BMC Microbiology

RESEARCH

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Antimicrobial susceptibility at intensive care units in Sudan, antibiogram development

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Abstract

Antibiograms are statistics on bacterial spectrum and resistance rates. It is of importance to regularly monitor the trends in antimicrobial resistance within the institution through the periodic cumulative resistance to provide the effective empiric antibiotic selection, enhanced infection control interventions, and containment strategies. Antimicrobial stewardship interventions improve quality and quantity of prescribing antimicrobial in ICUs without compromising any patient outcomes. The aim of this study was to develop a local unit-specific antibiogram for the Intensive Care Units based on the susceptibility rates of antimicrobials. Facility- based cross sectional study was done among ICU patients of a Tertiary hospital, Khartoum. Data were collected from the record of microbiology Laboratory from August-2021 to September-2022. Results were presented as tables and figures, Chi- square test was used to assess associations between variables, results were statistically significant when $p < 0.05$. Gram negative bacteria comprised 32% of the samples and only 4% of the samples had Gram positive bacteria, the remaining samples had no growth. *Klebsiella spp.* were the most prevalent 14.4% (44/306). The lowest susceptibility to antimicrobials were documented for *Acinetobacter spp.* and *Klebsiella spp.* Regarding *Pseudomonas aeruginosa*, it was susceptible to Meropenem but resistant to Pip/Tazo and Aminoglycosides. Gram positive bacteria, all were susceptible to Vancomycin and low Methicillin-resistant *Staphylococcus aureus* prevalence was observed. The antibiogram revealed high prevalence of Gram negative bacteria with low antimicrobials-susceptibility; especially *Klebsiella spp.* Low prevalence was recorded for *MRSA* and the most prevalent Gram positive bacteria were *E. faecalis.* This antibiogram of ICU can provide a reference for all future ICU antibiograms which will give a clear picture of the antimicrobial susceptibility pattern among ICU patients.

Clinical trial number Not applicable.

Keywords ICU, Infection, Antimicrobial resistance

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Introduction

Antimicrobial resistance is a global public health problem in hospitals and communities. Complicated infections, prolonged duration of treatment, and increased mortality are the main concerns related to the antimicrobial resistance [1–4]. The development of antimicrobial resistance is related to the rapid bacterial production that leads genetic mutations in relatively short periods of time, as well as, the exposure to antibiotics leads selection resistant bacteria with the acquired the mutations [5]. At global level, the spread of antimicrobial resistance has been enhanced by the mal-prescribing pattern and the poor infection control practices [6]. Since the pathogen responsible for the infection is usually unknown, broad-spectrum antibiotics such as meropenem are the regularly selected agents for the initial empirical therapy [7]. Moreover, increased mortality in the ICUs is related to high resistance levels of Gram negative bacteria with extensively limited therapeutic options [8–10]. Early-stage effective therapy is of high importance to assure optimum outcome among infected patients [11]. It is crucial to test bacterial susceptibility to select the most suitable antibiotics to treat the infectious process. Furthermore, collecting the susceptibility data can provide valuable epidemiological information about the pattern of antimicrobial resistance [12]. In order to provide the clinical information about the prevalence of resistant pathogens at an institution, antibiograms are considered the best tool for that. Antibiograms are defined as profiles of susceptibility of a specific microorganism to a battery of antimicrobials. The information given by all antibiograms are useful to construct the cumulative resistance, in other words, antibiograms are statistics on bacterial spectrum and resistance rates. Development of antibiograms is defined by the guidelines of The Clinical and Laboratory Standards Institute (CLSI) [https://clsi.org/media/3481/m100ed30_sample.pdf], as mentioned by Fridkin SK et al. in their study in analizing 260 facilities to create a reasonable antibiogram [13]. Microbiologists are at the heart of antibiogram development, from isolating and identifying pathogens to conducting antibiotic susceptibility tests, analyzing data, and compiling antibiograms that serve as vital tools for clinicians. Moreover, it is of importance to regularly monitor the trends in antimicrobial resistance within the institution through the periodic cumulative resistance to provide the effective empiric antibiotic selection, enhanced infection control interventions, and containment strategies. Not to forget that, antimicrobial stewardship interventions improve quality and quantity of prescribing antimicrobial in ICUs without compromising any patient outcomes [14]. Therefore, many medical institutions collect antimicrobial susceptibility test data developed by microbiology lab scientists conducted at their facilities to calculate susceptibility rates and prepare cumulative antimicrobial susceptibility [15]. The expertise of Microbiology lab specialists ensures that these reports accurately reflect local and regional resistance trends, helping to guide effective antimicrobial therapy and combat the global challenge of antibiotic resistance. Not to forget that, the development of new antimicrobial agents is being outpaced by the emergence of new antimicrobial resistance [12]. In Sudan, no studies were done regarding the development of cumulative antimicrobial susceptibility. The aim of this study was to develop a local unit-specific antibiogram for the Intensive Care Units at a tertiary hospital based on the susceptibility rates of antimicrobials. This will give a picture about the resistance level of bacterial infections among critically ill patients, as well as, guiding the initiation of effective initial antimicrobial therapy.

Materials and methods

Study design

A facility-based, cross-sectional investigation conducted at a tertiary hospital in Khartoum. Data were gathered from the laboratory records of culture and susceptibility test results over a one-year period, from August 2021 to September 2022. The information was collected anonymously, with patient records identified only by coded identifiers. The study focused on the retrospective analysis of microbiology culture and susceptibility results for ICU patients during the specified study period. Selection of culture media according to type of sample. Blood: Thioglycolate broth. Sputum: blood agar, chocolate agar, macconkey agar. Urine: Cystine–Lactose–Electrolyte-Deficient agar. Wound swab: blood agar and macconkey agar. Vaginal/ urethral swab: blood agar, chocolate agar or macconkey agar. Stool: Selenite broth + Deoxycholate citrate agar.

