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Original Article

Microbiological Culture Profile and Antimicrobial Susceptibility Pattern of patients admitted to Addis Ababa intensive care units

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Abstract

Background: *Intensive care unit infections are health care problems affecting millions globally each year. Intensive care unit mortality of infectious patients is increasing and as high as 14.31% to 45.4%. This study aimed to determine the microbiological culture profile and antimicrobial susceptibility pattern of patients admitted to two intensive care units in Addis Ababa.*

Methods and materials*: An institutional-based retrospective observational study was carried out on all patients with microbiological culture and susceptibility results after admission to the adult intensive care unit at two Addis Ababa hospitals from January 2019 to December 2019. Data were collected by trained data collectors using a standard and pretested questionnaire. Collected data were coded, entered into Epi-Info, and analyzed using SPSS version 25. Correlation and regression analysis was used for assessing associations. A p-value of less than 0.05 was taken as significant.*

Results: *A total of 106 patients with 173 culture results were analyzed. The majority, 68(64.2%), were males. The mean age of the patients was 35.08±1.6 years. The most common documented source of infection was the pulmonary system 84(54.5%), followed by urinary tract infection 26(16.9%). Forty-four (25.43%) of cultures had growth. Gram-negative was identified in 35(68.63%) isolates. Acinetobacter species account for 10(28.57%), followed by Klebsiella pneumoniae and E. coli 7(13.725%) respectively. Higher antimicrobial resistance was shown to cephalosporin and penicillin. The mortality rate among subjects was 32.1%.*

Conclusion and Recommendations: *Pulmonary source being the common infection site, resistant gram negatives were the predominant microorganisms identified. Designs of future multicenter and prospectively designed studies are crucial to improve the outcome of critically ill patients.*

Keywords: *Microbiological culture profile, antimicrobial susceptibility pattern, Intensive Care Unit.*
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Background

Intensive care unit infections are among the most serious infections and leading causes of morbidity and mortality in hospitalized patients, where indiscriminate and prolonged use of antimicrobials is common and leads to the emergence of resistant strains (1). A countrywide survey on the capacity of ICU care in Ethiopia showed that critical care service is flourishing. However, inadequate quality of care and poor infection prevention practices were reported. Studies from Africa indicate that the ICU mortality rate is high. For instance, ICU mortality in Uganda, Tanzania, and Kenya were 40.1 %, 41.1%, and 53.6 % respectively. Similar studies from Ethiopia also showed that ICU mortality raged 28% -50 % (2, 3).

It has been reported that ICU-acquired infections are common in low-resource settings. Resistant microorganisms are commonly reported in ICU-admitted patients. The common ones among these resistant microorganisms are *methicillin-resistant s. aureus* (MRSA), *and vancomycin-resistant enterococcus* (VRE) (3, 4). Tracheal aspirate (29.9%) and exudate were the most frequently received clinical specimens that tested positive for culture (22.7%). The most frequent organisms isolated were *Acinetobacter species* from tracheal aspirate and *Pseudomonas species* from blood samples, whereas *Escherichia coli* was the predominant organism found in urine, exudate, and other bodily fluids (5-7).

Knowledge of antimicrobial susceptibility in ICU is crucial and far more important for giving effective treatment and decreasing the spread of drug-resistant micro-organisms. It is a crucial step for early intervention, decreasing healthcare costs, improving the outcome of patients, and treatment provider satisfaction (8, 9). To the best of our knowledge, there was no study done in the ICU setting, both institutionally and country-wise. So, this study will be a significant input in addressing the gap.

Methods

Study setting and design

An Institutional based retrospective observational study was conducted at two intensive care units located at St. Paul`s hospital millennium medical college and Addis-Ababa burns, emergency, and trauma Hospitals. SPHMMC is a referral teaching hospital in Addis Ababa, Ethiopia. AaBET hospital is a branch of SPHMMC with an emergency complex that gives services to emergency, burns, and trauma cases. SPHMMC is a 14-bedded ICU admitting patients above the age of 14 years, and AaBET hospital is also a 14-bedded ICU that gives service to all patients regardless of age and clinical diagnosis, but mainly to trauma and burns. Both are general ICUs.

