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Patterns of antimicrobial consumption and bacterial resistance in intensive care units: a pilot study from Palestine

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ABSTRACT

Background: Antimicrobial resistance has become a worldwide issue as the number of multidrug-resistant (MDR) bacteria has risen considerably. The irrational use of antibiotics contributes significantly to this issue. **Methods:** A prospective study was conducted over three months at a teaching hospital in surgical and medical intensive care units (SICU, MICU) in Palestine. Antimicrobial consumption data were recorded and analyzed using the antimicrobial consumption tool. Microorganisms and their resistance patterns were obtained from the microbiology laboratory. **Results:** One hundred patients with a median age of 50 years were included in this study (65% males). More than half of the patients were admitted to the MICU (55 patients). Vancomycin, piperacillin-tazobactam, and fluconazole were the most highly consumed antimicrobials, in terms of defined daily dose(DDD)/100-bed day, in the SICU (37, 31, and 27, respectively). On the other hand, meropenem, vancomycin, and levofloxacin were the most commonly consumed antimicrobials in the MICU (49, 35, and 26, respectively). The most frequent organisms were *Coagulase-negative Staphylococci species, Escherichia coli,* and *Enterococcus faecalis* (15%, 12%, and 9%, respectively). There were two Vancomycin-resistant Enterococcus faecium (VRE) cases in each ICU. Methicillin-resistant Staphylococcus aureus (MRSA) was common in the MICUs (five isolates). *In both ICUs, A. baumannii, Escherichia coli, P. aeruginosa, and Klebsiella pneumonia showed extensive resistance to the tested antibiotic*s. The isolated *Enterococcus faecium* from both ICUs were highly resistant to the commonly used antibiotics. **Conclusion:** This study revealed high consumption of the most potent antibiotics and the prevalence of multidrug-resistant organisms (MDRO) in the tested ICUs. This highlights the need to adhere to the antibiotic stewardship policy to use antibiotics appropriately and reduce the presence of these MDROs.

KEYWORDS: Antimicrobial consumption, antimicrobial resistance, ICU, DDD/100 bed days, Palestine.

INTRODUCTION

Antimicrobial resistance is one of the biggest and most serious public health challenges. It poses a heavy burden on health services as it increases morbidity, mortality, and hospital stay and even leads to high economic loss at both the individual and governmental levels. Data from European Antimicrobial Resistance Surveillance Network 2015 showed that 671689 infections were due to antibiotic-resistant bacteria. These infections accounted for an estimated 33110 attributable deaths and 874541 disability-adjusted life-years. The burden was highest in infants and people aged 65 years or older (1). In a different study, infections related to antibiotic-resistant bacteria were associated with an increased length of stay in the pediatric intensive care unit after the onset of infection and increased mortality (2).

The highest percentage of resistance was recorded in intensive care units (ICUs), reaching the level of 52.2% multi-drug resistant organisms (MDRO) and 18.8% extensively drug-resistant organisms (XDRO) of the isolate (3). This is because critically ill patients have a 5 to 7 times higher risk for developing nosocomial infections than ward patients. Furthermore, they have an increased risk of being exposed to invasive devices and immunosuppressive drugs and consuming more antibiotics. The pattern of microorganism resistance is different among various countries and hospitals and even in the ICUs of the same hospital (4) (1).

Human misuse and abuse of drugs have certainly played a significant role in making microorganisms reach a dangerous and life-threatening resistance level. However, antibiotics are the most commonly prescribed drugs to patients, mainly in ICU and surgical departments (5,6). The most common organisms responsible for drug resistance are *Acinetobacter bumannii, Klebsiella pneumoniae, Staphylococcus aureus,* and *Pseudomonas aeruginosa*. The outer membrane lipid layer in gram-negative bacteria acts as a permeability barrier that prevents antibiotics from entering and acting on these bacteria (7). This progress of antimicrobial resistance can be slowed down by more rational use of antibiotics, health care regulations, and the restriction of unnecessary perioperative antimicrobial prescriptions. Furthermore, infection control in health care settings has shown its efficacy in decreasing resistance (8). Another effective way to reduce this outgrowing problem is through mass media campaigns to reduce the over-prescription and the threats of high antimicrobial consumption (9).

The objective of this study was to assess antimicrobial consumption and bacterial resistance patterns in patients admitted to the medical and surgical ICUs at a university teaching hospital in the West Bank, Palestine.