Clinical samples from ICU were received in the clinical microbiology laboratory and were processed as are referred in the microbiological guidelines. The inclusion criteria were the samples of ICU patients with complete microbiology results records within the period from August 2021 to September 2022. Samples were grown onto agars, incubation time varied based on the sample site. Blood samples incubation period was 7 days. For urine samples, if it doesn't grow aerobically within 18–24 h, we don't wait any further to report. While for sputum cultures the incubation period ranged between 2 and 5 days, typically within 48–72 h. Wound swabs were incubated for 2 to maximum of 7 days. Incubation temperature used was 35 °C ± 1 °C. Species identification were made through morphological assessment and gram staining. Isolation, identification and susceptibility were all done manually. Quality control measures scheme and breakpoints applied were the guidelines of CLSI M100 ED30, January 2020 https://clsi.org/media/3481/

m100ed30_sample.pdf [16]. Disk diffusion method was applied for antimicrobial susceptibility of Bacteria. Susceptibility by Kirby Baur disk diffusion method. Selection of antibiotics according to gram reaction and morphology. According to the type of the bacteria, the types of antibiotics were selected for 1st line antibiotics and 2nd line antibiotics. For Enterobacteriaceae, first line routine antimicrobials were Ampicillin, Amoxicillin, Cephalexin, Cephradine, Gentamicin, Co-Trimoxazole, Ciprofloxacin, and Nirofurantoin. For second line; if 1st line was resistant the antimicrobials were Amoxicillin-Clavulanic acid, Cefuroxime, Ceftriaxone, Cefotaxime, Ceftazidime, Amikacin, Meropenem, Imipenem, Cefepime and Colistin. For Pseudomonas species and other non-lactose fermenting, the antimicrobials were Gentamicin, Amikacin, Meropenem, Ciprofloxacin, Ceftazidime, Piperacillin/Tazobactam, and Tigycycline. For Staphylococcus aureus, the antimicrobials used were Clindamycin, Fusidic acid, Erythromycin, Tetracycline, Gentamicin, Co-Trimoxazole, Oxacillin, and Vancomycin. For Beta haemolytic Strepto cocci, the antimicrobials used were Bacitracin, Erythromycin, Clindamycin, Penicillin, Ampicillin, and Tetracyclin. For Enterococci, the antimicrobials were Ampicillin, Nitrofurantoin, Ciprofloxacin, Vancomycin, Co-Trimoxazole, Tigycycline, and Amoxicillin-Clavulanic acid. Regarding *Staphylococcus aureus*, Cefoxitin disc was used to determine methicillin resistance. Laboratory scientists in microbiology lab were responsible for the sample preparation and susceptibility testing. Our developed antibiogram was based on the lab results of the culture sample. Microbiology laboratories are considered one of the major parts of the antimicrobial stewardships.

Study variables

The data collected for the study included several key variables: age, site of the sample, type of isolated organism, and the antibiotic sensitivity of the isolated pathogens. These variables were essential for analyzing the distribution of infections and determining the appropriate treatments for the patients.

Table 1 Characteristics of the study participants ($n=306$)

Characteristics	*n*	%	Characteristics	
Gender			**Age**	
Male	199	65	Mean	51 ± 19
Female	107	35	Median	55
Total	306	100	Mode	65
ICU type			Min.- Max.	3 y-90 y
General ICU	293	95.8		
Neurosurgery ICU	13	4.2		
Total	306	100		

Potential bias

A limitation of the study is the lack of distinction between first-time isolates and subsequent isolates. The specimens were not categorized based on whether they were the first isolation of a particular organism or a recurrent isolate, which could introduce potential bias in interpreting antibiotic resistance patterns.

Study size

A total of 306 samples were included in the study. All records that met the inclusion criteria were considered, ensuring a comprehensive dataset for analysis.

Quantitative variables

The data were collected both as continuous and categorical variables, allowing for a thorough examination of the relationships between different factors such as patient demographics, infection sites, and the type of pathogens isolated.

Statistical methods

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS, version 23). The results were presented in tables and figures. To assess associations between variables, such as gender, age, sample site, and isolated pathogens, the Chi-square test was employed. A p-value of less than 0.05 was considered statistically significant, indicating meaningful relationships between the variables.

Ethical considerations

Ethical approval for the study was granted by the Review board Alribat University Hospital, Police Headquarters Hospitals and treatment centers on June 2022. Importantly, the researchers had no direct clinical contact with any of the patients, and the study relied solely on the microbiology reports generated by the laboratory. All collected data were used exclusively for the purposes of this study, ensuring anonymity and confidentiality for the patients involved as per declarations of Helsinki.

Results

Characteristics of the patients who had culture and sensitivity tests

Data included in the study were from 306 samples. The mean age of the participants was 51 ± 19 years. Males comprised higher percentage (65%). The most of the samples (95.8%) were obtained from patients from the general intensive care unit, Table 1.

Use of antibiotics prior to sampling of culture and susceptibility test

Only 14.4% (44/306) of the patients received no antibiotic prior to sample withdrawal for culture and sensitivity

test. On the other hand, 72.5% (222/306) of the patient had received one or two antibiotics before taking the samples for culture and sensitivity. While 13.1% (40/306) had received more than two antibiotics. The most frequently used antibiotics were Meropenem, vancomycin and Ceftazidime (24.8%, 76/306), (19.6%, 60/306), and (18.4%, 56/306) respectively. Figure 1 below illustrated the details.

Rate of culture and susceptibility test request among intensive care patients

The request rate for culture and susceptibility ranged between 4 and 45 requests per month. The highest rates were on July and August 2022. During those two months, urine and blood cultures were the most frequently requested. While, blood cultures were most frequently requested on May and March 2022 ($p=0.002$). Of the overall test requests, blood cultures were the most frequently requested, followed by sputum and urine cultures (35.6%, 109/306), (30.4%, 93/306) and 22.2% (68/306) respectively. Wound swab culture was requested at 11.1% (34/306) of samples. Figure 2 below detailed the results.