Sample size and sampling technique

Non-probability- convenience sampling technique was applied to all ICU patients from January 2019 to December 2019, with microbiological culture sent 48 hours after admission.

Data collection procedures

Data were collected from patient charts using pretested and structured questionnaires after ethical clearance was received from St. Paul's hospital millennium medical college`s institutional review board. The study was conducted in accordance with the procedures and guiding ethical principles of SPHMMC. All microbiological cultures and susceptibility results of patients sent after intensive care unit admission from January 2019 to December 2019 were included in the analysis. Data were collected by trained data collectors using pretested standardized checklists developed by the principal investigator. Socio-demographic data, comorbidities, sites of infection, causative micro-organisms, ICU admission category, associated organ failure, type of culture sent, antimicrobials given before culture sampling and based on susceptibility result, and patient outcome to ICU were retrieved. All data was taken from patient record charts with collected laboratory culture and susceptibility results after selecting their MRN from the ICU registration book.

Data management

Data were entered into Epi-Info and statistical analysis was performed using SPSS version 25. The Chi-square test was used for categorical variables. Mean, median, and standard deviation (SD) were used for continuous variables.

Ethical considerations

The need for informed consent was waived by the institutional review committee of St. Paul's hospital millennium medical college due to the retrospective nature of the study. The proposal was approved by St. Paul`s hospital millennium medical college IRB with Ref. No. of pm 23/384.

Results

Demographic characteristics

A total of 106 patients, having culture results after admission to ICU for over one year, were analyzed. The majority, 68(64.2%), were males, and the median age was 30.5 years, with a range of 3-82 years.

Most of the patients, 75(70.8%), were from the emergency department. The median length of ICU stay was 31 days (interquartile range of 3-128 days). And the hospital length of stay before ICU admission was 6.89±10.52 (mean ±SD). More than 99% of the patients have met the systemic inflammatory response syndrome (SIRS) criteria.

Clinical characteristics of patients

In most patients, 49(46.2%) had comorbidities during admission. The most common comorbidity was hypertension 14(28.6%, and congestive heart failure 10(20.4%). The majority of deaths, 22 (64.70%), were associated with comorbidity. The most common site of infection was the pulmonary system 84(54.5%), followed by urinary tract infection 26(16.9%), skin/soft tissue infection 18 (11.7%), Central nervous system 16(10.4%), and 10(6.5%) intra-abdominal focus. The pulmonary 55(65.47%) and urinary focus 18(69.23%) were in male patients, whereas intra-abdominal source was higher in females 9(90%). Organ failure occurred in the majority of 94(88.7%) patients, with the respiratory system comprising 84(44.7%) of organ failures, followed by the neurologic system 60 (31.9%), as shown in **Table 1.**

Table 1: Outcomes to ICU (discharge and death) among patients admitted to SPHMMC and AaBET ICUs from January 2019 to December 2019