METHODS

An observational prospective cohort study was carried out in the medical and surgical intensive care units (MICU and SICU) of a teaching hospital in Nablus. This hospital is one of the leading tertiary referral centers in Palestine; it has 107 beds with two separate 6-bedded SICU and five bedded MICU and the study period extended from Nov 1, 2019, until Feb 3, 2020. Patients were identified by daily visits to the ICUs and followed from the day of admission to recovery, discharge, or death. All patients admitted to the ICUs were included in the study except those who stayed for less than one hour or were under 18 years of age. Patients who were readmitted to the ICU were excluded.

Study setting: The patient's socio-demographic data such as sex, age, as well as information about the prescribed antimicrobial, dose, grams per unit dosage, number of doses per package, number of packages consumed, routes of administration of the antimicrobial, length of stay in the hospital and clinical outcome were obtained from the case record forms of each ICU. All specimens such as blood, urine, tracheal aspiration, wound, and others (fluids, tissue, and sputum) were considered as indicated based on the clinical suspicion of the treating physician, and they were referred to the Microbiology laboratory for culture and sensitivity. Bacterial identification and antibiotic susceptibility were determined using the Vitek2 Compact (bioMérieux, Marcy-l'Étoile, France). WHONET 5.6^{TM} was used to calculate data on antimicrobial resistance. Colistin sensitivity analysis was done using the broth microdilution method, which is the approved method for determining colistin resistance analysis according to the Clinical and Laboratory Standards Institute (CLSI)(10). Resistance to at least one agent in three or more antimicrobial categories was recognized as multidrug-resistant (MDR). In comparison, resistance to at least one agent in all antimicrobial categories was considered as extensively drug-resistant (XDR), and resistance to all antimicrobials in all categories was identified as pan drug-resistant (PDR) (11).

The antimicrobials were arranged according to the ATC system (Anatomical therapeutic chemical classification system). The antimicrobial consumption patterns of both medical and surgical units were compared using a defined daily dose (DDD/100-bed day). Antimicrobial consumption was calculated using the Antimicrobial Consumption tool (AMCtool 2019) (12). Antimicrobial information such as name, pack size, strength, route of administration, and the number of packages was assigned to the program, and the number of bed-days was applied as the denominator of each ICU as calculated from the case record forms.

No. of bed day = No. of beds in ICU × Occupancy index × No. of days (during the study period)

Definitions: Defined daily dose (DDD, expressed in grams) was defined as the average maintenance dose per day for a drug used for its main indication in a 70 kg adult, as per the world health organization and Anatomical Therapeutic Chemical (ATC) definition of a specific DDD. A bad day is a day during which a person is confined to a bed and in which the patient stays overnight in a hospital. Day cases are sometimes included as one-bed days and sometimes excluded (13).

Statistical Analysis: Collected data were tabulated and analyzed using Statistical Package for Social Sciences (SPSS), Version 21.0 (IBM Corporation, Armonk, NY, USA).).

RESULTS

Socio-demographic data: A total of one hundred patients were included in this study; 55 were admitted to the SICU and 45 to the medical ICU. The total bed days in the SICU were 362 with an occupancy index of 64%, while 340.5 in the MICU with an occupancy index of 72%. Among the SICU patients, 37(67%) were males with a median age of 46 years. About 58% of the patients were under 50 years, and their median age was 32. Those admitted to the MICU included 28 (62%) males with a median age of 57 years. About 42% of the patients were under 50 years old, and their median age was 35. During the study period, 15 patients died in the MICU, and 9 died in the SICU. The number of deaths due to infections in the MICU was eight (33.3%) and in the SICU was one (1.1%). (Table 1).

Table (1): Characteristics of medical and surgical ICU.

	MICU	**SICU**	**Total**
Number of beds	5	6	11
Number of admitted patients	45	55	100
Number of admitted patients Less than 50 years	19	32	51
Median age	57	46	
Sex (Male)	28	37	
Total Bed days	340.5	362	
Occupancy (%)	72	64	
Number of deaths	15 (33.3)	9(10.9)	24
Causes of deaths			
• Infectious	8(53.3)	1(1.1)	9
• Non-infectious	7(46.6)	8(8.9)	15

Antimicrobial consumption: The average number of drugs prescribed was about three per patient in both SICU and MICU, with 145 and 142 prescriptions in the SICU and MICU. The most commonly prescribed antimicrobials in the SICU were vancomycin [27(18.6%)] followed by piperacillin-tazobactam [25 (17.2%)]; while meropenem [25(17.6%)] and vancomycin [24(16.9%)] were the most commonly prescribed in the MICU. Fifteen patients did not receive antimicrobials in the surgical unit compared to only four patients in the medical unit. (Table 2) demonstrates the number of antimicrobials prescribed to patients in each ICU. Patients who received one or two antibiotics were 31% in both ICUs, and those who received three or more were 42% and 60% of total patients in the surgical and medical units, respectively.