Results of culture tests of the samples

No growth was reported for 55.2% (169/306) of the culture results. While, 25.8% (79/306) of the results had one pathogenic bacteria isolated. Two pathogenic bacteria or more were isolated in 7.2% (22/306) and 1% (3/306) respectively, Fig. 3. Regarding the prevalence of bacteria, Gram negative bacteria comprised 32% of the isolated

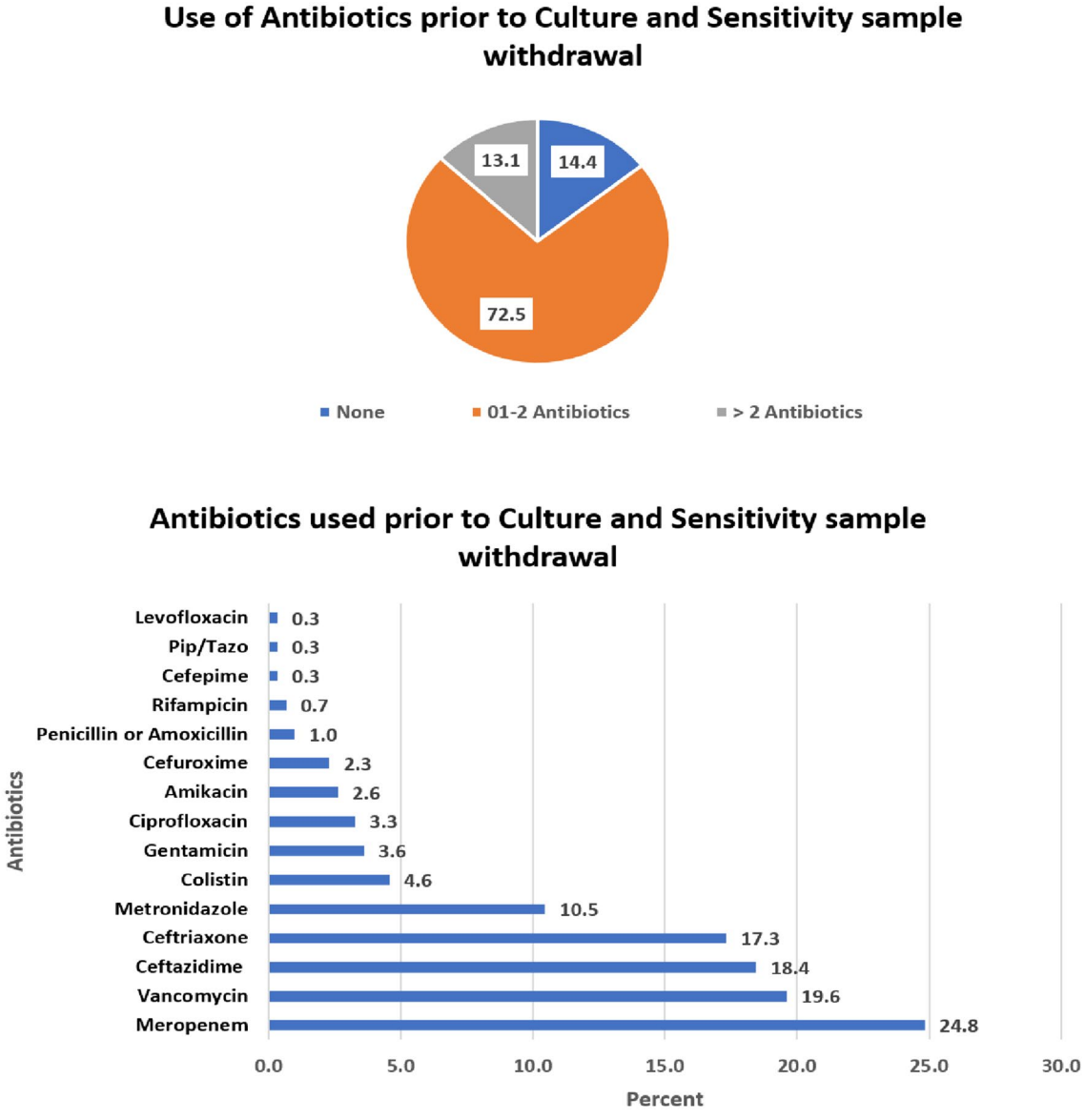

Fig. 1 Use of antibiotics prior to sampling of culture and sensitivity test (*n*=306)

