Egyptian Journal of Medical Microbiology Volume 29 / No.2 / April 2020 179-186 Online ISSN: 2537-0979

ORIGINAL ARTICLE

Burden of Device-Associated Infections in an Adult Medical and Surgical Intensive Care Units of a Tertiary Care Hospital in Egypt

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Key words:
ICUs, DA-HAIs, CAUTI, CLABSI, VAP

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ABSTRACT

Background*: Device-associated health care-associated infections (DA-HAI) are one of the significant threats to patient safety concerning increased morbidity and mortality, particularly in intensive care units (ICUs).* ***Objectives:*** *We aimed to assess device-associated infection (DAI) rates, microbiological profiles, and attributable mortality in ICUs from a large tertiary care hospital.* ***Methodology:*** *This retrospective surveillance study was done over a one-year period by applying the Centers for Disease Control and Prevention (CDC) and National Healthcare Safety Network (NHSN) case definitions for calculating ventilator-associated pneumonia (VAP), central line-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection.* ***Results:*** *A total of 2022 patients were hospitalized in ICUs and acquired 86 DAIs, with an overall rate of 4.4 DAIs per 1,000 device days. The most frequently recognized infection was VAP (55.8 %), followed by CAUTI (32.6%) then CLABSI (11.6%). The most commonly isolated organisms were Enterobacteriaceae (43%), followed by non-fermentative Gram-negative bacteria (41%) and Gram-positive cocci (12%). Multidrug resistance was identified in 80% of the isolates. The crude excess mortality for CLABSI (66.7%) was higher than VAP (45.4%) and CAUTI (19.5%).* ***Conclusions:*** *The high incidence rates of DA-HAIs together with the prevalence of antimicrobial resistance highlight the requirement to implement a comprehensive care-bundle approach program as well as an antimicrobial stewardship.*

INTRODUCTION

Device-associated health care-associated infections (DA-HAI) are one of the important threats to patient safety regarding increased morbidity and mortality, particularly in intensive care unit (ICU). Ventilator-associated pneumonia (VAP), central line-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI) are the three most common DA-HAIs[1].

Integrated infection prevention programs could reduce the rate of occurrence of DA-HAI and their associated consequences as mortality, prolonged lengths of stay (LOS), excess costs, antibiotic usage and bacterial resistance by more than 30%[2].

It is also essential to consider the burden of antimicrobial-resistant infections in infection control programs through reporting DA-HAI-associated pathogens and their antimicrobial susceptibilities[3].

Centers for Disease Control and Prevention (CDC) has developed benchmarking data on DA-HAIs in ICU patients, which has afforded an essential insight for infection control practitioners[4].

The aim of the current study was to assess device-associated infection (DAI) rates, microbiological profiles, bacterial resistance, and attributable mortality in medical and surgical ICUs at a tertiary care hospital in the Republic of Egypt over a one-year period.

METHODOLOGY

Setting and study design:

A retrospective active DA-HAIs surveillance study covering the period from January 2018 through December 2018. The study was conducted on two medical ICUs and one surgical ICU from a large tertiary care hospital with a total of 730 beds and 132 ICU beds. The study protocol was approved by the institutional review board of Cairo University.

Data collection:

Standardized data collection tools were used by the infection prevention and control (IPC) team to record laboratory, clinical and other indicative information of the patients to fulfill the criteria for an infection based on the CDC and National Healthcare Safety Network (NHSN) case definitions.

Patients were monitored for DA-HAIs until their death or discharge from the ICU. Site and date of DA-HAIs onset, duration of device usage (days), isolated organisms, antibiogram results, length of patient stay (LOS) and patient's outcome on discharge from ICU were recorded.

Case definitions (NHSN[5]; CDC[6]):

Healthcare-associated infection (HAI) is considered if the date of event of the site-specific infection criterion occurs on or after the 3rd calendar day of admission to

an inpatient location where day of admission to an inpatient location is calendar day 1. An infection meeting the HAI definition is considered a device-associated HAI (i.e., associated with the use of a ventilator, central line, or indwelling urinary catheter) if the corresponding device was in place for >2 calendar days on the date of event and was also in place on the date of event or the day before. If the device was in place for >2 calendar days and then removed, the date of event must be the day of discontinuation or the next day to be device associated. For a patient who has a central line in place on hospital admission, day of first inpatient access is considered Device Day 1. For a patient who has a ventilator or urinary catheter in place on the day of admission, Device Day 1 is day of admission.