Variables	Total (N*=106)	Discharge (N=65)	Death (N=34)	P value
Comorbidity	49(46.2%)	22(33.8%)	22(64.7%)	.196
RVI	3(6.1%)	1(1.5%)	2(5.9%)	.735
DM	8(16.3%)	5(7.7%)	3(8.8%)	.757
HTN	14(28.6%)	8(12.3%)	5(14.7%)	.047
CAD/CHF	10(20.4%)	4(6.15%)	6(17.6%)	.588
COPD/Asthma	2(4.1%)	1(1.5%)	1(2.9%)	.338
CKD	6(12.2%)	3(4.6%)	3(8.8%)	.146
CLD	1(2.0%)	-	1(2.9%)	.588
Malignancy	2(4.1%)	-	1(2.9%)	.977
Infection site	154	95	59	
Pulmonary	84(54.5%)	51(53.7%)	27(45.8%)	.036
Urinary	26(16.9%)	18(18.9%)	4(6.8%)	.282
CNS	16(10.4%)	9(9.5%)	7(11.9%)	.075
Skin/soft tissue	18(11.7%)	9(9.5%)	9(15.25%)	.395
Gastrointestinal	10(6.5%)	8(8.4%)	2(3.4%)	
Organ failure	188	105	71	
Neurologic	60(31.9%)	33(31.4%)	23(32.4%)	117
Respiratory	84(44.7%)	48(45.7%)	30(42.25%)	.119
Renal	31(16.5%)	17(16.2%)	13(18.3%)	.165
Cardiovascular	13(6.9%)	7(6.7%)	5(7.0%)	..603

*Number of patients

RVI- Retroviral Infection, DM- Diabetes Mellitus, HTN- Hypertension, CAD/CHF- Coronary artery disease/ congestive heart failure, COPD- Chronic Obstructive Pulmonary Disease, CKD- Chronic Kidney Disease, CLD- Chronic Liver Disease, CNS- central nervous system

Microbiological profile and antimicrobial susceptibility

Out of the 173 cultures analyzed, 84(48.55%) were blood cultures, urine 69(39.88%), pus 6(3.47%), CSF and body fluid 5(2.89%) each, and 2(1.16%) of the cultures were tracheal aspirate and stool culture each. Forty-four (25.43%) of the cultures had growth of 51 microorganism isolates. Gram-negative microorganisms were identified in 35(68.63%) isolates **(Table 2).**

Table 2: Type of microorganism isolates on microbiological culture among patients admitted to SPHMMC and AaBET ICUs from January 2019 to December 2019 (N=number of microorganism

Type of culture	Gram-negative (N=35)	Percentage % (68.7)	Gram-positive (N=10)	Percent-age %(19.6)	Fungus (N=6) 11.7%
Blood	5	9.80	7	13.73	-
Urine	23	45.10	1	1.96	6
Pus	3	5.90	2	3.92	-
Body fluid	1	1.96	-	-	-
Tracheal-aspirate	3	5.90	-	-	-

Acinetobacter species was the commonest organism isolated accounting for 10(28.57%), followed by *Klebsiella pneumonia* and *E. coli* 7(13.725%). Ten (19.60%) microorganisms were *gram-positive microorganisms*, of which 5(50%) were *coagulase-negative staphylococci*, 2(20%) *enterococci*, and *staphylococcus aureus* each, and 1(10%) *Streptococcus pneumonia*. Six (11.76%) microorganisms grown were fungal, all from urine culture **(Figure 1).** *Acinetobacter species* had shown sensitivity to meropenem 5(55.6%), ceftazidime 1(50%), amikacin 3(42.9%), and gentamicin 2(40%), but resistant at all test times to another cephalosporin (cefazoline, ceftriaxone, cefepime, and cefotaxime), TTC, nitrofurantoin and piperacillin.