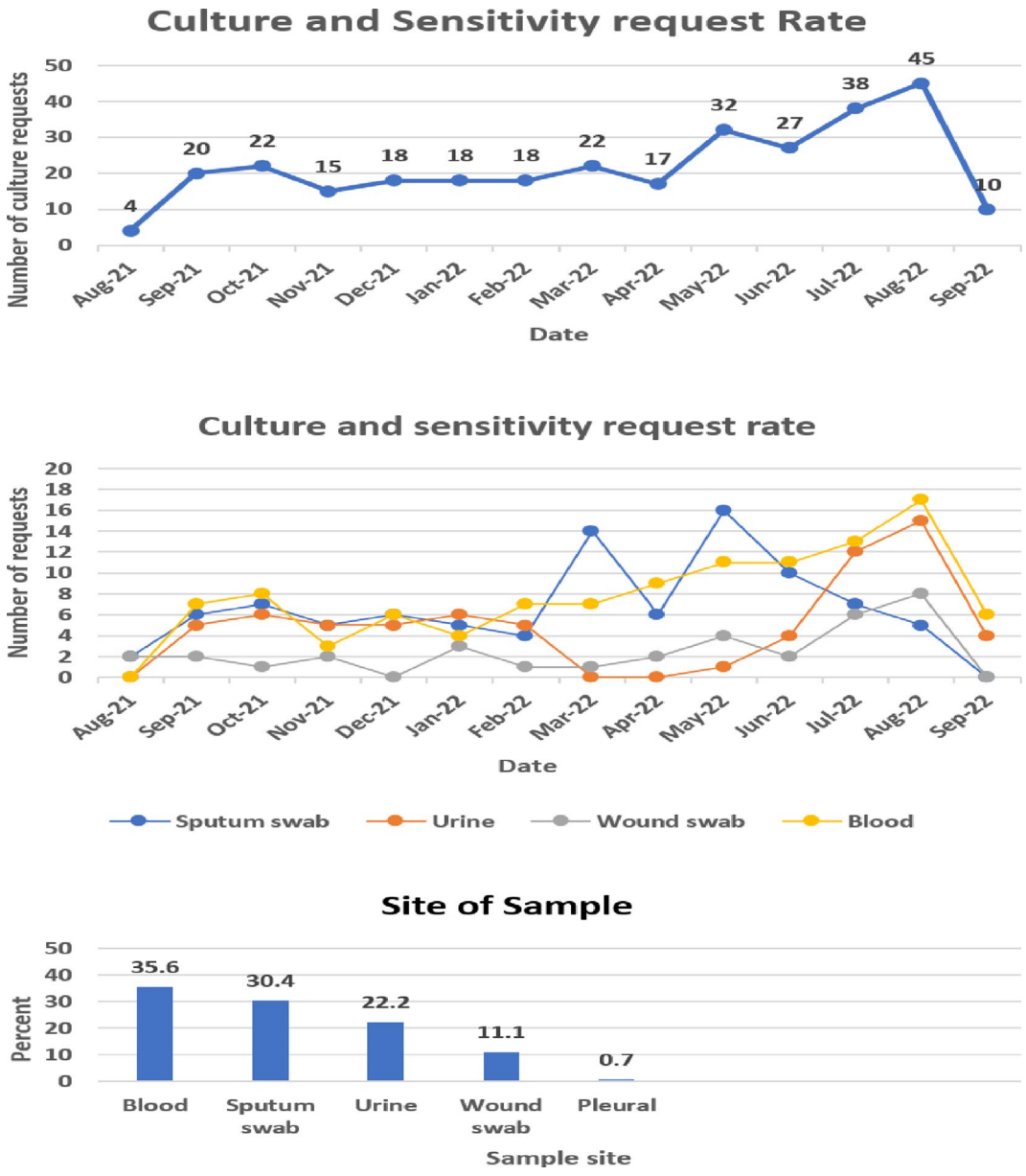

Fig. 2 Rate and the type of specimens ($n = 306$)

samples, while Gram positive bacteria were isolated in 4% of the samples. Among the gram negative isolated pathogens of all patients, *Klebsiella spp*. was the most prevalent pathogenic bacteria (14.4%, 44/306), followed by *Acinetobacter spp*. (9.2%, 28/306). *Pseudomonas aeruginosa* was prevalent among 7.5% (23/306) of the samples, while, *E coli* was prevalent in 5.6% (17/306). Among the isolated gram positive pathogens, *E. faecalis* was isolated in 3.6% (11/306) of the samples, *Moraxella Spp*. (1.3%, 4/306). Other pathogens were detailed in Fig. 3 below.

Association between the isolated organisms and the previous use of antibiotics

In assessing the association between the isolated organisms and the prior use of antibiotics, no statistically significant association was found regarding the growth of pathogens and the use of antibiotics, Table 2.

Isolated pathogens among the types of specimens

Pathogens in each type of specimens were determined. Regarding *Klebsiella Spp.*, 47.7% of these bacteria were isolated in sputum swab ($p = 0.002$). While, 43.8% of *E. coli* were isolated in urine specimens ($p = 0.023$), as well as *Candida spp.* (75.8%, $p = 0.000$)). Regarding *Acinetobacter Spp.*, they were most prevalent in sputum swab (64.3%)

