious challenges for patient management [3].

Despite the importance of understanding and addressing this issue, there remains a significant knowledge gap in Kenya regarding the risk factors contributing to the carriage of CRAB in patients admitted to ICU. Gaining comprehensive insights into these aspects is crucial for implementing targeted interventions to mitigate the spread of drug-resistant *A. baumannii* and improve patient outcomes in Kenyan healthcare settings. This study therefore determined risk factors associated with MDR and CR *Acinetobacter baumannii* carriage among ICU patients hospitalized at MOI Teaching and referral hospital, Kenya.

2. Materials and Methods

2.1. Study Area

This study was carried out in the ICU section of MOI teaching and Referral hospital (MTRH). The facility is the second largest public hospital in Kenya. It is located in Eldoret, Uasin Gishu county (311 kilometers Northwest of Nairobi), Kenya. It serves residents from 24 counties in Kenya, Southern Sudan, parts of Eastern Uganda and Democratic Republic of Congo. At the time of this study, MTRH had a bed capacity of 1020 serving as a level six referral hospital. It offers inpatient, outpatient and specialized care services such as the ICU [4]. The intensive care unit had a bed capacity of 20 beds at the time of study. These hospital demographics made the facility more ideal for the current study.

2.2. Study Design

This study adopted a cross-sectional descriptive study design among patients admitted to the ICU at MTRH between January and December, 2020.

2.3. Study Population

Patients admitted in the ICU at MTRH between July 2019 and July 2020 constituted the study population for this study. This cohort serves as high-risk individuals for *A. baumannii* co-infection in the hospital setup and ICU environs within a hospital settings [5]. One hundred and thirty two (132) were recruited in this study.

2.4. Sample Size Determination

The study sample size was calculated according to the Chow *et al.* 2007 [6] formula. The prevalence rate used was 9.5% [7] with a sample size of 132 patients participating in this study.

2.5. Sampling Technique

Adult patients (≥18 years) admitted to the ICU for at least 48 hours and consenting to participated in this study through close relatives or legal representatives were enrolled. Purposive sampling technique according to Palinkas *et al.* 2013 [8] was used to select subjects who satisfied the inclusion criteria. Sampling interval Kth was calculated as; where, MTRH has intensive care units (ICUs)

services with an annual capacity of 1500 patients and the sample size is n (132), giving a sampling interval (K) of 12. Every day for the year of study, intervals of 12 was used to sample participants. The recruitment process was done continuously until 132 study participants were recruited.

2.6. Data Collection

Demographic data, such as gender, age and hospital stay duration, comorbidities, and treatment outcomes, were collected using a standardized questionnaire. The questionnaire was designed and standardized to capture essential variables and clinical information of the study subjects and the factors associated with MDR and CR *Acinetobacter baumannii* among ICU patients. Pretesting of the questionnaire was done at Nakuru County referral hospital (level 6) with 14 (10%) of the study sample patients. The results of pretesting were used in improving data collection tool (**Appendix**).

2.7. Ethical Considerations and Permit

The study was conducted with approval from the School of Medicine, MOI University and the superintendent at MOI Teaching and Referral Hospital (ELD/MTRH/R&P/10/2/V.2/2010), while ethical clearance was granted by the Institutional Research and Ethics Committee (IREC) at MOI University under reference number (IREC/2019/126 - 0003392). The National Commission of Science Technology and Innovation (NACOSTI) also issued a permit for data collection under licensure number (NACOSTI/P/19/75649/29865). Prior to sample collection, informed consent was obtained from all participants or their representatives and anonymized codes were used to ensure confidentiality of patients' data.

2.8. Data Analysis

Mean values and standard deviations were used to present data in tables. Statistical analysis was carried out using SPSS Statistics version 25.0 [9]. Percentages and proportions were utilized to characterize the social and clinical demographics of the subjects. Additionally, odds ratios (aORs) were computed to assess the presence or absence of *Acinetobacter baumannii* carriage. Furthermore, multivariate logistic regression analysis was employed to further explore and identify significant associations between these variables. Statistical significance was set at $p \leq 0.05$.