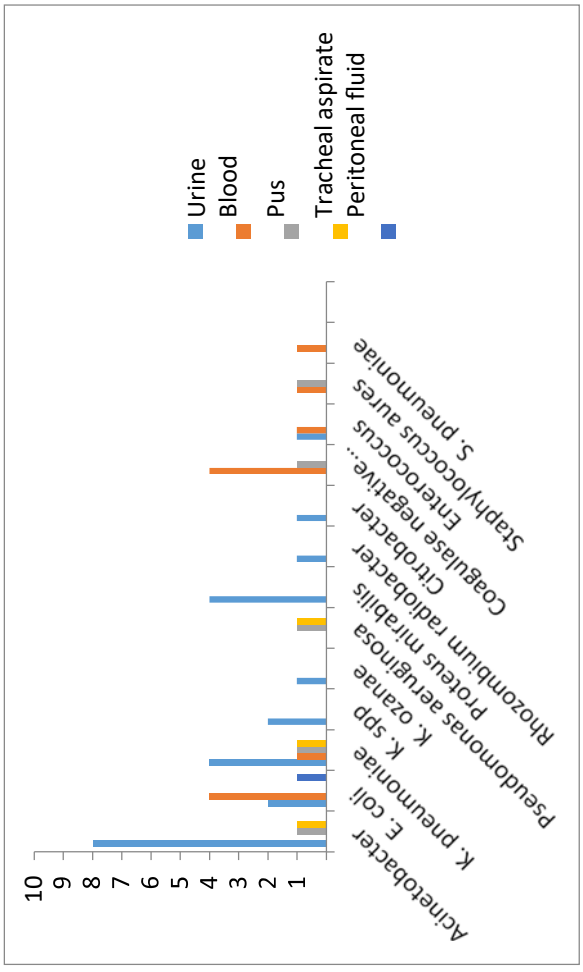

Figure 1: Microorganism isolates from each culture sample among patients admitted to SPHMMC and AaBET ICUs from January 2019 to December 2019 (Y-axis shows the number of microorganism isolates, X-axis shows the name of microorganisms).

Klebsiella pneumonia was sensitive to imipenem 1 (100%), piperacillin/tazobactam 1(50%), chloramphenicol 1(50%), meropenem 3(42.9%), and ciprofloxacin 1 (20%), but resistant to all tested cephalosporin antimicrobials (like cefuroxime, ceftazidime, cefepime, and cefotaxime), nitrofurantoin, ampicillin, and gentamicin.

Escherichia coli had shown sensitivity to meropenem 4(100%), amikacin 1(100%), chloramphenicol and nitrofurantoin 2(100%) each, gentamicin (80%), piperacillin/tazobactam 1(50%), ciprofloxacin 2(33.3%), and TMP/SMX 1(25%). Whereas, resistant to cephalosporin (cefazoline, cefotaxime, and cefuroxime), amoxacillin/clavulanate, piperacillin, and tetracycline at all test times. *Pseudomonas aeruginosa* was sensitive to ciprofloxacin 2 (100%), amoxicillin, cefepime and piperacillin 1 (100%) each, meropenem and tobramycin 1(50%) each. As detailed in (Table 3) (Figure 2) below.

Microorganisms isolated from urine culture which were resistant to all tested antimicrobials were *Klebsiella ozaena* (ceftriaxone, gentamicin, nitrofurantoin, piperacillin, cotrimoxazole, and tobramycin), and *Rhizobium radiobacter* (ampicillin, amoxicillin/clavulanate, ceftriaxone, cefepime, ciprofloxacin, nitrofurantoin, TTC, cotrimoxazole, and tobramycin).

Citrobacter isolated from urine culture was sensitive to amikacin but resistant to a cephalosporin (ceftriaxone and cefuroxime), TMP/SMX, ciprofloxacin, gentamicin, Amox/Clav, TTC, and piperacillin. *Enterococcus* isolated from urine culture had shown sensitivity to ciprofloxacin, daptomycin, and vancomycin, intermediate activity against erythromycin, but resistance to penicillin G.