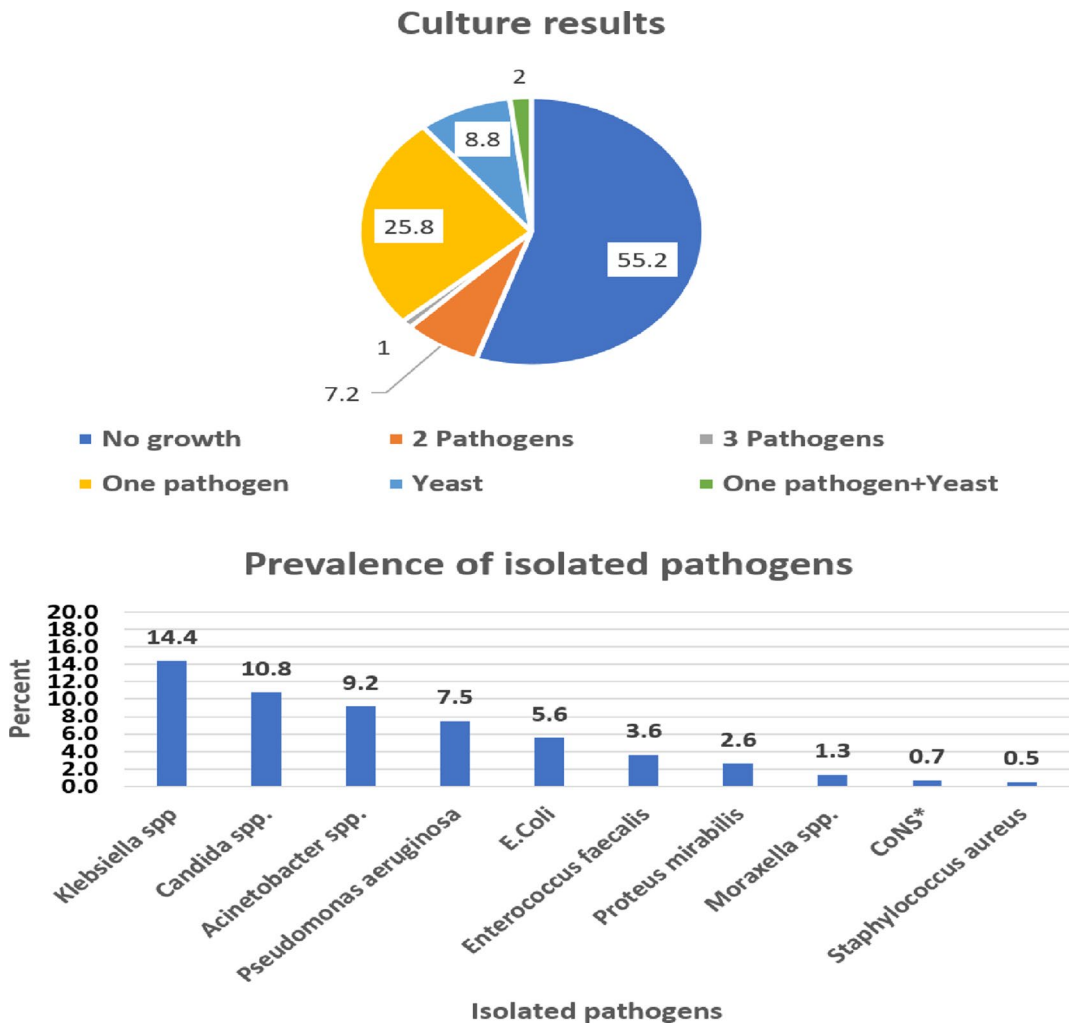

Fig. 3 Results of culture tests of the samples ($n = 306$) * Coagulase-Negative Staphylococci

Table 2 Results of culture tests of the samples of intensive care units patients

	Previous antibiotics							
Isolated Organisms	**None**	**%**	**1–2 Antibiotics**	**%**	**> 2 Antibiotics**	**%**	**Total**	***p*-value**
No growth	23	13.6	128	75.7	18	10.7	169	0.782
1 pathogen	13	16.5	54	68.4	12	15.2	79	
2 Pathogens	3	13.6	15	68.2	4	18.2	22	
3 Pathogens	0	0.0	3	100.0	0	0.0	3	
Yeast	4	14.8	17	63.0	6	22.2	27	
1 pathogen + Yeast	1	16.7	5	83.3	0	0.0	6	
Total	44	14.4	222	72.5	40	13.1	306	

and none was isolated in the urine ($p = 0.000$). 56.5% of *Pseudomonas aeruginosa* were isolated in sputum swabs ($p = 0.004$). 75% of *Proteus mirabilis* and all *Moraxella spp.* were isolated in sputum swab ($p = 0.042$ and 0.027 respectively). Table 3 below illustrated the details. Figure 4 below showed the percent of each organism in each type of specimen. In sputum swab, the most prevalent pathogen was *Klebsiella Spp.* (20%). In urine, *Candida albicans* and *E. coli* were the most prevalent (36% and 10% respectively). Regarding wound swab, *Klebsiella* and *Acinetobacter Spp.* were the most prevalent (24% and 17% respectively). While, in blood, the most prevalent bacteria were *Klebsiella Spp.* (6%), Fig. 4.

Association between the number of isolated pathogens across the different types of specimens

Growth rates were reported for each type of samples. No growth was reported in 168 samples, of those, 54.8% were

Table 3 Isolated pathogens among the types of specimens

	Sample									
Pathogens	**Sputum swab**	**%**	**Urine**	**%**	**Wound swab**	**%**	**Blood**	**%**	**Total**	***p*-value**
Klebsiella spp.	21	47.7	5	11.4	11	25.0	7	15.9	44	0.002*
E.Coli	4	25.0	7	43.8	4	25.0	1	6.3	16	0.023*
Acinetobacter spp.	18	64.3	0	0.0	8	28.6	2	7.1	28	0.000*
Pseudomonas aeruginosa	13	56.5	2	8.7	6	26.1	2	8.7	23	0.004*
Proteus mirabilis	6	75.0	0	0.0	1	12.5	1	12.5	8	0.042*
Enterococcus faecalis	2	18.2	5	45.5	2	18.2	2	18.2	11	0.187
Staphylococcus aureus	1	100.0		0.0		0.0		0.0	1	
*CoNs***	0	0.0	0	0.0	0	0.0	2	100.0	2	0.249
Moraxella spp.	4	100.0	0	0.0	0	0.0	0	0.0	4	0.027*
Candida spp.	8	24.2	25	75.8	0	0.0	0	0.0	33	0.000*