Table (2): Antimicrobials prescribed for patients in each ICU.

Antimicrobial	MICU N (%)	SICU N (%)
Carbapenems	25 (17.6)	10 (6.9)
Vancomycin	24 (17)	27 (18.6)
Fluoroquinolones	16 (11.3)	21 (14.5)
Bate-lactam/beta-lactamase inhibitors	15 (10.6)	25 (17.2)
Colistin	12 (8.5)	6 (4.1)
Cephalosporins	10 (7)	18 (12.4)
Tigecycline	10 (7)	1 (0.7)
Aminoglycosides	9 (6.3)	17 (11.7)
Trimethoprim-sulfamethoxazole	5 (3.5)	0
Macrolides	4 (2.8)	4 (2.8)
Metronidazole	1 (0.7)	5 (3.5)
Doxycycline	0	1 (0.7)
Rifaximin	0	1 (0.7)
Antifungal	11 (7.7)	9 (6.2)
Total	**142**	**145**

The surgical unit's most commonly consumed antibiotic (DDD/100-bed day) was vancomycin, followed by piperacillin-tazobactam and fluconazole (37, 31, and 27, respectively). Cefuroxime was the least consumed antimicrobial (<1). The most commonly consumed antimicrobials in the MICU were meropenem, followed by vancomycin and levofloxacin (49, 35, and 26 respectively), while the least used antimicrobials were metronidazole and cefazolin (<1). (Table **Error! Reference source not found.**3) compares the antimicrobial consumption in both the medical and surgical units.

Table (3): Antimicrobial consumption (DDD/100 patient-days)in both ICUs.

Antimicrobial agent	ATC code	WHO DDD	DDD/100 bed days	
		(g)	SICU	MICU
Amoxicillin-clavulanate	J01CR02	3	2.58	-
Piperacillin-tazobactam	J01CR05	14	31.57	17.96
Cefazolin	J01DB04	3	2.3	0.1
Cefuroxime	J01DC02	3	0.69	-
Ceftriaxone	J01DD04	2	1.38	3.23
Cefotaxime	J01DD01	4	1.59	1.1
Ceftazidime	J01DD02	4	12.15	2.42
Meropenem	J01DH02	3	13.72	49.34
Ciprofloxacin	J01MA02	0.8	4.28	0.73
Levofloxacin	J01MA12	0.5	19.06	25.99
Vancomycin	J01XA01	2	37.15	35.1
Gentamycin	J01GB03	0.24	1.93	1.37
Amikacin	J01GB06	1	10.36	6.9
Erythromycin	J01FA01	1	2.49	-
Clindamycin	J01FF01	1.8	3.31	2.94

Antimicrobial agent	ATC code	WHO DDD	DDD/100 bed days	
		(g)	SICU	MICU
Azithromycin	J01FA10	0.5	-	2.06
Doxycycline	J01AA02	0.1	5.52	-
Tigecycline	J01AA12	0.1	1.93	25.4
Colistin	J01XB01	9 MU	2.58	10.7
Metronidazole	J01XD01	1.5	2.95	0.49
Trimethoprim/sulfamethoxazole	J01EE01	4 UD	-	13.8
Rifaximin	A07AA11	0.6	15.19	-
Fluconazole	J02AC01	0.2	27.35	3.08
Voriconazole	J02AC03	0.4	-	14.98
Amphotericin B	J02AA01	35mg	1.58	-
Caspofungin	J02AX04	50 mg	-	1.47
Total			201.66	219.16

Microbiologic results and resistance patterns: One hundred eighty-one specimens were obtained from 38 patients in the SICU; 55 cultures were tested positive in 18 patients. **Error! Reference source not found.**The total number of isolates in the SICU was 55; 25 (46%) gram-negative bacteria, 26 (47%) gram-positive bacteria, and 4 (7%) Candida spp. The most frequent gram-negative organisms were *Escherichia coli* with 9 (36%) and *Acinetobacter baumannii* with 7 (28%). On the other hand, Coagulase-negative Staphylococcus spp ([11; (42%)], *Enterococcus spp* [(12; (46%)] and *Staph. aureus* [3; (11.5)] were the most commonly isolated bacteria among gram-positive isolates. (Table 4).