SAMPLES:

Isolates were obtained by cultivating the following clinical specimens: sputum, bronchoalveolar lavage (BAL), endotracheal tube (ETT) aspirate, urine and blood. The isolation was done using blood agar and MacConkey agar plates incubated aerobically at 37°C for 24–48 hours.

Identification of the isolates:

Further processing was done according to the type of the isolate, as was determined by Gram staining and colony morphology then, necessary biochemical tests were performed. Gram negative organisms were identified using oxidase test, triple sugar iron (TSI), lysine decarboxylation, indole production, citrate utilization and urea hydrolysis. *Staphylococcus* spp. were identified using catalase test, coagulase test and growth on mannitol salt agar. *Enterococcus* spp. were identified by negative catalase test and esculin hydrolysis. Yeasts were identified by Gram-staining and germ tube test (GTT)[7].

Antimicrobial susceptibility testing:

The antimicrobial susceptibility testing was done using the Kirby Bauer disk diffusion method, as per the CLSI guidelines[8]. The antimicrobial disks (Oxoid, UK) which were used were ampicillin (20µg), aztreonam (30µg), gentamicin (10µg), amikacin (30µg), cefaclor (30µg), cefazolin (30µg), cefoxitin (30µg), ceftazidime (30µg), cefotaxime (30µg), cefepime (30µg), amoxicillin-clavulanic acid 30(20+10)µg, piperacillin/tazobactam 110 (100+10)µg, imipenem (10µg), meropenem (10µg), ertapenem (10µg), ciprofloxacin (5µg), levofloxacin (5µg) and trimethoprim-sulfamethoxazole 25 (1.25 + 23.75) µg for the Gram-negative bacilli.

Ampicillin (20µg), amoxicillin-clavulanic acid 30 (20+10) µg, cefoxitin (30µg), imipenem (10µg), clindamycin (2µg), erythromycin (15µg), gentamicin (10µg), amikacin (30µg), ciprofloxacin (5µg), levofloxacin (5µg), trimethoprim- sulfamethoxazole 25 (1.25 + 23.75) µg, fusidic acid (10µg) and Linezolid (30µg), were used to study the susceptibility patterns of the Gram-positive cocci.

MRSA, ESBL and carbapenem resistance were detected as per the CLSI guidelines[8]

MRSA detection: The phenotypic test for the detection of MRSA was done by using a cefoxitin (30µg) disk. A zone of inhibition of ≥ 22 mm was considered as cefoxitin sensitive and the organism was considered methicillin sensitive *Staphylococcus aureus*. While isolates which produced a zone of inhibition of ≤ 21 mm were considered as methicillin resistant *Staphylococcus aureus* (MRSA).

ESBL:

ESBL producing strains were detected by combined disk method using disks of ceftazidime (30µg) and ceftazidime plus clavulanic acid (30 µg + 10 µg). An increase in the zone diameter ≥ 5 mm of ceftazidime plus clavulanic acid as compared to ceftazidime disk alone was considered positive for ESBL.

Carbapenem resistance screening by Disk Diffusion:

Isolates were screened for carbapenem resistance by Kirby Bauer disk diffusion method; using carbapenems as ertapenem, imipenem and meropenem.

According to the European Centre for Disease Control (ECDC) and CDC, the multidrug-resistant (MDR) bacteria was defined as resistance to at least one agent in three or more antimicrobial classes[9].

Statistical analysis:

Outcomes measured during the surveillance period included the incidence of overall DAIs, VAPs, CAUTIs, and CLABSIs. The overall DAI rate per 1,000 device-days was calculated by dividing the total number of DAIs by the total number of device days and multiplying the result by 1,000. Rates of VAP, CLABSI, and CAUTI per 1,000 device-days were calculated by dividing the total number of specific DAIs by the total number of specific device-days and multiplying the result by 1,000[10,11].