*Statistically significant ** Coagulase-Negative Staphylococci

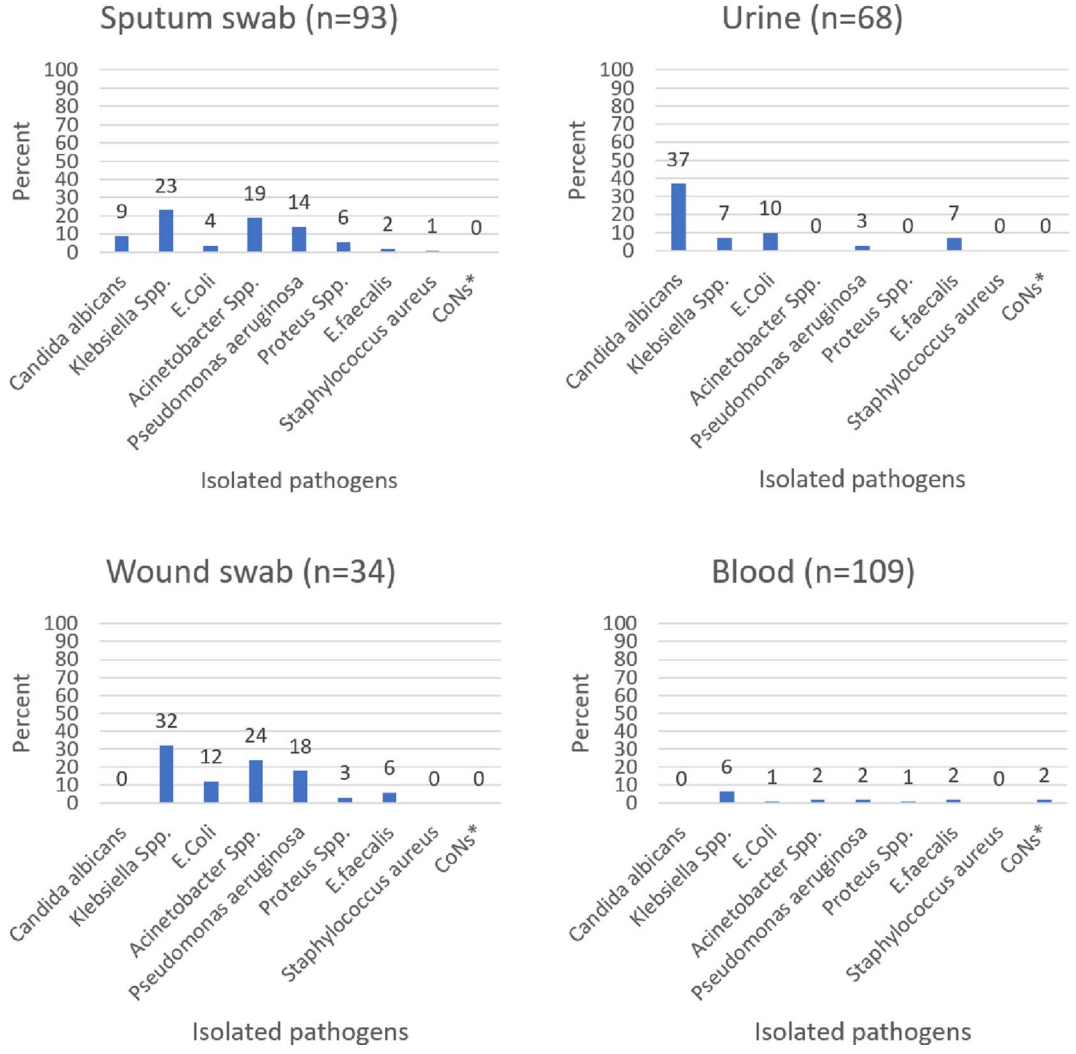

Fig. 4 Prevalence of pathogens on each type of samples. * Coagulase-Negative Staphylococci

Table 4 Association between the number of isolated pathogens across the different sample sites

	Sample									
Isolated Organisms	**Sputum swab**	**%**	**Urine**	**%**	**Wound swab**	**%**	**Blood**	**%**	**Total**	***p*-value**
No growth	31	18.5	32	19	13	7.74	92	54.8	168	0.000*
1 Pathogenic bacteria	42	53.8	8	10.3	11	14.1	17	21.8	78	
2 Pathogenic bacteria	11	50	3	13.6	8	36.4	0	0	22	
3 Pathogenic bacteria	1	33.3	0	0	2	66.7	0	0	3	
Yeast	8	29.6	19	70.4	0	0	0	0	27	
1 Pathogenic bacteria + Yeast	0	0	6	100	0	0	0	0	6	
Total	93	30.6	68	22.4	34	11.2	109	35.9	304	

*Statistically significant

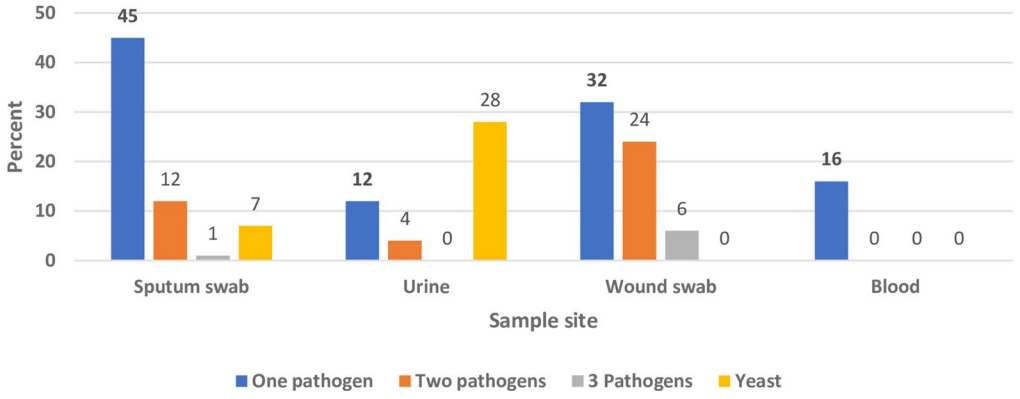

Fig. 5 Number of isolated pathogens across the different sample sites

Table 5 Prevalence of pathogens across different age groups

	Age							
Isolated organism	**< 35 years**	**%**	**35–60 years**	**%**	**> 60 years**	**%**	**Total**	***p*-value**
Candida albicans	9	27.3	12	36.4	12	36.4	33	0.696
Klebsiella Spp.	9	28.1	14	43.8	9	28.1	32	0.564
E.Coli	1	7.1	8	57.1	5	35.7	14	0.319
Acinetobacter Spp.	4	17.4	11	47.8	8	34.8	23	0.769
Pseudomonas aeruginosa	5	25.0	10	50.0	5	25.0	20	0.587
Proteus Spp.	2	33.3	2	33.3	2	33.3	6	0.794
E.faecalis	2	20.0	4	40.0	4	40.0	10	0.959
*CoNs**	1	50.0	1	50.0	0	0.0	2	0.485
Moraxella Spp.	0	0.0	1	25.0	3	75.0	4	0.229

* Coagulase-Negative Staphylococci

blood samples. One pathogen was isolated in 78 samples, 53.8% of them were sputum swabs. While, two pathogens were isolated in 22 samples, mostly sputum (50%). Three pathogens were isolated in 3 samples, 2 of them were wound swabs. A statistically significant association was found between the number of isolated pathogens across the different types of specimens ($p = 0.000$). Table 4; Fig. 5 below detailed the results.

Prevalence of pathogens across different age groups and gender

On the bases of age, no statistically significant difference was found in the prevalence of pathogens among different age groups ($p > 0.05$), Table 5 below illustrated the details.

With regards to gender, females had more candida positive cultures than males ($p = 0.012$). No statistically significant difference was found in the prevalence of bacteria between males and females, Table 6.

