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Research Article

Epidemiology and Microbiological Profile of Common Healthcare Associated Infections among Patients in the Intensive Care Unit of a General Hospital in Kuwait: A Retrospective Observational Study

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ABSTRACT

Background: Patients admitted to the Intensive Care Unit (ICU) are prone to develop nosocomial infections due to Multidrug-Resistant (MDR) organisms. Inappropriate and overuse of antibiotics play an important role in the emergence of MDR organisms, which cause life-threatening infections resulting in significant morbidity and mortality.

Methods: Retrospective surveillance-based study on healthcare-associated infections. The study conducted over two consecutive years 2018 and 2019, looking at ICU related infections of a regional secondary care general hospital and the data were recorded using the methods and definitions of the Kuwait National Healthcare-associated infections Surveillance System (KNHSS).

Results: A total of 1408 patients, admitted to ICU for 7922 days during the 2 years period. Eighty-nine patients were included in this study, where 48 developed one Hospital-acquired Infections (HAI) in the ICU while 25 and two patients presented with two and three HAIs, respectively. The HAIs included Bloodstream Infections (BSI) – 42.3%, pneumonia – 28.8%, Urinary Tract Infections (UTI) – 15.3%, skin and soft tissue infections – 9.6% and *Clostridium difficile* infection – 3.4%. The overall infection rate was 13.14 per 1000 patient-days. The rates for Device-associated (DA)-HAIs were 6.27 for Central Line-associated BSI (CLABSI) per 1000 Central Line (CL)-days, 4.21 for Ventilator-associated Pneumonia (VAP) per 1000 Mechanical Ventilator (MV)-days, and 1.91 Catheter-associated UTI (CAUTI) per 1000 Urinary Catheter (UC)-days. Data showed that device use ratios for CL, MV, and UC were 0.81, 0.74, and 0.98, respectively. *Acinetobacter baumannii* and *Klebsiella pneumoniae* were the most common organisms isolated from the ICU infections with highest rates of antibiotic resistance.

Conclusion: Among DA-HAIs CLABSI was found to be most common in our ICU, followed by VAP and CAUTI. Gram-negative organisms with *A. baumannii* and *K. pneumoniae* being the leading causative agents with high antimicrobial resistance profiles.

1. INTRODUCTION

Patients requiring life-saving support are invariably admitted to the Intensive Care Unit (ICU) of a health facility. They often undergo invasive procedures such as intra-tracheal intubation for mechanical ventilation, insertion of intravascular and urinary catheters, using monitoring devices as part of a routine or to closely monitor and deliver therapies resulting in Device-associated Hospital-acquired Infections (DA-HAIs) in some of the patients, especially if proper care-bundle is not observed [1,2]. Furthermore, there are usually several other risk factors in these patients making them vulnerable to develop nosocomial infections leading to high morbidity and mortality [3,4]. The rate of occurrence of infection among patients in the ICU is five to sevenfold higher as compared to general inpatient admissions contributing to 20–25% of all nosocomial infections in a hospital [5–7]. There has been a global escalation in both community- and HAIs due to Antimicrobial-resistant (AMR) bacteria compromising the ability to treat these patients effectively, thereby underscoring the need for continued surveillance, appropriate prescribing of antibiotics, implementation and adherence to stringent infection control measures, and availability of newer effective treatment alternatives [8–11]. Several reports are describing the epidemiology and microbiology of ICU-acquired nosocomial infections such as Ventilator-associated Pneumonia (VAP), Central Line-associated Bloodstream Infection (CLABSI), and Catheter-associated Urinary Tract Infection (CAUTI) [8]. Studies have shown that there is a higher prevalence of pathogens, including the resistant genotypes of Methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus*, Extended-Spectrum