3. Results

3.1. Socio-Demographic and Clinical Characteristics of the Study Population

A total of 132 patients were enrolled in the study. Majority of the participants (51.5%, 68/132) were male. The median age was 52 (IQR = 36 - 58) years with (38.6%, 51/132) of the participants aged between 45 and 59 years. Most of the

participants (74.2%, 98/132) were married. In investigating education level, (39.4%, 52/132) had primary level of education with equal percentage having secondary level education. Almost half of the participants, (44.7%, 59/132) were self-employed. All of the participants had at least one comorbidity with renal related conditions (50.8%, 67/132) and respiratory related conditions (42.4%, 56/132), Table 1.

3.2. Factors Associated with *A. baumannii* Carriage among Patients Admitted to the ICU at MOI Teaching and Referral Hospital

Bivariable analysis showed that employed participants were 3.4 times more likely to have *A. baumannii* compared to the unemployed (cOR = 3.38, 95%, CI: 1.09 - 10.43, p = 0.035), and patients referred to the study site was 83% less likely to have infection compared to non-referral (cOR = 0.17, 95%, CI: 0.06 - 0.51, p = 0.002). Multivariable analysis showed an independent association between *A. baumannii* carriage with occupation and referral status, where the employed patients were 4.4 times more likely to harbor *A. baumannii* (aOR = 4.41, 95%, CI: 1.32 - 14.79, p = 0.016), while those referred from other facilities were 86% less likely compared to non-referred patients (aOR = 0.14, 95%, CI: 0.05 - 0.45, p = 0.001). Patients who were having high BMI were likely to be infected by *A. baumannii* compared to those who had normal/low BMI (aOR = 11.2, 95%, CI: 3.57 - 21.11, p = 0.004). However, gender, age, marital status and education factors were not significantly associated with *A. baumannii* carriage among patients admitted to the ICU (Table 2).

3.3. Factors Associated with Carbapenem-Resistant *Acinetobacter baumannii* (CRAB) among ICU Patients Hospitalized at MOI Teaching and Referral Hospital

Bivariable analysis established that those who were aged ≥ 50 years were 21 times more likely to be carbapenem-resistant *Acinetobacter baumannii*, COR = 21.0, 95% CI: 1.83 - 240.52, p = 0.011. Those who stayed in ICU for more than 30 days were 16 times more likely to be carbapenem-resistant *Acinetobacter baumannii* compared to those who had been admitted (COR = 16.0, 95% CI:1.45 - 176.45, p = 0.019). Those who had underlying comorbidity were 46 times more likely to be carbapenem-resistant *Acinetobacter baumannii* compared to those without underlying comorbidity, COR = 46.0, 95% CI:3.33 - 634.88, p = 0.003. Variables were subjected to multivariable model where none of the variables were statistically significant (Table 3).

4. Discussion

This study found that employed participants exhibited a 4.4-fold higher likelihood of harboring *A. baumannii*, suggesting occupational exposure's potential role in colonization. Consistent findings emerged in previous studies across various healthcare settings, employing retrospective cohort designs and cross-sectional

Table 1. Socio-demographic and clinical characteristics of the study population.

Characteristic	Frequency	%
Gender		
Male	68	51.5
Female	64	48.5
Age (Median, IQR)	**52.0 (36 - 58.0)**	
<24	10	7.6
25 - 44	42	31.8
45 - 59	51	38.6
≥60	29	22.0
Marital status		
Single	34	25.8
Married	98	74.2
Education level		
No formal education	17	12.9
Primary level	52	39.4
Secondary level	52	39.4
Tertiary level	11	8.3
Occupation		
Unemployed	50	37.9
Self employed	59	44.7
Employed	23	17.4
Referral status		
Referral	116	87.9
Non-referral	16	12.1
Comorbidities		
Respiratory related conditions	56	42.4
Renal related conditions	67	50.8
CNS related conditions	10	7.6
Autoimmune related conditions	14	10.6
Metabolic disorder	11	8.3
Asthmatic	10	7.6
Burns	6	4.5
Injuries	8	6.1
Blood stream conditions	8	6.1
Other Conditions	20	15.2

Table 2. Factors associated with *A. baumannii* carriage among patients admitted to the ICU at MTRH.