The antibiogram of the adult intensive care units

Based on the culture and sensitivity results of the samples of the intensive care unit patients we developed the antibiogram (Fig. 6). It is a Unit-specific Antibiogram for the intensive care units. Among the isolated bacteria; Gram negative bacteria were more than the gram positive in both count and types. *Klebsiella spp.* had low

Table 6 Prevalence of pathogens among males and females

	Gender					
Isolated pathogens	**Male**	**%**	**Female**	**%**	**Total**	***p*-value**
Candida albicans	15	45.5	18	54.5	33	0.012*
Klebsiella Spp.	23	71.9	9	28.1	32	0.257
E.Coli	8	57.1	6	42.9	14	0.356
Acinetobacter Spp.	17	73.9	6	26.1	23	0.245
Pseudomonas aeruginosa	16	80.0	4	20.0	20	0.111
Proteus Spp.	3	50.0	3	50.0	6	0.351
E.faecalis	6	60.0	4	40.0	10	0.486
*CoNs***	2	100.0	0	0.0	2	0.422
Moraxella	2	50.0	2	50.0	4	0.437

*Statistically significant ** Coagulase-Negative Staphylococci

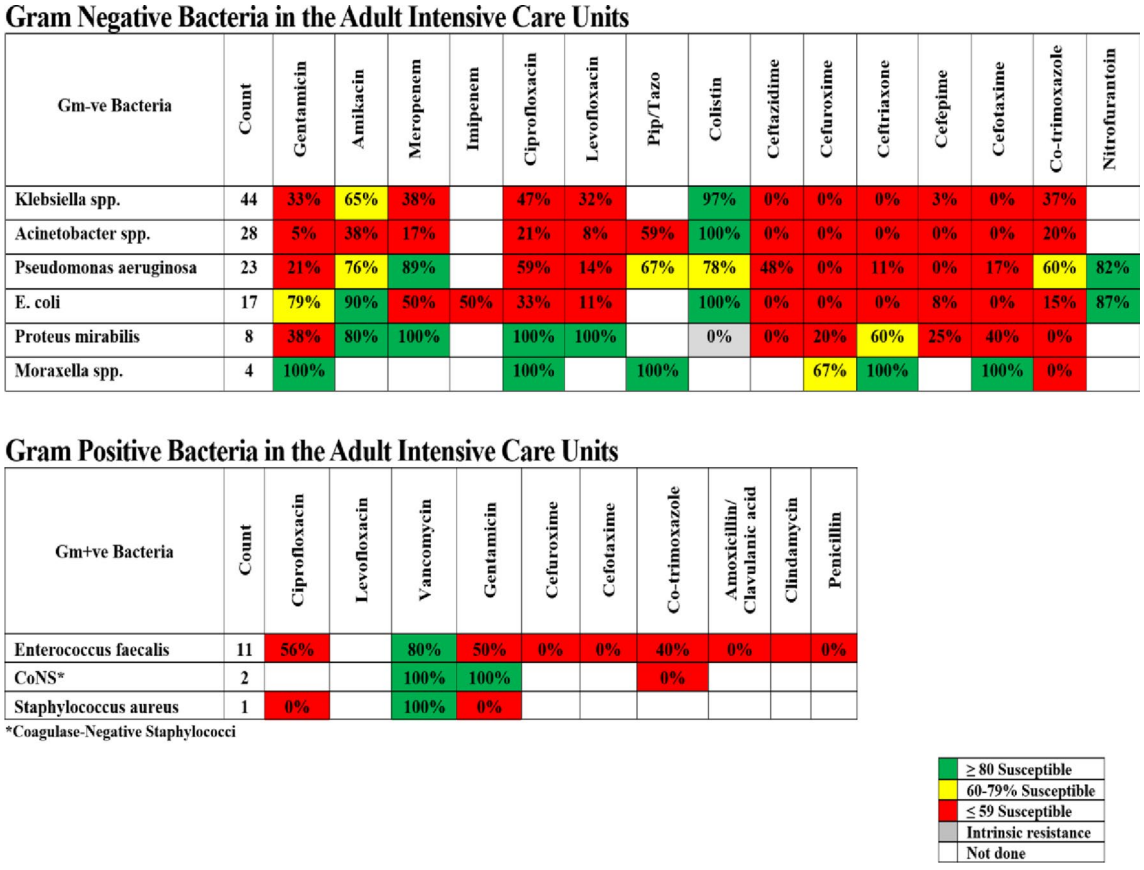

Fig. 6 The Antibiogram of the Adult Intensive Care Units

susceptibility to Meropenem (38% susceptible), while these bacteria had moderate susceptibility to amikacin (65% Susceptible) and high susceptibility to Colistin (97% susceptible). Furthermore, *Acinetobacter spp.* had low susceptibility to all antibiotics except for Colistin (100% susceptibility). *Pseudomonas aeruginosa* had better susceptibility pattern with >80% susceptibility to Meropenem and moderate susceptibility to Amikacin (76%), Pip/Tazo (67%), Colistin (78%), and Co-Trimoxazole (60%). Regarding Nitrofurantoin, it was tested for urine samples only as it is approved and recommended specifically for uncomplicated UTIs caused by susceptible organisms. *E. coli* was less susceptible to Carbapanems (50% susceptible). Figure 6 below illustrated all the details.

Discussion

The Antibiogram is considered a simplified tool to summarize the changes in empiric antimicrobials; especially among nonresponding patients [17]. In this study, we have developed a unit-specific antibiogram for the intensive care units based on the laboratory data of microbiology lab. As antibiograms cannot be used interchangeably

between different units [18], yet they can be a useful tool for public health surveillance by involving cumulative antibiograms to detect changes in trends of antimicrobial resistance [19].

Our ICU antibiogram revealed that, Gram negative bacteria were much more prevalent than the gram positive bacteria in both count and types. Gram negative bacterial infections were especially associated with an increased 28-day mortality [9].

Infections that are caused by gram negative bacteria are hard to be treated; especially among critically ill patients [20]. Lack of effective initial empiric antimicrobial treatment within 24 h was related to increased mortality rates [9]. Multidrug-resistant (MDR) bacteria were of high importance when selecting antimicrobial treatment plans; of those, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *E. coli* and *Proteus mirabilis* were considered prevalent with different susceptibility patterns [10, 21–26]. In our ICU, the most prevalent Gram negative bacteria were *Klebsiella spp.* While in Zambia, the most prevalent Gram negative bacteria were *E. coli* followed by *Klebsiella spp.* [27].