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Beta-Lactamase (ESBL)-producing *Escherichia coli* and *Klebsiella* spp. and carbapenem-resistant *E. coli*, *Klebsiella* spp., *Pseudomonas aeruginosa* and *Acinetobacter baumannii,* causing HAIs, especially in the ICU setting. Available therapeutic options for AMR organisms are severely limited as these organisms frequently exhibit a Multidrug-Resistance (MDR) phenotype [9,10]. Empirical treatment of infections in patients in the ICU is often attempted by the administration of broad-spectrum or combination of antibiotics before tailoring the antimicrobial therapy based on culture and susceptibility results. It is well known that inappropriate and irrational use of antibiotics for the treatment of infections leads to the emergence of MDR among the common bacterial isolates [11]. This translates into a prolonged hospital stay, a significant increase in morbidity and mortality as well as an escalating economic burden. The Frequency of occurrence of infections among patients admitted to the ICU may vary from one geographical region to another, from one hospital to another, and even among the ICUs within one hospital. The type of infection, the profile of pathogens causing these infections, their antimicrobial susceptibility patterns also vary according to the location. It is, therefore, imperative for the treating clinician to have adequate information of the spectrum of microorganisms and the AMR patterns prevalent in that particular setting for initiating empirical therapy with appropriate antimicrobial agents [3].

There is limited literature regarding common ICU-acquired infections in Kuwait. This study aimed to determine the prevalence, rate, site, and causative organisms of HAIs in the ICU patients of a single center in Kuwait.

2. METHODOLOGY

2.1. Setting and Design

The patient-based surveillance data on HAIs were collected retrospectively for two consecutive years (2018 and 2019) for patients admitted to a combined medical/surgical 17-bed ICU at Farwania Hospital, which is a secondary-care facility with a capacity of 866 beds. In Kuwait, all the government hospitals under the umbrella of Ministry of Health (MOH) are obligated to participate in the Kuwait National Healthcare-associated infections Surveillance System (KNHSS). This surveillance system is required to continuously collect and analyze HAIs, outbreaks, and drug-resistant pathogens from all locations in the hospital.

2.2. Data Collection

All patient data are collected by the infection control practitioners and recorded on a standard questionnaire form approved by the MOH, Kuwait. To determine ICU-acquired infections, KNHSS module includes different indicator infections such as infection of the lower respiratory tract (VAP or non-VAP), UTI (CAUTI or non-CAUTI) and Laboratory-confirmed BSI (LCBI), whether CLABSI or non-CLABSI.

Data collected includes patient name, gender, age, nationality, hospital file number, location code, patient risk factors for infection, symptoms and signs, date of device insertion and removal, relevant diagnostic tests performed as part of septic workup, radiologic imaging results, laboratory culture results, number of isolated pathogens and their antimicrobial susceptibility profile, date of discharge or death (when infection is the attributable cause of death).

2.3. Definition of ICU-acquired Infections

1. Primary BSI is defined as LCBI that are not secondary to an infection at another body site (KNHSS January 2018). LCBI 1 is diagnosed when pathogenic bacteria or fungi are isolated from one or more blood culture bottles. However, LCBI 2 is identified when a potential non-pathogen (usually skin contaminants such as coagulase-negative *Staphylococcus*, diphtheroid, or *Bacillus* spp.) being isolated from more than one positive blood culture collected from two different sites or drawn on separate occasions and the patient has fever >38°C), chills, or hypotension [12,13].
2. CLABSI: LCBI where Central-Line (CL) is in place for >2 calendar days on the date of event, with the day of device placement being day 1 and a CL is in place on the date of event or the day before [12,13].
3. Pneumonia is diagnosed by using a combination of clinical, laboratory, and imaging criteria, which include: patients ≥70 years old with altered mental status or no other recognized cause for raised septic markers, fever >38.0°C, leukopenia (<4000 WBC/mm^3), or leukocytosis (≥12,000 WBC/mm^3) with or without microbiological confirmation of respiratory sample [endotracheal aspirate or Bronchoalveolar Lavage (BAL)] cultures. Radiologic findings include new and persistent or progressive infiltrates, consolidation, or cavitation on chest X-ray. In addition to at least two of the following: new onset of purulent sputum or change in the character of sputum, increased respiratory secretions, increased suctioning requirements, new onset or worsening cough, dyspnea, tachypnea, rales, bronchial breath sounds, worsening gas exchange (e.g., O_2 desaturation with PaO_2/FiO_2 ≤ 240), increased oxygen requirements, or increased ventilator demand [14,15].
4. VAP: Pneumonia where the patient is on Mechanical Ventilation (MV) for >2 calendar days on the date of event, with the day of ventilator placement being day 1 or the day before and the ventilator was in place on the date of event or the day before [14,15].
5. UTI is diagnosed when the patient has at least one of the following signs or symptoms: fever (>38.0°C), suprapubic tenderness, costovertebral angle pain or tenderness, urinary urgency, frequency, dysuria. In addition to positive urine culture with no more than two species of organisms, at least one of which is a bacterial isolate with a colony count of ≥10^5 CFU/ml in the absence of an alternative source of infection [16,17].
6. CAUTI: A UTI where an indwelling Urinary Catheter (UC) is in place for >2 calendar days on the date of event, with the day of device placement being day 1 and an indwelling UC is in place on the date of event or the day before [16,17].