Device days are the total number of days of exposure to each device (endotracheal tube, central venous catheter, or urinary catheter) for all the patients during the selected period of time.

Excess mortality is defined as the difference between the overall case-fatality of patients with a DAI and those without a DAI who were hospitalized in an ICU during the surveillance period[2].

Relative risk (RR) ratios, 95% confidence intervals (CIs), and *P* values were determined to test significance. A *P* value <0.05 was considered statistically significant.

RESULTS

During the study period from January through December 2018, 2022 patients were hospitalized in the participating ICUs comprising 866 (43%) patients in the SICU and 1156 (57%) patients in the medical ICUs. Out of 2022 patients, HAIs was detected in 121 (5.9%)

patients during their ICU stays among which; 47 (38.8%) were from SICU and 74 (61.2%) from medical ICUs.

Distribution of DAIs by site and unit:

Out of the 121 HAIs, 86 (71.1%) were identified as DAIs, with an overall rate of 4.4 DAIs per 1,000 device days (95% CI, 3.56–5.43). Among them, 35 (40.7%) were from SICU and 51 (59.3%) from medical ICUs. Ventilator-associated pneumonia was the most frequently recognized infection and accounted for 55.8% of all DAIs, followed by CAUTI (32.6%) and finally CLABSI (11.6%). The overall VAP rate was 12.7 per 1000 ventilator-days (95% CI, 9.49-16.64), the CLABSI rate was 1.3 per 1000 catheter-days (95% CI, 0.68-2.34) and the CAUTI rate was 3.5 per 1,000 catheter-days (95% CI, 2.36-4.94). Incidence of DAIs by site in surgical and medical ICUs is shown in table 1.

Table 1: Incidence of DAIs in ICUs

Parameter		SICU	Medical ICUs	Overall
Overall DAI	**No. (%) of infections**	35 (40.7)	51 (59.3)	86 (71.1)
	Total device days	7,866	11,571	19,437
	Rate/1000 device days *	4.4	4.4	4.4
VAP	**No. (%) of infections**	20 (57.1)	28 (54.9)	48 (55.8)
	MV days	1,416	2,366	3,782
	Rate/1000 device days*	14.1	11.8	12.7
CLABSI	**No. (%) of infections**	5 (14.3)	5 (9.8)	10 (11.6)
	CL days	3,159	4,425	7,584
	Rate/1000 device days *	1.6	1.1	1.3
CAUTI	**No. (%) of infections**	10 (28.6)	18 (35.3)	28 (32.5)
	UC days	3,291	4,780	8,071
	Rate/1000 device days *	3	3.8	3.5

VAP, Ventilator-Associated Pneumonia; CLABSI Central Line-Associated Bloodstream Infection; CAUTI, Catheter-Associated Urinary Tract Infection; MV, Mechanical Ventilator; CL, Central Line; UC, Urinary Catheter.
*Device-associated infection rate= Number of DAIs for an infection site divided by the number of device days x 1000

Type and distribution of the organisms isolated from DAIs:

A total of 144 organisms was isolated through the year; 56 isolates from the SICU (38.9%) and 88 isolates from the medical ICUs (61.1%). Out of which, 116 (80.55%) organisms were isolated from DAIs and distributed as 49 (42.2%) isolates from the SICU and 67 (57.8%) isolates from medical ICUs.

Among the 116 DAIs' isolates, *Enterobacteriaceae* was the most common isolated pathogens constituting 50/116 (43%) of the total isolates, followed by non-fermentative Gram-negative bacteria constituting 48/116 (41%) of the total isolates. Whereas, Gram-positive cocci constituted 14/116 (12%) of the isolates. *Klebsiella* spp. and *Acinetobacter* spp. were the most frequently isolated pathogens, both accounting for 27.6% of all isolates, followed by *E. coli* (13.8%) and *Pseudomonas* spp. (12.9%). The percentage of isolated organisms from the different DAIs is shown in table 2.