Succeptibility of isolated pathogens of ICU patients was assessed for major antibiotics groups; aminoglycosides, Carbapanems, Flouroquinolones, Cephalosporins, as well as Polymixin. Polymixins had high susceptibility rates for *Pseudomonas spp.* and *Acinetobacter spp.* making Colistin an option in treating MDR bacteria [5]. In our study, *Acinetobacter spp.* were the most resistant bacteria; susceptible only to Colistin, a study reported high resistance of this bacteria to aminoglycosides and Carbapenems [6]. While, another study reported low resistance rate [22]. It was alarming that among our ICU patients, susceptibility to Carbapenem was low. This was due to the high use of them. Specifically, Meropenem as a Carbapenem, a high end drug whose use should be under restrictive prescribing. It was being overused among our ICU patients. The reported Carbapenem resistance among Gram negative bacteria was generally considered low [28, 29]. This highlighted the urgent need of antibiotic policy and antibiotic stewardship policies, not only in Sudan but all of the East African region. Prescription patterns significantly deviated from WHO recommendations suggesting inappropriate antimicrobial use in the East African countries [30]. In more details, *Klebsiella spp.* were less susceptible to Carbapenems as well as Flouroquinolones, unlike reported susceptibility patterns [13]. *P. aeruginosa* was the first bacterium to present multidrug-resistant (MDR) phenotypes [10, 22], yet, fortunately, *Pseudomonas aeruginosa* isolated from our ICU patients had high susceptibility to Meropenem and Nitrofurantoin. However, this bacterium had low susceptibility to Pip/Tazo, unlike other studies that reported high susceptibility to Pip/Tazo, as well as Aminoglycosides [10, 13, 15, 23]. Furthermore, *E. coli* was highly susceptible to Amikacin, Nitrofurantoin, and Colistin, but it had low susceptibility to Imipinem unlike Fridkin et al. [13]. Therapeutic approaches were directed towards antibiotic combinations to reduce resistance risk as Imipenem/Relebactam [8]. However, in our microbiology labs, no combined antibiotics were tested for susceptibility and all the results were for single agents. In our study, Colistin was the only agent covered all Gram negative bacteria among our ICU patients. The development of new antimicrobials had become an urgent necessity because the rapid evolution of multiple resistance to existing antimicrobials among pathogens poses a significant problem for efficient control and management of infectious diseases [31].

With regards to Gram positive bacteria, studies have reported increased prevalence of MRSA [6]. In Zambia, Staphylococcus aureus prevalence was the highest aming Gram positive bacteria [27]. However, in this study, the most prevalent was *E. faecalis.* Interestingly, Methicillin resistant Staphylococcus aureus had no prevalence in our ICU. Yet, in Ethiopia, *S. aureus* and *CoNS* resistance was observed for β-lactam antibiotics in patients with infected wound [32].

Increased rates of antimicrobial resistance across the sub-Saharan Africa, impacting cost, morbidity, and mortality. This emphasized the necessity of implementing rapidly national action plans and monitoring the progress [33]. Pooled resistance rates reported in a systematic review of African countries, indicated alarming rates of methicillin-resistant and Extended Spectrum-ß-lactamase-producing pathogens [34]. Building effective capacity for research; as done in South Africa, reporting th strategies and policies for antimicrobial resistance contribute majorly to success [35]. Our study was not without limitations; all the data were obtained from the records of the microbiology lab and only the details mentioned in the records were collected. The Clinical and Laboratory Standards Institute (CLSI) recommended the inclusion of only the first isolate of a given species cultured from a specimen of any source per patient per year [36]. In our study, isolated specimens were not defined weather they were first isolates or not. Susceptibility of fungal species were not included because the microbiology lab had no sensitivity tests done. Furthermore, the sample size was small to draw reasonable conclusions and larger scale studies would help to get a complete picture. Moreover, the timeframe was one year and the results without growth made the sample even smaller. Not to mention that, the type of systemic conditions was not mentioned in our collected data.

Conclusions

Gram negative bacteria were the most prevalent with low susceptibility rates; especially *Klebsiella spp.* and *Acinetobacter spp. P. aeruginosa* showed high susceptibility to meropenem but resistance to Pip/Tazo and aminoglycosides. *E. coli* was resistant to carbapenem group of antimicrobials. With regards to Gram positive bacteria, all were susceptible to vancomycin. Low prevalence was recorded for MRSA and the most prevalent spp. were E. faecalis. Antibiotics stewardship and policies are needed and local ICU protocols should be developed and implemented. This antibiogram of ICU can provide a reference for all future ICU antibiograms which will give a clear picture of the antimicrobial susceptibility pattern among ICU patients.

Abbreviations

CLSI	Clinical and Laboratory Standards Institute
ICU	Intensive Care Unit
MDR	Multidrug-resistant
MRSA	Methicillin resistant Staphylococcus aureus

Acknowledgements

The authors are grateful to the cooperation of the departments of the hospital.

Author contributions

AOHG: Conceptualization, Data collection, Data analysis, Writing and reviewing.DEAM: Data collection, Writing and reviewing.EEBM: Data collection. EESH: Conceptualization, Writing and reviewing.ZEAL: Conceptualization, Data collection.AOSD: Data collection.MAAM: Conceptualization.GAAO: Project supervision.AMEH: Project supervision.

Funding

The authors received no specific funding for this work.

Data availability

All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

No experimental protocols were applied, we only collected the retrospective data to develop the Antibiogram from the lab records. The study was approved by the Institutional Review board Alribat University Hospital, Police Headquarters Hospitals and treatment centers on June 2022, Ref: 01-2022. All methods were carried out in accordance with relevant guidelines and regulations (declarations of Helsinki). Informed consents were obtained from all participants.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

Received: 23 September 2024 / Accepted: 2 May 2025
Published online: 14 May 2025

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