2.4. Clinical and Microbiological Data

Cultural data including the sampling site, identification, and antimicrobial susceptibility were retrieved from Laboratory Information System (LIS) while the clinical information (ICU length of stay (LOS), antimicrobial therapy was obtained from the Hospital Information System (HIS). Although both clinical and microbiological data were available from KHSS format, LIS and HIS were used for any missing information.

Microbiological cultures and antimicrobial susceptibilities were performed according to the laboratory Standard Operational Procedures, based on Clinical and Laboratory Standards Institute recommendations. Generally, relevant clinical samples such as blood, endotracheal aspirate, BAL, urine, vascular catheter tips, wound swabs and others were cultured on 5% sheep blood agar, chocolate agar, MacConkey agar, and Sabouraud dextrose agar. The isolates were identified by Vitek 2 or Vitek MS (bioMérieux, Marcy-l'Étoile, France) or Phoenix (Becton and Dickinson, MD, USA). The resistance markers were identified by GenExpert or Nanosphere. Antimicrobial susceptibility results were obtained from Vitek 2 or Phoenix. The resistant strains of microorganisms were defined as (i) MDR – resistant to at least one antibiotic from three or more groups of antibacterial drugs active for a particular type of microbial genus, (ii) Extensively Drug-resistant (XDR) – resistant to one or more antibiotics in all groups of antibiotics, or (iii) pan drug-resistant – resistant to all antibiotics in all groups of antibiotics active for a particular genus.

2.5. Statistical Analysis

For epidemiological purposes, rates for different infections acquired in the ICU and Device Utilization Ratio (DUR) were calculated as follows:

1. Overall HAI rate/1000 = number of all types of infections/ number of patient days × 1000
2. DA-HAI rate/1000 = number of DA-HAI (MV, CL, or UC)/ number of device days × 1000
3. Patient infection rate (%) = number of patients with one or more HAI/number of patients × 100
4. DUR = number of device days/number of patient days

The pooled mean and 95% confidence intervals were calculated for the CL, MV, and UC DURs as well as for the CAUTI, CLABSI, and VAP rates. The median and Interquartile Range (IQR) were calculated for the LOS data. All calculations were performed in STATA statistical software ver. 15.1 (Stata Corp., College Station, TX, USA).

Antimicrobial resistance proportions of selected pathogens were calculated as the number of resistant isolates divided by the total number of the same species.

3. RESULTS

During 2018 and 2019, a total of 1408 patients received therapy in the ICU. Each of these patients required treatment for more > 48 h. Of 672 patients admitted to the ICU during 2018, 46 (6.84%) developed HAIs and of 736 patients who received ICU care in 2019, 43 (5.84%) experienced HAIs. Among 89 patients, a total of 104 HAIs was observed during 2018 and 2019 with 48 patients developing one HAI while 25 and two patients presenting with two and three HAIs, respectively. The HAIs included BSI – 42.3%, pneumonia – 28.8%, UTI – 15.3%, Skin and Soft Tissue Infections (SSTI) – 9.6% and *Clostridium difficile* Infection (CDI) – 3.4%. The overall infection rate for 2018 and 2019 was determined to be 13.65 and 12.64 infections per 1000 patient-days, respectively. The number of male patients who developed HAIs during the study period was 71/89 (79.7%). The age of male and female patients who developed HAIs in the ICU ranged from 19 to 78 years and 18 to 73 years, respectively. The median duration of patient's stay in the ICU in 2018 and 2019 was found to be 32 days (IQR, 21–43) and 30 days (IQR, 22–40), respectively. Among 89 patients in the ICU who developed HAIs, the overall mortality rate was determined to be 21.34% (19/89) with 63.1%, 21.0%, 5.3%, 5.3%, and 5.3% attributable to CLABSI, VAP, CAUTI, SSTI, and CDI, respectively (Table 1).