Factor	*A. baumannii* present n (%)	*A. baumannii* absent n (%)	*cOR* (*95%* CI)	p-value	*aOR* (*95% CI*)	p-value
Gender						
Male	16 (53.3)	52 (51.0)	1.10 (0.47 - 2.48)	0.839		
Female	14 (46.7)	50 (49.0)	*Ref*			
Age						
<24	2 (6.7)	8 (7.8)	1.27 (0.22 - 7.45)	0.789		
25 - 44	12 (40.0)	30 (29.4)	0.80 (0.27 - 2.35)	0.679		
45 - 59	9 (30.0)	42 (41.2)	1.49 (0.49 - 4.52)	0.487		
≥60	7 (23.3)	22 (21.6)	*Ref*			
Marital Status						
Single	10 (33.3)	24 (23.5)	1.63 (0.67 - 3.94)	0.343		
Married	20 (66.7)	78 (76.5)	*Ref*			
Education level						
No formal	5 (16.7)	12 (11.8)	0.53 (0.08 - 3.40)	0.506		
Primary level	10 (33.3)	42 (41.2)	0.93 (0.17 - 5.01)	0.936		
Secondary level	13 (43.3)	39 (38.2)	0.67 (0.13 - 3.49)	0.631		
Tertiary level	2 (6.7)	9 (8.8)	*Ref*			
Occupation						
Unemployed	8 (26.7)	42 (41.2)	*Ref*		*Ref*	
Self employed	13 (43.3)	46 (45.1)	2.28 (0.81 - 6.43)	0.121	2.66 (0.89 - 7.93)	0.080
Employed	9 (30.0)	14 (13.7)	3.38 (1.09 - 10.43)	**0.035**	4.41 (1.32 - 14.79)	**0.016**
BMI						
<18.5	4 (13.3)	8 (7.8)	0.44 (0.11 - 1.73)	0.237		
18.5 - 24.9	10 (33.3)	48 (47.1)	*Ref*			
25 - 29.9	16 (53.3)	46 (45.1)	0.65 (0.27 - 1.58)	0.345		**0.004**
Referral status						
Referral	21 (70.0)	95 (93.1)	0.17 (0.06 - 0.51)	**0.002**	0.14 (0.05 - 0.45)	**0.001**
Non-referral	9 (30.0)	7 (6.9)	*Ref*		*Ref*	
Sample type						
Urine	16 (53.3)	44 (43.1)	1.51 (0.67 - 3.41)	0.405		
Tracheal aspirate	11 (36.7)	38 (37.3)	0.98 (0.42 - 2.27)	0.566		
Blood	3 (10.0)	20 (19.6)	0.46 (0.13 - 1.65)	0.282		
Outcome						
Discharged	24 (80.0)	69 (67.6)	1.91 (0.71 - 5.13)	0.256		
Died	6 (20.0)	33 (32.4)	*Ref*			
LOHS	41.8 ±21.3	38.1 ±23.0	0.99 (0.98 - 1.01)	0.421		

BMI: Body Mass Index, **LOHS:** Length of Hospital Stay, **Ref:** Reference, **CI**: Confidence Interval, **cOR:** crude Odd Ratio, **aOR:** adjusted Odd Ratio.

Table 3. Factors associated with Carbapenem-Resistant *Acinetobacter baumannii* (CRAB) among ICU patients hospitalized at MOI Teaching and referral hospital.