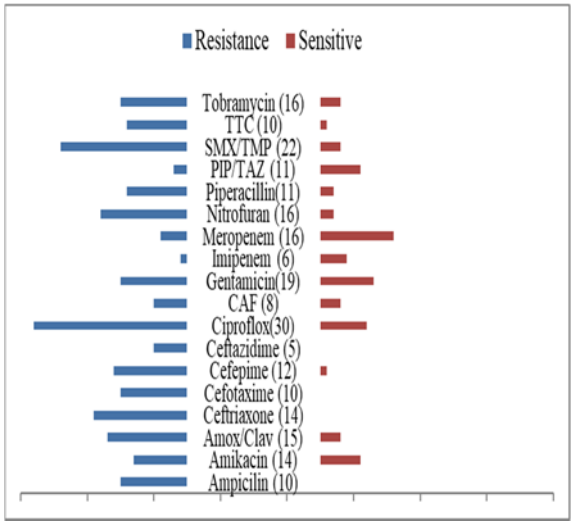

Figure 2: Antimicrobial resistance and sensitivity distribution among patients admitted to SPHMMC and AaBET ICUs from January 2019 to December 2019. (Number in bracket means the frequency of testing with the subsequent antimicrobial, and color is to show the strength of resistance and sensitivity).

TTC- Tetracycline, SMX/TMP- Sulfamethoxazole/ Trimethoprim, PIP/TAZ- Piperacillin/Tazobactam, CAF- Chloramphenicol.

Table 3: Antimicrobial resistance and sensitivity frequency among patients admitted to SPHMMC and AaBET ICUs from January 2019 to December 2019 (N= number of tests).

Antimicrobials	Resistance: N (%)	Sensitive: N (%)
Ampicillin	10(100%)	-
Amikacin	12(80%)	8(57.2%)
Amoxacillin/ Clavulanate	12(80%)	3(20%)
Ceftriaxone	14(100%)	-
Cefotaxime	10(100%)	-
Cefepime	11(91.7%)	1(8.3%)
Cefuroxime	4(100%)	-
Ceftazidime	5(71.4%)	1(14.3%)
Cefazoline	4(100%)	- 7(23.3)
Ciprofloxacin	23(76.7%)	3(37.5%)
CAF	5(62.5%)	1(50%)
Clindamycin	1(50%)	2(100%)
Daptomycin	-	-
Erythromycin	1(33.3%)	8(42.1%)
Gentamycin	10(52.6%)	4(66.7%)
Imipenem	1(16.7%)	2(66.7%)
Intrapenem	1(33.3%)	11(68.7%)
Meropenem	4(25%)	2(13.3%)
Nitrofurantoin	13(86.7%)	1(50%)
Norfloxacin	1(50%)	-
Oxacillin	2(100%)	-
Penicillin	2(100%)	2(18.2%)
Piperacillin	9(81.8%)	6(54.6%)
PIP/TAZ	2(18.2%)	3(13.6%)
SMX/TMP	19(86.4%)	1(10%)
TTC	9(90%)	3(18.7%)
Tobramycn	10(62.5%)	-
Vancomycin	2(66.7%)	-

Antimicrobial use and ICU outcome of patients

Almost all patients, 103(97.3%) took antimicrobials before ICU admission or before culture sampling, and ceftriaxone was used in 67(62.3%) patients, followed by vancomycin in 62(58.5%), and metronidazole in 56 (52.8%) patients. The most common indications were pulmonary infection in 68(37.2%), followed by empiric therapy in 26(14.2%), and urinary-tract infection in 25 (13.7%) patients (see **Table 4).** Almost a third of (32.1%) patients died during their ICU stay. Patients with urinary tract infection and septic shock before admission were significantly associated with a higher risk of death.

Table 4: Comparison among outcomes in ICU and indication for antimicrobial use before admission or before culture sampling among patients admitted to SPHMMC and AaBET ICUs from January 2019 to December 2019 (N= Number of patients).