The overall infection rate during the study period was 13.14 per 1000 patient-days, with CLABSI as the most common HAI observed in ICU patients. The rates for DA-HAIs were 6.27 for CLABSI per 1000 CL-days, 4.21 for VAP per 1000 MV-days, and 1.91 CAUTI per 1000 UC-days. Data showed that Device Utilization Ratios (DUR) for CL, MV and UC were 0.81, 0.74, and 0.98, respectively (Table 2).

Of a total of 104 HAIs identified, 100 (96.15%) were microbiologically confirmed. All three cases of pneumonia (non-VAP) that

Table 1 | Demography of HAIs in the ICU

Patient characteristics	HAIs (*n*) during the year	
	2018 (52)	2019 (52)
Age groups (Years)		
≤30	11	15
31–40	10	6
41–50	9	9
51–60	12	7
>60	4	6
Gender		
Male	38	33
Female	8	10
Nationality		
Kuwaiti	10	14
Non-Kuwaiti	36	29
Admitting diagnosis		
Trauma	19	16
CVA	2	5
Respiratory disease	3	2
Renal disease	3	3
Intra-abdominal condition	10	6
SSTI	2	3
Miscellaneous	7	8
Length of stay (days)	32 (IQR, 21–43)	30 (IQR, 22–40)
Mortality	10	9
CLABSI	6	6
VAP	3	1
SSTI	1	–
CAUTI	–	1
CDI	–	1

CVA, cardiovascular accident; SSTI, skin and soft tissue infection.

remained unidentified by culture were diagnosed radiologically and by other laboratory data. The majority of the HAIs were caused by Gram-negative bacilli with *A. baumannii* (30.0%) being the most common organism while others included *K. pneumoniae* (23.0%), *P. aeruginosa* (16.0%), *E. coli* (9.0%), other *Enterobacteriaceae* (11.0%) and *Candida* spp. (13.0%). The microorganisms isolated from different HAIs are presented in Table 3. The highest rates of antimicrobial resistance were seen to occur among *A. baumannii* strains with 65.2% isolates (15/23) showing XDR profile whereas 31.5% of *K. pneumoniae* strains (6/19) tested as ESBL producers (ESBL$^+$) and 10.5% were MDR and XDR strains each. Among *P. aeruginosa* isolates only 23.0% (3/13) were characterized as MDR strains (Table 4).

4. DISCUSSION

Continued epidemiological surveillance of nosocomial infections in the ICU is an essential exercise to recognize types of infections and their causative agents, the emergence of resistant strains of pathogens, and any escalation in the spread of infection. These data guide in modulating the preventive and therapeutic management measures to decrease the HAI rate in the ICU. A study from India documented ICU nosocomial infection rate of 33.3% [18]. Similar rates, such as 33.5%, 28.6% and 27.6% were also reported in earlier studies from India, China, and Europe, respectively [19–21]. An infection rate of 58.9% was documented in a mixed medical/surgical ICU report from India in 2017 [22]. Lower HAI incidence rates, ranging from 9% to 16% have also been reported in the literature [23,24]. In our ICU, the incidence rate of HAIs was found to be 6.34%, which is lower as compared to an earlier study from Kuwait, reporting nosocomial infection rate of 10.6% in a mixed medical/surgical ICU [25]. Similar to this report, 9.6% of infection rate was found in a medical ICU [26] and a rate of 4.6% was observed in a high volume cardiac surgical ICU in India [27]. In a WHO systematic review and meta-analysis, it was shown that HAI density in adult ICUs in developing countries was 47.9 per 1000 patient-days (95% CI 36.7–59.1), which was found to be at least three times higher than densities reported from the USA [28]. This variation in the incidence of ICU-acquired infections is

Table 2 | Benchmarking of device-associated healthcare-acquired infection rates in our ICU (2008 and current reports) against the reports of International Nosocomial Infection Control Consortium (INICC) in a medical/surgical ICU