Factors	CRAB resistant		cOR (95% CI)	p-value	aOR (95% CI)	p-value
	Yes, n (%)	No, n (%)				
Age						
<50 years	4 (16.0)	4 (80.0)	Ref			
≥50 years	21 (84.0)	1 (20.0)	21.0 (1.83 - 240.52)	0.011	8.33 (0.25 - 278.33)	0.236
Gender						
Male	14 (56.0)	2 (40.0)	1.91 (0.27 - 13.50)	0.642		
Female	11 (44.0)	3 (60.0)	Ref			
Sample type						
Blood	3 (12.0)	0				
Tracheal	8 (32.0)	3 (60.0)				
Urine	14 (56.0)	2 (40.0)				
Body mass index						
<18.5	3 (12.0)	1 (20.0)				
≥25	10 (40.0)	0				
Normal	12 (48.0)	4 (80.0)				
Marital status						
Single	9 (36.0)	1 (20.0)	2.25 (0.22 - 23.32)	0.64		
Married	16 (64.0)	4 (80.0)	Ref			
Education level						
Primary or lower	13 (52.0)	2 (40.0)	1.63 (0.23 - 11.46)	0.595		
Secondary or higher	12 (48.0)	3 (60.0)	Ref			
Employment status						
Unemployed	7 (28.0)	1 (20.0)	1.56 (0.15 - 16.45)	0.595		
Employed	18 (72.0)	4 (80.0)	Ref			
Length of ICU stay						
≤30 days	5 (20.0)	4 (80.0)	Ref			
>30 days	20 (80.0)	1 (20.0)	16.0 (1.45 - 176.45)	0.019	6.90 (0.23 - 211.55)	0.269
Presence of comorbidity						
Yes	23 (92.0)	1 (20.0)	46.0 (3.33 - 634.88)	0.003	4.91 (0.12 - 205.73)	0.404
No	2 (8.0)	4 (80.0)	Ref			
ICU admission outcome						
Died	5 (20.0)	1 (20.0)	1.0 (0.09 - 11.03)	0.746		
Discharged	20 (80.0)	4 (80.0)	Ref			

CRAB: Carbapenem-Resistant *Acinetobacter baumannii*, **ICU:** Intensive Care Unit, **cOR:** Crude Odds Ratio, **aOR**: adjusted Odds Ratio, **CI:** Confidence Interval.

surveys. These investigations consistently reported increased *A. baumannii* colonization rates among healthcare workers, supporting the notion that occupation may influence colonization risk in hospital environments [10] [11].

Participants referred to MTRH were at a lower risk of being colonized with *A. baumannii* as compared to those that were initially being treated at MRTH. This is because, in most cases, patients referred to the study's site had already been managed with a course of antibiotics without positive outcomes, necessitating their referral to MTRH. The prior management with a course of antibiotics lessens the probability of referral patients to be colonized with bacteria such as *A. baumannii* as at the time of screening. Moreover, this may be attributed to differences in patient populations, infection control practices, or colonization patterns in different healthcare settings [12].

Patients with a high BMI were more likely to be colonized with *A. baumannii* as compared to those who had low or normal BMI. This is consistent with the knowledge that a high BMI predisposes an individual to having a weakened immune system and common health complications like hypertension and diabetes among many others. Gender, age, marital status and a participant's level of education were found to have no significant association with carriage of *A. baumannii* among patients admitted to the ICU, explainable by the fact that *A. baumannii* is an opportunistic pathogen that will almost randomly colonize any suitable host, without regard to either Gender, age, marital status and a participant's level of education [13].

On factors associated with carbapenem resistance among ICU patients, this study established that participants with a longer ICU stay such as that of more than 30 days were 16 times more likely to be colonized with carbapenem-resistant *A. baumannii* compared to those who had just been recently admitted to the ICU. This is because patients with long stays in the hospital generally are more predisposed to contracting hospital acquired infections that are adamant to treatment by commonly prescribed drugs, as the causative pathogens circulating within the hospital environment are better adapted for survival even against agents designed to eliminate them [14].