Table 2: Number and percentage of isolated organisms from different DAIs

Isolates	Total no.	Percentage
Klebsiella spp.	32	27.6%
E. coli	16	13.8%
Enterobacter spp.	2	1.7 %
Acinetobacter spp.	32	27.6 %
Pseudomonas spp.	15	12.9%
Stenotrophomonas maltophilia	1	0.9 %
Methicillin-resistant *S. aureus* (MRSA)	9	7.8 %
Coagulase-negative staphylococci (CoNS)	1	0.9 %
Enterococcus spp.	4	3.4%
Candida spp.	4	3.4%
Total	116	100%

Out of the 116 isolates from the DAIs, 93 (80%) isolates were MDR divided as follows: 21 (23%) isolates were ESBL, 7 (7.5%) isolates were AmpC producers, 56 (60%) isolates were carbapenem resistant and 9 (9.5%) isolates were MRSA.

Out of the 116 isolates from the DAIs; 65 (56%) isolates were derived from VAP, 16 (14%) isolates from CLABSI and 35 (30%) isolates from CAUTI. Among the 65 isolates recovered from VAP, 58 (89.2%) isolates were MDR, while for CLABSI 11/16 (68.7%) and CAUTI 24/35 (68.5%) isolates recovered were MDR (Figure 1).

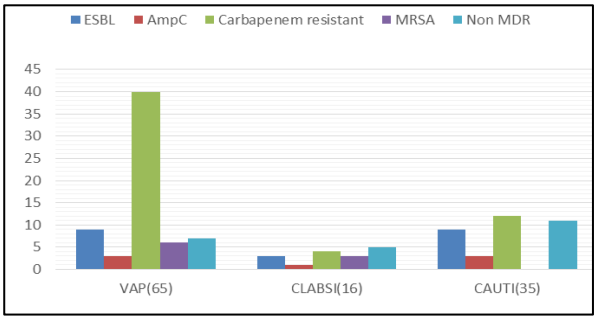

Fig. 1: Number and pattern of MDR organisms among different DAIs

Percentage of ESBL, AmpC and carbapenem resistance among the different Gram-negative isolates is shown in table 3.

Table 3: Number and percentage of ESBL, AmpC and Carbapenem resistance among the different Gram-negative isolates

	Total	Non- MDR	ESBL	AmpC	Carbapenem resistant
Klebsiella spp.	32	8 (25%)	10 (31.25%)	2 (6.25%)	12 (37.5%)
E. coli	16	2 (12.5%)	10 (62.5%)	1 (6.25%)	3 (18.75%)
Enterobacter spp.	2	1 (50%)	1 (50%)	0	0
Acinetobacter spp.	32	2 (6.25%)	0	4 (12.5%)	26 (81.25%)
Pseudomonas spp.	15	1 (6.7%)	0	0	14 (93.3%)
Stenotrophomonas maltophilia	1	0	0	0	1 (100%)
Total	98	14	21	7	56

Pooled crude mortality and pooled crude excess mortality:

The total number of admitted patients to both medical and surgical ICUs was 2022, out of which 86 acquired DA-HAI, so total number of patients admitted and didn't acquire DA-HAI was 1936 patients. The total mortality (total number of deaths from HAI and any other cause) in both medical and surgical ICUs was 507 patients, out of which 54 was related to DA-HAI. Pooled crude mortality and pooled crude excess mortality in those patients with VAP, CLABSI and CAUTI in both surgical and medical ICUs are demonstrated in table 4.

Table 4: Crude mortality and excess mortality in ICUs

Patients		Patients' no.	Pooled Crude mortality		Pooled crude excess mortality, %	RR ratio	*p*-value	95% CI
			Deaths, no.	%				
Without DA-HAI		1936	453	23.3	---	---	---	---
With DA-HAI	**Total**	86	54	62.7	39.4	2.684	<0.001	2.238-3.218
	With VAP	48	33	68.7	45.4	2.938	<0.001	2.389-3.614
	With CLABSI	10	9	90	66.7	3.846	<0.001	3.081-4.801
	With CAUTI	28	12	42.8	19.5	1.832	0.016	1.185-2.830

Patients' length of stay (LOS):

Among the 86 patients with DAIs; 7 (8%) had a LOS ranging from 2-7 days, 62 (72%) had a LOS ranging from one week up to one month while 17 (20%) had a LOS of longer than one month.