The number of collected specimens from the MICU was 278 from 37 patients; 78 cultures were positive in 27 patients. Of the total 78 isolates, there were 22(28%) gram-negative bacteria, 31 (40%) gram-positive bacteria, and 25 (32%) Candida spp. *Escherichia coli* (7; 32%) and *Klebsiella pneumonia* (5; 23%) were the most common gram-negative pathogens. Enterococcus spp (12; 39%), Coagulase-negative Staphylococcus spp (9; 29%), and *Staphylococcus aureus* (7; 23%) were the most common gram-positive bacteria. *Candida* isolates were included only from blood, urine, and tracheal aspirates in SICU and MICU. (Table 4).

Table (4): Frequency of isolated organisms from both ICUs.

Microorganism	MICU	SICU	Total
	N (%)	N (%)	N (%)
Gram Negative organisms	**22 (28)**	**25 (46)**	**47 (35.3)**
E. coli	7 (31.8)	9 (36)	16 (12)
Klebsiellapneumoniae	5 (22.7)	2 (8)	7 (5.3)
Acinetobacterbaumannii	2 (9.1)	7 (28)	9 (6.8)
Enterobacter cloacae	2 (9.1)	2 (8)	4 (3)
Pseudomonas aeruginosa	2 (9.1)	2 (8)	4 (3)
Others	4 (18)	3 (12)	7 (5.3)
Gram Positive organisms	**31 (40)**	**26 (47)**	**57 (42.9)**
Enterococcus faecalis	7 (22.6)	5 (19.2)	12 (9)

Microorganism	MICU	SICU	Total
	N (%)	N (%)	N (%)
Enterococcus faecium	5 (16.1)	4 (15.4)	9 (6.8)
Staph. aureus (MRSA)	5 (16.1)	2 (7.7)	7 (5.3)
Staph. aureus (MSSA)	2 (6.5)	1 (3.84)	3 (2.3)
Coagulase negative Staph.	9 (29)	11(42.3)	20 (15)
Others	3 (9.6)	3 (11.5)	6 (4.5)
Candida species	**25 (32)**	**4 (7)**	**29 (21.8)**
Candida glabrata	9 (36)	1 (25)	10 (7.5)
C. albicans	7(28)	1 (25)	8 (6)
Other Candida spp	9 (36)	2 (50)	11 (8.3)
Total number of isolates	**78 (58.6)**	**55 (41.4)**	**133 (100)**

The resistance patterns of gram-negative and gram-positive microorganisms are illustrated in (Tables 5 and 6) for both ICUs, respectively. MDRs are highly present in the SICU, where 66.6% of *E.coli*, 86% of *A.baumannii*, 100% of *K.pneumonia*, 88% of *Enterococcus* were MDRs, and two-thirds of *S.aureus* were MRSA.

Table (5): Antibiotic resistance of gram-negative bacteria.

ICU (no of isolates)	*A. baumannii*		*P. aeruginosa*		*K. pneumoniae*		*E. coli*	
	MICU (2)	SICU (7)	MICU (2)	SICU (2)	MICU (5)	SICU (2)	MICU (7)	SICU (9)
Amoxicillin/Clavulanic acid	-	-	-	-	60	100	14	78
Ceftazidime	100	86			60	100	57	78
Cefotaxime	-	-	-	-	-	100	57	78
Ceftriaxone	-	-	-	-	60	100	57	78
Cefepime	100	86	100	0	60	100	57	67
Piperacillin/Tazobactam	100	86	50	0	60	100	0	33
Meropenem	100	86	100	0	20	100	0	11
Amikacin	-	-	100	0	20	100	0	22
Gentamicin	100	86	100	0	20	100	29	11
Ciprofloxacin	-	-	-	0	60	100	29	33
Trimethoprim/Sulfamethoxazole	100	57	-	-	40	100	14	56
Tigecycline	-	-	-	-	-	0	-	-
Tetracycline	-	-	-	-	-	0	-	0

Table (6): Antibiotic resistance of gram-positive bacteria.