DUR/DA-HAI rate	INICC[a] (2007–2012)	Leblebicioglu et al.[b] (2003–2012)	Aly et al.[c] (2004–2005)	This report[d] (2018–2019)
CL, DUR/ CLABSI rate	0.54 (0.54–0.54) 4.9 (4.8–5.1)	0.65 (0.65–0.65) 8.5 (8.0–9.1)	0.88 5.5	0.80 (0.8–0.84) 6.70 (4.7–8.8)
MV, DUR/ VAP rate	0.36 (0.36–0.36) 16.5 (16.1–16.8)	0.54 (0.54–0.54) 22.3 (21.3–23.2)	0.78 9.1	0.98 (0.97–0.99) 2.10 (0.94–3.2)
UC, DUR/ CAUTI rate	0.62 (0.62–0.62) 5.3 (5.2–5.8)	0.88 (0.88–0.88) 7.9 (7.5–8.4)	0.95 2.3	0.73 (0.71–0.76) 4.30 (2.8–5.7)

[a]Worldwide report [41]. [b]Report from Turkey as part of the INICC [36]. [c]2008 report from our ICU [25]. [d]Pooled mean and 95% confidence intervals.

Table 3 | Microorganisms isolated from HAIs in the ICU

Clinical isolates	HAIs (*n*)					
	n	BSI (65)	PNEU[a] (30)	UTI (19)	SSI/SSST[b] (10)	GI[c] (4)
Gram-negative bacilli	30	14	9	6	1	
A. baumannii	23	14	7	1	1	
K. pneumoniae	16	8	3	2	3	
P. aeruginosa	9	1	2	4	2	
E. coli	5	1	2		2	
Enterobacter cloacae	1	1	–			
Klebsiella oxytoca	1	1	–			
Serratia marsescens	2	1	1			
Morganella morganii	3	2	1			
Citrobacter koseri						
Gram-positive bacteria						
Staphylococcus epidermidis	2				2	
MRSA	4	4				
MSSA[d]	4	2	1	1		
Enterococcus faecalis	3	0		3		
Enterococcus faecium	2				1	
Fungi						
Candida spp.[e]	13	11		2		
Trichosporon asahii	1	1				

[a]Pneumonia (includes four lower respiratory tract infections with no positive respiratory sample culture (diagnosed clinically/radiologically). [b]Surgical site infection/skin and soft tissue infections including one with ear infection with *E. coli*. [c]Gastrointestinal infections with *C. difficile* (toxin +ve). [d]Methicillin-susceptible *S. aureus*. [e]*C. albicans*-5, *C. auris*-2, *C. famata*-1, *C. parapsilosis*-2, *C. tropicalis*-2, *C. utilis*-1.

Table 4 | Resistance profile of common organisms associated with HAIs in the ICU

Isolate[a] (*n*)	Resistance profile *n* (%)		
	ESBL+[b]	MDR	XDR
A. baumannii (23)	–	–	15 (65.2)
K. pneumoniae (19)	6 (31.5)	2 (10.5)	2 (10.5)
P. aeruginosa (13)	–	3 (23.0)	–

[a]Number of strains per episode of infection. [b]Extended spectrum beta-lactamase producer.

dependent on the type of ICU, patient population, and the definition used to identify these infections [29]. Furthermore, of all patients admitted to the ICU, 5–10% cases acquire one or more infections [28,30,31]. More often, there are three types of infections which account for 60% of all nosocomial infections in the ICU. These are usually device-associated, such as VAP, CLABSI and CAUTI [32]. In a study from Saudi Arabia involving 12 adult ICUs during 2013 through 2016, data showed that VAP was the most common HAI (57.4%) followed by CAUTI (28.4%) and CLABSI (14.2%) [2]. This finding was in contrast to an earlier study from the same region, which revealed that CAUTI was the most common DA-HAI (42.2%) followed by CLABSI (38.5%) and VAP (19.3%) [33]. Similarly, while an earlier study from Kuwait reported mean rates of HAIs as VAP, 9.1/1000 MV-days, CLABSI, 5.5/1000 CL-days, and CAUTI 2.3/1000 UC-days [25], the data from the present study shows rates for CLABSI as 6.27, VAP as 4.21 and CAUTI as 1.91 per 1000 device-days, respectively. A surveillance study conducted by the International Nosocomial Infection Control Consortium (INICC) from 2007 to 2012 showed higher rates of these infections in the ICUs of Latin America, Asia, Africa, and Europe [33–35]. However, in a similar surveillance study done in Kuwait in which adult, pediatric and neonatal patients were followed during 2013–2015, the rates of DA-HAIs were found to be CLABSI (3.5), VAP (4.0), and CAUTI (3.3), which were lower than INICC rates (CLABSI, 4.9; VAP, 16.5; CAUTI, 5.3) but higher than National Healthcare Safety Network (NHSN) rates of CLABSI, 0.9; VAP, 1.1 and CAUTI, 1.2 per 1000 device-days, respectively [36].