DISCUSSION

The current retrospective study was carried out in the medical-surgical ICUs from a large tertiary care hospital of Cairo University, Egypt. This surveillance study uses the definitions standardized by the U.S. CDC for the NHSN program to estimate the rates of DAI and the related antimicrobial resistance in Cairo University Hospitals. Our study revealed that HAIs constitute 5.9% of admitted patients. This was found to be lower than a surveillance study conducted on medical-surgical ICUs of 4 University-affiliated hospitals and 4 community hospitals in Greece (18.4%)[12].

Our surveillance paid attention to determine the incidence rate of DAIs in our ICUs, since a significant proportion of these HAIs are considered preventable[12]. In our study, we found that DAIs accounted for 71.1% of all HAIs, with an overall rate of 4.4 DAIs per 1,000 device days (95% CI, 3.56–5.43). This rate is found to be markedly lower than a surveillance study carried out in medical-surgical ICUs at Emergency Hospital of Tanta University (24.17/1,000 device-days)[13]. Meanwhile, in this study, it has been shown that DAI rate among the medical ICUs was found to be 4.4 DAIs per 1,000 device days. A higher rate (7.1 per 1,000 device days) was reported by a study conducted at medical ICUs of 3 hospitals at Cairo University[14].

The relative high incidence of DA-HAIs observed in the current study can be explained by the fact that guidelines on specific infection control measures are not adequately implemented and the national infection control surveillance is not effectively applied. There is especially high risk in cases of hospital overcrowding, low nurse-to-patient staffing, lack of medical supplies, and an insufficient number of trained health care workers[15].

In our study, VAP was the most common DAI and accounted for 55.8% of all DAIs followed by CAUTI (32.5%) and finally CLABSI (11.6%). This order is in agreement with a study carried out in Tanta University[13], but with different percentages (73.17%, 19.51% and 7.32%, respectively). Similarly, VAP was the most frequent infection (66.7%), followed by CAUTI (22.2%) and CLABSI (11.1%) in one more Egyptian study conducted in adult medical ICUs of Cairo University hospitals[14]. On the other hand, a study done in Cyprus revealed that CLABSI was the most commonly encountered infection accounting for 48.8% of all the DA-HAIs, followed by VAP (37.2%) and CAUTI (14%)[1].

The VAP rate in our ICUs was 12.7 (95% CI, 9.49-16.64) infections per 1,000 ventilator-days, which is closely similar to the international nosocomial infection control consortium (INICC) report's rate (13.1 per 1,000 ventilator-days [95% CI, 12.9–13.4])[16] and higher than the CDC-NHSN rate (0.9 per 1,000 ventilator-days [95% CI, 0.8–1.0])[17]. This rate is similar to a study reported in Greece with 12.5 (95% CI, 10.7-14.4) infections per 1,000 patient-days[12], and closely similar to the Cyprus study (10.1/1000 device days)[1]. Higher rates were reported by the Egyptian study (52.17/1,000 ventilator-days)[13] and the Greek study (20/1,000 ventilator-days)[18] One more Egyptian study reported that late onset VAP represented 41.2 per 1000 ventilator days which is higher than our study[19] Several causal factors can contribute to the high VAP rates in our study including inadequate supplies and inappropriate recycling of respiratory care tubing as well as the close proximity of patient beds.

In our study, the CAUTI rate was 3.5 (95% CI, 2.36–4.94) infections per 1,000 urinary catheter-days, which is lower than the INICC report's rate (5.07 per 1,000 urinary catheter-days [95% CI, 4.9–5.2)])[16] and higher than the CDC-NHSN rate (1.7 per 1,000 urinary catheter-days [95% CI, 1.6–1.8])[20]. Interestingly, a similar CAUTI rate of 3.5 infections per 1,000 urinary catheter-days (95% CI 2.7-4.5) was reported in Greece[12]. In another study done in Egypt[13], the CAUTI rate was 11.63 per 1,000 catheter days, which is higher than the results found in the present study. Whereas, a lower rate was detected in the Cyprus study (2.7/1000 device days)[1]. The reasons for lower CAUTI rates detected in the current study compared with other studies may be related to the effectiveness of the interventions implemented in our hospital settings. They included educational strategies, avoidance of urinary catheterization unless indicated, well-established policies for urinary catheter insertion, daily necessity evaluation and limiting catheter days that have been proven to decrease CAUTI events