Antibiotic/ ICU (no of isolates)	*E.faecalis*		*E.faecium*		*S.aureus*	
	MICU (7)	SICU (5)	MICU (5)	SICU (4)	MICU (7)	SICU (3)
Amoxicillin/Clavulanic acid	14	0	100	100	71	67
Oxacillin	-	-	-	-	71	67
Cefuroxime	-	-	-	-	71	67
Erythromycin	100	100	100	50	43	67
Clindamycin	-	-	-	-	29	67

Antibiotic/ ICU (no of isolates)	*E.faecalis*		*E.faecium*		*S.aureus*	
	MICU (7)	SICU (5)	MICU (5)	SICU (4)	MICU (7)	SICU (3)
Vancomycin	0	0	40	50	0	0
Tetracycline	100	80	60	50	14	67
Doxycycline	-	0	0	0	0	0
Tigecycline	0	0	0	0	0	0
Ciprofloxacin	57	80	100	100	29	0
Levofloxacin	57	80	100	100	29	0
Rifampin	-	-	-	-	0	0
Gentamicin	71	80	100	75	0	0
Trimethoprim/Sulfamethoxazole	-	-	-	-	29	0

In the medical ICU, 28% of *E.coli*, 60% of *K.pneumonia*, all isolates of *A.baumannii* and *P.aeruginosa*, and 75% of *Enterococcus spp* were MDR. Seventy-one percent of *S.aureus* were MRSA. Moreover, 4 out of 9 (44%) urinary isolates of *Candida glabrata* in the medical ICU were voriconazole-resistant.

DISCUSSION

The increased consumption of antimicrobials is a major cause of the increased incidence of MDRO. ICU patients are prescribed antimicrobials more often than any other wards in the hospital (4) because these patients are severely ill, and the empirical use of antimicrobials is more frequent. We conducted this observational cohort study in both medical and surgical ICUs at a teaching hospital in Palestine to assess the antimicrobial consumption, frequency of microorganisms, and antimicrobial resistance patterns in each ICU.

A total of 20 antimicrobial agents were used in the medical ICU, and 22 drugs were used in the surgical unit. Among the 145 prescriptions made in the surgical unit, vancomycin was the most commonly prescribed, followed by beta-lactam/beta-lactamases and cephalosporins. Carbapenems were the most commonly prescribed for the medical ICU, followed by vancomycin. The highest consumption in the surgical unit was for vancomycin (37) and piperacillin-tazobactam (32), and fluconazole (27). Among the medical unit, the highest were meropenem (49) and vancomycin (35). A similar result was reported in Saudi Arabia in 2018, where the consumption of carbapenems, piperacillin/tazobactam, vancomycin, and colistin were the most commonly consumed antimicrobials in five adult ICUs (14). Alone et al. in 2019 reported that ceftriaxone, imipenem, and vancomycin were the most highly consumed antimicrobials in intensive care units at North West (Tabuk) hospitals, Saudi Arabia (14). Cephalosporins and carbapenems were most frequently prescribed in adult ICUs in Jordan (15). In 2013, the most prescribed antibiotic in intensive care units of Tabriz Imam Reza hospital was the cephalosporin family, and ceftriaxone was the most utilized antibiotic (16). In Turkey, the most frequently prescribed antibiotics were first-generation cephalosporins (16.1%), third-generation cephalosporins (15.2%), aminoglycosides (12.1%), carbapenems (10.7%) and ampicillin-sulbactam (8.7%)(17). In a more recent report from Asmara, Eritrea, benzylpenicillin was the most consumed antibiotic, and ceftriaxone and ciprofloxacin were among the most commonly consumed antibiotics in both hospitals (18). In a study conducted in India to assess antibiotic consumption in the ICU of a tertiary care hospital, the authors found that metronidazole was the most highly consumed antimicrobial [100.9], followed by fluconazole [76.6] and levofloxacin [62.7](4). In Oman, the most commonly prescribed antimicrobials were the antipseudomonal penicillin (piperacillin in combination with beta-lactam tazobactam) 31%; followed by cephalosporins 17%, meropenem 11%, macrolides 15%, and quinolones 10% (19). This antimicrobial consumption was low compared with the New Delhi study and Oman (3,20).

The high vancomycin consumption could be due to the empirical use in both ICUs and the ease of ordering this antibiotic in the hospital; moreover, high resistance rates could be attributed to the high consumption of antibiotics. Similar results were reported by an Israeli study where vancomycin and imipenem were among the most consumed antibiotics (21). In contrast, in the New Delhi study, the consumption of metronidazole and fluconazole was the highest, while vancomycin consumption was the lowest (4). In both the medical and surgical ICUs, there was a very high level of extended-spectrum beta-lactamases (ESBL) producers among gram-negative bacilli, and beta-lactams had a high consumption, especially in the medical ICU where carbapenems were prescribed to 55% of the patients. They were the most commonly prescribed antimicrobials in the medical ICU. This high prescription would result in resistant bacteria, leading to treatment failure; therefore, this class of antimicrobials should be culture-guided because carbapenems are potent inducers of class C beta-lactamases could explain the high resistance to beta-lactams (4,22,23). Similar results were seen in the NewDelhi and Omani studies (4,20).