The average age of the patients who developed HAIs in our ICU ranged from 18 to 78 with male and female ratio as 3.9. In other studies, the average age of patients treated for infections in the ICU varied from 58 to 61 years with male to female ratio as 1.5 [21,37,38]. Earlier studies have shown that the duration of ICU stay is dependent on whether or not the patient acquires HAI while being treated for the primary medical/surgical condition, co-morbidities, and severity of the underlying disease [18–20, 38–40]. Whereas patients without HAIs remain in the ICU on an average of 10 days, those who acquire HAIs usually have extended stay in the ICU [21]. Mortality rates in ICU patients who develop HAIs have been reported to vary from 10% to 40%, significantly higher than what is observed in patients without HAIs [41]. The mortality rate of 21.34% among our ICU patients with HAIs was similar to the study from Saudi Arabia and India, which reported a mortality rate of 21.3% and 25.14%, respectively [2,18].

During our 2-year study period, BSI (42.3%) was the most common infection among all the HAIs observed in the ICU with an overall infection rate of CLABSI as 6.27/1000 CL-days. Our results are in concordance with a study of ICUs, which was part of the INICC involving seven Indian cities, reporting an overall CLABSI rate of 7.92/1000 CL-days [42]. Also, studies from Poland and Turkey reported density of CLABSI as 8 and 8.5/1000 CL-days, respectively while European Center for Disease Prevention and Control (ECDC) in 2012 reported an average rate of CLABSI as 3/1000 CL-days in European countries, which was similar to 1.8/1000 CL-days, data analyzed by NHSN and reported to CDC in 2012 [21,37,43,44]. In contrast to these findings, a study from eight developing countries involving 55 ICUs, the density of CLABSI ranged from 8 to 19 (average of 13)/1000 CL-days [7]. During 2010 through 2015, another study by INICC involving medical-surgical ICUs from 50 countries reported pooled rate of CLABSI as 4.1/1000 CL-days, which was fivefold higher than the rate reported from CDC-NHSN ICUs although the device used in the two studies was similar [45]. The most common pathogens isolated from patients with BSI in our study were *K. pneumoniae* and *A. baumannii*, each representing 21.5% of all organisms isolated from blood samples. These were followed by *Candida* spp. (16.9%) and *P. aeruginosa* (12.3%). Our findings were not in agreement with a European study where the dominant Gram-positive organisms isolated in BSI were mostly Coagulase-Negative Staphylococci (CNST) (44%) and *S. aureus* (6%) followed by Gram-negative organisms such as *A. baumannii* (17%) [21]. However, it is not evident if CNST isolates in these cases were considered as infective agent or contaminants. Another study from India also reported 25.9% cases of CLABSI due to staphylococci followed by Gram-negative organisms [45]. However, in concordance with our results, a study from India revealed that Gram-positive organisms comprised only a small proportion of all organisms whereas *Klebsiella* spp. (19.6%), *Pseudomonas* spp. (11.9%), *Acinetobacter* spp. (11.9%), *E. coli* (9.8%) and *Candida* spp. (8.7%) were the most frequently isolated organisms from patients with CLABSI [46]. The MDR profile was observed in 88.6% of *Acinetobacter* spp. and 81.4% of *Pseudomonas* spp. The mortality rate among our patients with BSI was 63.15%, which is higher than 45% reported by a study from Poland [21] and 34.6% by another report from India [46].