The CLABSI rate of our study was 1.3 per 1000 catheter-days (95% CI, 0.68–2.34), which is lower than the INICC report's rate (4.11 per 1,000 catheter-days [95% CI, 4.0-4.2])[16] and higher than the CDC-NHSN report (0.8 per 1,000 catheter-days [95% CI, 0.8-0.9])[20]. In addition, our CLABSI rate was lower than a study done in Egypt (6.93 per 1,000 central line-days)[13], in Cyprus (15.9/1000 device days)[1] and the Greek study (12.1 infections per 1,000 central line-days)[12]. The low CLABSI rate reported in our study may be explained by the adherence to adequate aseptic techniques during central line insertion and maintenance.

In the current study, out of the 144 organisms isolated from HAIs; 116 (80.55%) organisms were DAIs (42.2% and 57.8% isolates belonged to the SICU and medical ICUs, respectively) Amongst the 116

DAIs' isolates; 65 (56%) isolates were derived from VAP, 16 (14%) isolates from CLABSI and 35 (30%) isolates from CAUTI. A former study in Egypt demonstrated that out of 72 bacterial isolates causing all DAIs; 60 (83.3%), 9 (12.5%) and 3 (4.2%) were isolated from patients with VAP, CLABSI and CAUTI, respectively[14].

Our study revealed that *Enterobacteriaceae* were the most common isolated spp. constituting 50/116 (43%) of the total DAIs isolates, followed by non-fermentative Gram-negative bacteria constituting 48/116 (41%) of the total isolates. Whereas, Gram-positive cocci constituted 14/116 (12%) of the isolates. This could be corresponding to other studies signifying that most of the infections occurring in the ICU are noted to be caused by Gram-negative bacteria[21,22].

Both *Acinetobacter* spp. and *Klebsiella* spp. were the most frequently isolated pathogens, accounting each for 27.6% of all isolates, followed by *E. coli* (13.8%) then *Pseudomonas* spp. (12.9%). The findings observed in this study mirror those of the previous study in Egypt in which *A. baumannii* was the most commonly isolated pathogen (36.1%) of all isolates, followed by *K. pneumoniae* (9.2%) then *P. aeruginosa* (22.2%)[14].

Staphylococcus aureus is the predominant Gram-positive pathogen in our study which is analogous to findings from most studies on nosocomial infections where *S. aureus* is usually the prime Gram-positive pathogen recovered in HAIs[23,24].

International health organizations, including the ECDC and the CDC, have employed terms such as "crisis," "catastrophic consequences" and "nightmare scenario" to highlight the rapid emergence and spread of antibiotic resistance[25].

In our study, 93 (80%) of DAIs isolates were MDR; 21 (23%) isolates were ESBL, 7 (7.5%) isolates were AmpC producers, 56 (60%) isolates were carbapenem resistant and 9 (9.5%) isolates were MRSA. Notably, ESBL production was detected in 62.5% of *E. coli* isolates, 31.23% of *Klebsiella* spp., and in one of the two isolated *Enterobacter* spp. Whereas, AmpC production was detected in 12.5% of *Acinetobacter* spp. and in 6.25% of both *Klebsiella* spp. and *E. coli* isolates. Carbapenem resistance was seen in 93% of *Pseudomonas* spp., 81% of *Acinetobacter* spp., 37.5% of *Klebsiella* spp., 18.75% of *E. coli* isolates and in the single isolated *Stenotrophomonas maltophilia*.

