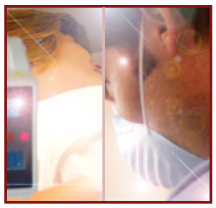

Surveillance of Device-Associated Infection Rates and Mortality in 3 Greek Intensive Care Units

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Background Several studies suggest that device-associated, health care–associated infections (DA-HAIs) affect the quality of care in intensive care units, increasing patients' morbidity and mortality and the costs of patient care.

Objectives To assess the DA-HAIs rates, microbiological profile, antimicrobial resistance, and crude excess mortality in 3 intensive care units in Athens, Greece.

Methods A prospective cohort, active DA-HAI surveillance study was conducted in 3 Greek intensive care units from July 2009 to June 2010. The rates of mechanical ventilator–associated pneumonia (VAP), central catheter-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI) were calculated along with microbiological profile, antimicrobial resistance, and crude excess mortality.

Results During 6004 days in intensive care, 152 of 294 patients acquired 205 DA-HAIs, an overall rate of 51.7% of patients or 34.1 DA-HAIs per 1000 days (95% CI, 29.3-38.6). The VAP rate was 20 (95% CI, 16.3-23.7) per 1000 ventilator-days, the CLABSI rate was 11.8 (95% CI: 9.2-14.8) per 1000 catheter-days, and the CAUTI rate was 4.2 (95% CI, 2.5-5.9) per 1000 catheter-days. The most frequently isolated pathogen was *Acinetobacter baumannii* among patients with CLABSI (37.8%) and *Candida* species among patients with CAUTI (66.7%). Excess mortality was 20.3% for VAP and CLABSI and 32.2% for carbapenem-resistant *A baumannii* CLABSI.

Conclusion High rates of DA-HAIs, device utilization, and antimicrobial resistance emphasize the need for antimicrobial stewardship, the establishment of an active surveillance program of DA-HAIs, and the implementation of evidence-based preventive strategies. (*American Journal of Critical Care.* 2013;22:e12-e20)

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Health care–associated infection (HAI) is one of the most common adverse events affecting patients in intensive care units (ICUs). Rates of HAIs in the ICU are 3 to 5 times higher than rates in other care areas in the hospital.[1,2] Although patients in the ICU represent only 10% of all hospital admissions, they account for nearly 50% of all HAIs in US hospitals.[3-5] In Europe, 3% of patients staying more than 2 days in an ICU acquire bloodstream infections, and 6.2% acquire pneumonia.[6]

The results of the European Prevalence of Infection in Intensive Care study highlighted the relative importance of medical devices as risk factors for HAIs.[1] In the United States and several other high-income countries, surveillance of device-associated, health care–associated infections (DA-HAIs) in the ICU plays an important role in hospitals' infection control and quality assurance programs.[7] Likewise, surveillance was reported by the Centers for Disease Control and Prevention's (CDC's) study of the effectiveness of nosocomial infection control,[8] and validated by the nationwide nosocomial infection surveillance system in Germany as an effective tool for reducing the occurrence of DA-HAIs.[9]

Several studies suggest that DA-HAIs are among the factors that affect the quality of care in the ICU, increasing both patients' morbidity and mortality and the costs of patient care.[10-12] The CDC[13] and the National Healthcare Safety Network[14] (NHSN) have published standardized criteria for surveillance of DA-HAIs: those definitions and methods for the detection of DA-HAI rates per 1000 device-days and device utilization ratios can be used as benchmarks for interhospital and intrahospital comparisons. The comparison of infection rates has proven to be a key component in reducing infection risk.[15] The device utilization ratio constitutes an extrinsic risk factor for DA-HAI and can serve as a marker for severity of illness or the patient's intrinsic susceptibility to infection. If the device utilization ratio is greater than the 90th percentile, a specific hospital is considered a high outlier and further investigation of that specific practice could be warranted.[16] Similar standards have been implemented in Europe, and national ICU surveillance networks have been developed.[17]

In contrast, data on DA-HAIs rates obtained by using standardized definitions and methods are limited in Greece.[18] The aim of this study was to perform an active targeted prospective surveillance to assess DA-HAIs rates, microbiological profile, antimicrobial resistance, and crude excess mortality due to DA-HAIs in 3 large ICUs in Athens, Greece.

> Device-associated, health care–associated infections are an important aspect of hospital's infection-control efforts.