It was also interesting to note that participants that had underlying comorbidities were 46 times more likely to harbor isolates of *A. baumannii* that were resistant to carbapenems as compared to those without underlying comorbidities. This is because underlying comorbidities complicate treatment of the target disease, as the clinician has to most often than not consider the drug interactions of the primary disease with the underlying conditions, which most often leads to use of superior drugs of higher critical activity. This, when often done even in undeserving situations goes a long way to cause the increase in numbers of bacteria strains that exhibit insensitivity to the highly active antibiotics like Colistin and Carbapenems [15].

5. Limitations of the Study

The study was conducted only to patients who gave their informed consent. The

study was also purposively limited to patients admitted to MTRH-ICU only and not in other hospitals in the county where patients could have been admitted and maybe different data could have been obtained.

6. Conclusion

Increased length of hospital stay, obesity and marital status were the factors found to be significantly associated with *A. baumannii* infections among ICU admitted patients. On the other hand, gender, age, level of education, occupation, referral status and presence of infection were found to have no significant association with *A. baumannii* infections among ICU admitted patients. Therefore, all patients admitted to the intensive care units should be screened for colonization with *A. baumannii*, owing to the poor treatment outcomes associated with carriage of this multidrug resistant pathogen. Proper infection control in the ICU settings should be upheld to mitigate the spread of *A. baumannii* in the intensive care units. To improve treatment outcomes, special attention should be given to patients noted to have risk factors established to have significant association with *A. baumannii* colonization while in the ICU.

Acknowledgements

We would like to extend our sincere gratitude to Mr. Ben Kipturgo, Laboratory In-Charge Technologist at MTRH, for his immense support. Our appreciation also goes to Mr. Hadan Baiwo for his diligent work in the laboratory and to Dr. Josephat Tonui for providing essential protocol guidelines. Their contributions have been instrumental in the successful execution of this study.

Funding

The study did not receive any funding.

Authors' Contributions

The authors made significant contributions to this study. FK was responsible for data collection, cleaning, and analysis, as well as writing the manuscript. AM assisted with data analysis and manuscript review. NM conducted data analysis and reviewed the manuscript.

Conflicts of Interest

The authors have no conflict of interest concerning the work reported in this paper.

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Appendix: Questionnaire

PART I: Demographic Information

1) Patient No……..

Age: …… Gender: ……

Nationality: ……

Date of Admission: ……

Occupation:

a) Employed……. b) Self-employed…… c) Unemployed……..

Highest Level of education:

a) Primary……. b) Secondary…… c) Tertiary…….. d) None……..

Marital status:

a) Married…… b) Single……

2) Referral status:

a) Referral……. b) Non Referral……

3) Which ward are you currently admitted to……

4) Length of stay at the hospital: ……

PART II: Clinical Information

1) Prior admission what other disease were you suffering from or diagnosed with? ……

2) Any comorbidity apart from the one diagnosed you may be suffering from?

Yes…….. No…….

If yes: examples:

Diabetes……Renal related conditions……

CNS related conditions……. Autoimmune related conditions……..

Respiratory related conditions……. Metabolic disorder……..…

Injuries……. Asthmatic……. Burns…… Blood stream conditions……..

Specify (others conditions)…….

3) Are you an immunocompromised patient?

Yes…… No……

If yes! PITC (HIV)……

Cancer……

Specify (Others)……

4) What is your current diagnosis? …….

5) Tests done before/during or after Admission? Yes/No. When was it done?……

If yes! State tests done……

What were the diagnosis? ……

What organisms were isolated? ……

Antibiotics prescribed? State…….

6) Antibiotics used before admission preferably 7 days prior to admission?

Yes…… No…….

If yes! Which antibiotics have you used? ……

7) Were you hospitalized in another health facility prior to your admission?

Yes……. No…….

If Yes! Which facility and for how long…….
Diagnosis……
Antibiotics prescribed……
Reason for Discharge? ……..
8) Referral from another hospital?
Yes…….. No…….
If Yes! Reason/Need for referral……..
9) What are your current prescribed antibiotics?……..
Are the antibiotics effective?
Yes…….. No…….
If Yes! State them……..