An earlier study in Egypt documented 76.9% of *A. baumannii* isolates and 56.3% of *Pseudomonas aeruginosa* isolates were resistant to imipenem, whereas 76.2% of *Klebsiella pneumoniae* isolates were ESBL producers[14]. Antibiotic selection of ESBL-producing Gram-negative pathogens may be linked to the frequent use of the fluoroquinolones as well as second and third generation cephalosporins[26]. Carbapenems are another chief last-line group of antibiotics for infections encompassing multidrug-resistant Gram-negative *Enterobacteriaceae* spp. The most important mechanism of carbapenem resistance in this group is the production of carbapenemase, however, resistance can also occur due to the synergistic activity between AmpC-type or ESBLs combined with decreased outer membrane permeability[27]. Moreover, there is a crucial need for development of new agents with activity against MDR organisms. The Infectious Diseases Society of America (IDSA) supported a program against MDR organisms, with the goal of developing ten new systemic antibacterial drugs by 2020[28].

In our study, a crude ICU mortality rate of 62.7% for the patients who acquired DA-HAI and 23.3% for patients who did not, was observed. This finding is almost similar to a study done in Cyprus[1] who found that crude ICU mortality rate for the patients who acquired DA-HAI (40%) was two times higher than that of patients who didn't (17.9%). This is also in agreement with a Greek study which showed that the crude ICU mortality rate for the patients who acquired DA-HAI (46.7%) was one and half times more than that of patients who didn't (31.2%)[18]. This could be explained by the fact that ICUs are healthcare settings with the highest HAI rates, in which patients' safety is most seriously threatened, due to their critical condition and increase use of invasive interventions.

In our study, the crude excess mortality for CLABSI (66.7%) was higher than VAP (45.4%) and CAUTI (19.5%). This is in agreement with a study done in Greece[18] which showed that crude excess mortality in ICUs for CLABSI (20.6%) was higher than CAUTI (18.7%) and VAP (13%,), respectively. However, another Egyptian study showed that the crude excess mortality for CAUTI (48%) was the highest followed by CLABSI (45.7%) and then VAP (12.9%)[14]. Nevertheless, a study in Cyprus showed that crude excess mortality for VAP (21.9%) was higher than CLABSI (16.7%) and CAUTI (16.7%)[1].

In our study, CLABSI crude excess mortality (66.7%) was found to be four times higher than the Cyprus study report (16.7%)[1], three times higher than the Greece study (20.6%)[18] and one and half times higher than the Egyptian study (45.7%)[14].

In our study, VAP crude excess mortality (45.4%) was found to be three to three and half times higher than the studies done in Egypt[14] and Greece[18] (12.9% and 13%, respectively). While it was two times more than the Cyprus[1] (21.9%) study report.

In our study CAUTI crude excess mortality (19.5%) was found to be almost similar to the Cyprus[1] (16.7%) and Greek[18] (18%) study reports. Whereas, it was almost two times lower than the Egyptian[14] (48%) study.

Among the 86 patients with DAIs; 7 (8%) had a LOS ranging from 2-7 days, 62 (72%) had a LOS ranging from one week up to one month, while 17 (20%) had a LOS of longer than one month. Inpatient

stays in hospitals could also affect the incidence of HAI due to cross contamination, patients' vulnerability to infection, as well as other clinical and non-clinical reasons. It was found that extending the LOS by one day rises the likelihood of catching an infection by 1.37 percent[29].

The current study has certain limitations being conducted on only three ICUs from a large tertiary care hospital. These results cannot be generalized to other public or private hospital settings. Additionally, the cost estimation for DA-HAIs was not estimated due to the shortage of financial reports.

CONCLUSIONS

In the current study, the high incidence rates of DA-HAIs together with the high levels of antimicrobial resistance pattern, were found to highlight the necessity to implement an inclusive care-bundle approach program and to establish an antimicrobial stewardship. Moreover, a nationwide dynamic infection surveillance system can be arranged to improve existing infection control measures, data collection systems as well as minimizing device usage *via* application of preventive bundles measures.

Conflicts of interest: The authors declare that they have no financial or non-financial conflicts of interest related to the work done in the manuscript.

- Each author listed in the manuscript had seen and approved the submission of this version of the manuscript and takes full responsibility for it.
- This article had not been published anywhere and is not currently under consideration by another journal or a publisher.

Funding: None

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