Indication for antimicrobial use	N (%)	Death	Discharge	P value
Bacterial sepsis	14(13.2%)	3(21.4%)	9(64.3%)	.809
Septic shock	5(4.7%)	1(20%)	4(80%)	.053
CNS infection	11(10.4%)	6(54.5%)	5(45.5%)	.258
Urinary-tract infection	25(23.6%)	5(20%)	16(64%)	.086
Pulmonary infection	68(64.2%)	24(35.3%)	39(57.4%)	.266
Intra- abdominal infection	8(7.5%)	1(12.5%)	7(87.5%)	.255
Soft-tissue/skin ifection	16(15.1%)	7(43.75%)	9(56.3%)	.655
Infective endocarditis	1(0.9%)			-
Empiric therapy	26(24.5%)	6(23.1%)	18(69.2%)	.345
Prophylaxis	9(8.5%)	2(22.2%)	7(26.9%)	.294

Discussion

With this study, we have shown there was a high gram-negative resistant bacterial growth from patients admitted to intensive care units of the hospitals. The patients were also younger with a mean age of 35.8±1.6 years and the median length of stay in the ICU was prolonged to 31 days. The mean age was lower than in studies from other centers (8). The reason for younger age and prolonged stay may be partly the patient population where AaBET hospital is being a trauma center, and trauma victimizes the young.

In patients with culture growth, there was high underlying comorbidity found in 49(46.2%) of patients, hypertension was the most common comorbidity in 14(28.6%), lower than and different from the TASH study revealed 89.5% associated comorbidity and immunosuppression being the most common in 33.9% of patients (9).

It can be from an epidemiologic shift that NCDs are affecting the young. Of the 106 patients studied, 173 cultures were analyzed, and only 44(25.43%) of cultures had growth of microorganisms with 51 isolates, which was similar to a study in eastern Ethiopia hospitals with an isolation rate of 27.9% but higher than in TASH 16.5% and lower than a study done in Nepal 39.6% (10, 12-13).

In the study centers, the most common source of infection was the pulmonary and urinary tract, which is similar to a study of five ICUs of Imam Reza hospital and TASH ICU, but different from Jimma university hospital, from which surgical site infection was the most common source (14, 15).

The pulmonary and urinary focus was higher in male patients 55(65.47%) and 18(69.23%), while the intra-abdominal focus was higher in females 9(90%) in our study (16, 17).

Gram-negative were the most commonly identified microorganisms similar to other studies, but the isolated species were different (13, 18). And patients with CAD/ CHF, urinary tract source of infection, and septic shock before admission had a greater risk of death which was different from other studies which revealed a high risk of death with different factors such as infection with *acinetobacter species*, renal replacement therapy, use of mechanical ventilation, COPD, malignancy, pulmonary cause of infection and antibiotic use before admission (19, 20).

The study found 32.1% mortality with ICU infections was similar to other different studies, 14.31% to 45.4%, lower than that of an African study, 47.2% (19, 21-22). A high antibiotic resistance rate (>60%) was observed with ciprofloxacin, cephalosporin, piperacillin, cotrimoxazole, chloramphenicol, tetracycline, nitrofurantoin, tobramycin, and penicillins similar to a study in Chad-Ndjamena general hospital and other studies (23-25).

Almost all patients 103(97.3%) studied took antimicrobials before ICU admission, which contributes to antimicrobial resistance that was directly proportional to the volume of antimicrobials consumed (25, 26).

Conclusion

This study shows gram-negative bacteria were the predominant microorganisms identified which pose the greatest risk of patient death and prolonged ICU stay complications. It also showed patients with a urinary source of infection, and septic shock pose a greatest risk of death.

This research will help the intensive care unit to consider the targeted provision of antimicrobials and strengthen the quality and availability of microbiology laboratories. It will also use as a reference for future studies.

Abbreviations

AaBET- Addis-Ababa Burn Emergency and Trauma Hospital, CSF- Cerebro Spinal Fluid, ICU- Intensive and Critical care Unit, MRN- Medical Registration Number, SIRS- Systemic Inflammatory Response Syndrome, SPHMMC- Saint Paul`s Hospital Millennium Medical College, TASH- Tikur Anbessa Specialized Hospital.

Conflict of interest

The authors declare no conflict of interest.

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Author Contribution

All authors contributed to the study equally. YG prepared the manuscript. MS edited and commented on the manuscript. DT helped with the study design and literature review. All authors agreed on the final version and publication.

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