Furthermore, in the surgical ICU, gram-negative bacilli were highly resistant to amoxicillin-clavulanic acid and piperacillin-tazobactam (84%, 52%, respectively), and beta-lactam/beta-lactamases were prescribed to 45% of the patients. This may result in treatment failure due to the high resistance among gram-negative bacilli. Vancomycin was the most commonly prescribed drug in the surgical ICU, given to 49% of the patients.

Candida spp in the medical ICU (30% of the total isolates) was higher than in the surgical ICU (7% of the total isolates), and the most common species was *Candida glabrata*. This might be due to the empirical use of fluconazole in the surgical ICU with a DDD/100-bed day of 27 compared with three for fluconazole and 14 for voriconazole in the medical ICU.

In the surgical ICU, *E.coli* and *A.baumannii* were the most common organisms, and most of these isolates were MDR; more than half of *S.aureus* isolates were MRSA, while the most commonly isolated organisms in the MICU were *S.aureus* and *Enterococcus spp* and most of the *Enterococci* were MDR and majority of *S.aureus* were MRSA. In the New Delhi study, the most common microorganisms isolated in the surgical ICU were *S.aureus* and *K.pneumonia*, and most of them were MDR, while 60% of *S.aureus* was MRSA(4). Another study from Dhaka- Bangladesh, showed that *P.aeruginosa* (29%) and *Acinetobacter spp* (27%) were the most commonly isolated in the general ICU and the majority of these isolates were MDR (77%) of *S.aureus* were MRSA (22). In European ICUs, the most common isolated organisms were *S.aureus* (30%) and *P.aeruginosa* (28%) (24). In a study conducted in the Sultanate of Oman, the most common organisms were *P.aeruginosa* (21%) and *K.pneumonia* (20%) (22). *S.aureus* and *K.pneumonia* were the most frequently isolated in a Romanian study, with 53% of *S.aureus* being MRSA (25). Half of the isolates were MDR on both surgical and medical units. This is similar to a study conducted in India which showed that 52% of the total isolates taken from general ICUs were MDR, and this was significantly higher than the ward results, which showed a lower percentage of MDR (11).

In the surgical ICU, the most common isolates from blood cultures were *Coagulase-negative staph,* while *A. baumannii*, *E.coli*, and *Enterococcus spp* were the most common in urine. *Staph. Aureus* was the most common in tracheal aspirations.

In the medical ICU, *Coagulase-negative staphylococcal* species and *K.pneumonia* were the most common in blood; *Candida glabrata* and *E.coli* were the most common in urine. *Candida albicans* and *S.aureus* were the most common in tracheal aspirations. Rambam Hospital in Haifa, Israel, reported that *P. aeruginosa* and *Acinetobacter spp* were the most commonly isolated organisms from blood (23). Another study in Romania showed that the most commonly isolated organisms were *candida*, *E. coli,* and *S. aureus* of blood, urine, and tracheal aspirations, respectively (25).

CONCLUSION

This study showed a difference in the frequency of organisms in the medical and surgical ICUs, and antimicrobial consumption was high. Antimicrobials of last resort, such as tigecycline, meropenem, and vancomycin, were highly consumed in the medical ICU. This highlights the need to adhere to the antibiotic stewardship policy to use antibiotics appropriately and reduce the incidence of these MDROs in Palestine.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Institutional Review Board of An-Najah National University and the hospital's administration.

Consent for publication: We declare that all authors have read and approved the paper.

AVAILABILITY OF DATA AND MATERIALS

Not applicable

AUTHOR'S CONTRIBUTION

Suhaib Hattab: conceptualization, writing-original draft, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, and writing review & editing. **Adham Abu-Taha:** conceptualization, writing-original draft, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, and writing review & editing. **Mohammad Mohalwes:** writing-original draft, data curation, formal analysis, investigation, resources, software, validation, visualization, and writing review & editing. **Mohamoud Duraidy:** writing-original draft, data curation, formal analysis, investigation, resources, software, validation, visualization, and writing review & editing. **Motasem Sbaih:** writing-original draft, data curation, formal analysis, investigation, resources, software, validation, visualization, and writing review & editing.

COMPETING INTEREST

The authors declare that there are no conflicts of interest.

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