In our study, pneumonia was the second most frequently diagnosed infection with an incidence rate of 28.8%. VAP constituted 25% of all HAIs, which is higher than 6% reported in 2014 by a study from India [47] but lower than 33% as recorded earlier from our ICU [25]. Using data from 2007, ECDC reported the average incidence of pneumonia as 7% although the range among European countries varied from 3% to 36% [37]. In a report, which included data from 50 counties the VAP incidence ranged between 0.9 and 13.1 per 1000 MV-days [43]. The mean VAP rate was found to be 9.1/1000 MV-days (95% CI, 5–13.2) in an earlier study from Kuwait [25], which was higher than our figure of 4.21/1000 MV-days. The most common organism isolated from respiratory tract samples in our study was *A. baumannii* followed by *K. pneumoniae* and *P. aeruginosa.* Similar to our findings, a study from Poland reported *A. baumannii* (41%) as the leading cause of ICU-acquired pneumonia. However, other causative pathogens included *P. aeruginosa* (12%), *S. aureus* (9%), *E. coli* (9%) and *K. pneumoniae* (8%) [21]. A study from India reported three most common organisms isolated from VAP patients as *Acinetobacter* spp. (32.1%), *Klebsiella* spp. (21.5%), and *Pseudomonas* spp. (17.5%). The antimicrobial susceptibility tests revealed that 63.6% of *Acinetobacter* spp., 50% of *Klebsiella* spp. and 36.4% of *Pseudomonas* spp. presented with MDR profile and were susceptible only to colistin [46].

More often than not CAUTI is ranked as the third most common HAI, after CLABSI and VAP, in the ICUs [21,25,46]. Our data showed that the incidence of CAUTI was 15.53% and the density amounted to 1.96/1000 UC-days. These figures can vary widely as reported by studies from different countries. The incidence of CAUTI in European countries, according to an ECDC report in 2007, was 7% and the density ranged from 1 to 21/1000 UC-days [37] while in another report from INICC (2010–2015) involving 50 countries, CAUTI ranged from 1.7 to 5.1/1000 UC-days [44]. Similar to our data, CAUTI density was found to be 1.7/1000 UC-days as reported by CDC (NHSN program in 2012), which was, however, lower than 2.3/1000 UC-days (95% CI, 1.2–3.4) reported from our ICU in 2008 [25,43]. The microorganisms causing CAUTI reportedly vary in ICUs of different countries. In contrast to the common organisms such as *E. coli* (25%), *C. albicans* (17%), *Enterococcus* spp. (18%), and *P. aeruginosa* (11%) isolated from CAUTI patients in some of the European countries the leading organisms in our study were *A. baumannii* (37.5%), *E. coli* (25%), *E. faecalis* (18.7%) and *P. aeruginosa* (12.5%) [21].

Limitations of the study: since the details of the patients who did not acquire ICU infection were not collected, it was not possible to calculate rates of CLABSI, VAP, and CAUTI in our ICU. Although it has been well established that longer the ICU stay period, higher are the odds for a patient to get colonized and consequently infected with MDR organisms. However, this could not be corroborated in our study as we did not collect LOS (in the hospital) information of patients without infections. Our study being a single-center study does not reflect the epidemiology of ICU-acquired infections in other general or specialized center ICUs.

5. CONCLUSION

Central line-associated bloodstream infection was the most common infection observed in our hospital ICU followed by VAP and CAUTI. Gram-negative bacteria especially *A. baumannii*, *K. pneumoniae* and *P. aeruginosa* were more often isolated from HAIs, followed by *Candida* spp. while Gram-positive bacteria were least common. Antimicrobial resistance was often seen among *A. baumannii*, and *K. pneumoniae* strains, which emphasizes the importance of implementing a robust antibiotic strategy with strict monitoring of infection control measures.

CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

AUTHORS' CONTRIBUTION

WA and RD contributed in study conceptualization and writing (review & editing) the manuscript. WA contributed in data curation, and writing (original draft). RD and WQA project administration and formal analysis. AAR and NMA supervised the project.

ETHICAL APPROVAL

Ethical approval was obtained from MOH committee.

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