Patients and Methods

This prospective observational study was carried out in 3 university-affiliated hospitals in Athens, Greece, from July 2009 to June 2010. All the ICUs were case mixed, providing care for adult medical and surgical patients with a total number of 24 beds. In each of the 3 ICUs, the nurse to patient ratio was 1 to 3. The units are part of the referral center that serves mainly the region of Athens. The study protocol was approved by the institutional review board at each hospital, and patients' confidentiality was guaranteed.

Surveillance

During the surveillance period, all patients admitted to the ICUs who received mechanical ventilation for at least 48 hours were actively monitored for DA-HAIs until their discharge or death. A standardized survey record form has been used, according to the DA-HAI definitions provided by the CDC's NHSN.[14] Patients' data included demographic characteristics, disease severity as reflected in the Acute Physiology and Chronic Health Evaluation (APACHE) II score on

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admission, comorbidity shown by the weighted Charlson Comorbidity Index on admission, date of onset and site of infections (central catheter–associated bloodstream infection [CLABSI], catheter-associated urinary tract infection [CAUTI], and ventilator-associated pneumonia [VAP]), time and duration of exposure to invasive devices, isolated pathogens, antibiogram results, administered antibiotics, and outcome on discharge from the ICU.

DA-HAI Rate Calculations

Outcomes measured during the surveillance period included the incidence density rates of VAP (number of VAP cases divided by 1000 ventilator-days and multiplied by 1000), of CLABSI (number of CLABSI cases divided by 1000 catheter-days and multiplied by 1000), and of CAUTI (number of CAUTI cases divided by 1000 catheter-days and multiplied by 1000).

Greece has a low budget for conducting blood cultures.

Device utilization ratios have been calculated by dividing the total number of device-days by the total number of patient-days. Device-days are the total number of days of exposure to each device (ventilator, central catheter, or urinary catheter) for all of the patients during the selected time period. Patient-days are the total number of days that patients are in the ICU during the selected time period.[19]

Crude Excess Mortality

Comparisons were made between patients with a DA-HAI and patients admitted without an HAI who did not acquire a DA-HAI during the ICU stay. Crude excess mortality in the ICU was defined as the difference between the crude overall case fatality rate of patients with a DA-HAI and that of patients admitted without an HAI who did not acquire a DA-HAI in the ICU during the same period.

Laboratory Testing

In all the cases, standard laboratory methods were used to identify microorganisms. Antimicrobial susceptibilities were determined by disk diffusion method and an automated method (bioMerieux, Vitek II). Isolates resistant to imipenem and meropenem (minimum inhibitory concentration > 8 mg/L) were considered carbapenem-resistant regardless of their susceptibility to other antibiotics. Intermediately susceptible strains were accepted as resistant.

Antibiotic therapy was considered appropriate if the drugs used at therapeutic doses had in vitro activity against the strain isolated. Antibiotic therapy was considered inappropriate if the drug used did not have in vitro activity against the strain isolated, or if the patient did not receive antibiotic treatment. The 3 ICUs did not have an established protocol for blood cultures. Blood samples for culture are usually collected whenever it is suspected that a patient has septicemia. Greece is one of the countries that has a low budget for conducting blood cultures.

For CLABSIs, central catheters were removed aseptically and the distal 5-cm portion of the catheter was amputated and cultured by using a standardized semiquantitative method. Concomitant blood samples for culture were obtained percutaneously in nearly all cases.[20] For CAUTIs, a urine sample was aseptically aspirated from the sampling port of the urinary catheter and cultured quantitatively. For VAP, a quantitative culture for aerobic bacteria was done for samples of lower respiratory tract secretions (endotracheal secretions $>10^6$ colony-forming units [CFU]/mL, protected brush catheter $>10^3$ CFU/mL, and bronchoalveolar lavages $>10^4$ CFU/mL) or isolation of an etiologic agent on culture of blood or pleural fluid. Patients could not be entered into the study more than once.

Statistical Analysis

Medians and interquartile ranges were used for continuous variables, which were compared by using the Mann-Whitney U test. Categorical variables were compared by using the Fisher exact test. Ninety-five percent confidence intervals (95% CIs) for incidence rates were calculated on the basis of the Poisson distribution for rare events. All *P* values less than .05 were considered statistically significant. Relative risk has been calculated for the 2 groups of patients (mortality rate for patients due to an infection in the ICU versus mortality rate for patients admitted without an HAI who did not acquire a DA-HAI). Analysis was performed by using IBM-SPSS software, version 20.

Results

During the study period, surveillance data were prospectively collected for 294 patients hospitalized in 3 medical-surgical ICUs for 6004 ICU days. The group included 164 male (55.8%) and 130 female patients. Median age was 71 years (interquartile range [IQR], 60-78). The median APACHE II score on admission was 16 (IQR, 12-20), and the median Charlson Comorbidity Index was 2 (IQR, 1-3). Median ICU length of stay was 14 days (IQR, 8-27). The median time interval between admission and identification of the first DA-HAI was 9 days (IQR, 6-12). Eighty of the 294 patients (27.2%) were admitted without an HAI and did not acquire a DA-HAI in the ICU. Patients' baseline characteristics are summarized in Table 1.

Table 1
Characteristics of patients with and without device-associated, health care–associated infections (DA-HAIs)

Characteristic	Patients with infection[a] (n = 152)	Patients without infection[a] (n = 142)	*P*
Sex			.29
Male	80 (52.6)	84 (59.2)	
Female	72 (47.4)	58 (40.8)	
Age, median (IQR), y	68 (48-76)	64 (48-78)	.61
Days in ICU, median (IQR)	26 (7-13)	9 (7-13)	<.001
Previous hospitalization >5 days	47 (30.9)	24 (16.9)	.006
APACHE II score on admission, median (IQR)	16 (13-21)	15 (12-19)	.06
Charlson Comorbidity Index, median (IQR)	2 (1-3)	2 (1.5-3.5)	.33
Type of patient			.54
Medical	102 (67.1)	90 (63.4)	
Surgical	50 (32.9)	52 (36.6)	
Location before ICU admission			
Community	26 (17.1)	29 (20.4)	.55
Operating room	11 (7.2)	21 (14.8)	.04
Other ICU	19 (12.5)	19 (13.4)	.86
Medical care area	73 (48.0)	57 (40.1)	.20
Other hospital	23 (15.1)	16 (11.3)	.39
Cause of ICU admission			
Pulmonary disease	81 (53.3)	81 (57.0)	.56
Neurological disease	16 (10.5)	13 (9.2)	.42
Intra-abdominal surgery	17 (11.2)	18 (12.7)	.42
Cardiovascular disease	17 (11.2)	13 (9.2)	.70
Multiple injuries	21 (13.8)	17 (12.0)	.73
Status on admission to ICU			
Health care–associated infection	47 (30.9)	62 (43.7)	.03
Coma	40 (26.3)	18 (12.7)	.003
Shock	37 (24.3)	29 (20.4)	.48
Procedures during ICU stay			
Tracheostomy	77 (50.7)	23 (16.2)	<.001
Tube thoracostomy	28 (18.4)	15 (10.6)	.07
Hemodialysis	41 (27.0)	31 (21.8)	.34
Days of mechanical ventilation, median (IQR)	24.5 (15-39)	8 (6-12)	<.001
Days with central venous catheter, median (IQR)	26 (15-40)	8 (6-12)	<.001
Days with indwelling urinary catheter, median (IQR)	26 (15-40)	8 (6-12)	<.001

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; ICU, intensive care unit; IQR, interquartile range.

[a] Values are number (percentage) of patients unless otherwise specified in first column.

DA-HAI Rates and Mortality

A total of 205 DA-HAIs were detected in 152 of the 294 patients, resulting in an overall rate of 51.7% of patients or 34.1 DA-HAIs per 1000 ICU days (95% CI, 29.3-38.6). VAP was the most commonly encountered type of infection, accounting for 56.1% of all DA-HAIs, followed by CLABSI (32.2%) and CAUTI (11.7%). The device utilization ratio was 0.95 for mechanical ventilation, 0.94 for central catheters, and 0.95 for urinary catheters. The VAP rate was 20.0 per 1000 ventilator-days (95% CI, 16.3-23.7), the CLABSI rate was 11.8 per 1000 catheter-days (95% CI, 9.2-14.8), and the CAUTI rate was 4.2 per 1000 catheter-days (95% CI, 2.5-5.9; Table 2).

The crude ICU mortality rate was 46.7% (71/152) for patients who acquired a DA-HAI and 45.1% (64/142) for those without a DA-HAI, yielding an overall crude excess mortality rate of 1.6% (95% CI, -9.6 to 12.8). The crude ICU mortality rate was 31.2% for the patients admitted without an HAI who did not acquire a DA-HAI in the ICU. Mortality data associated with DA-HAIs are shown in Table 3. The crude ICU mortality rates for patients with CLABSI

Table 2
Type of device-associated, health care–associated infections per 1000 device-days

Type of infection	Device-days	Device use	No. of infections	% of infections	Rate per 100 patients, %	Rate per 1000 device-days
VAP	5735	0.95	115	56.1	39.1	20.0
CLABSI	5615	0.94	66	32.2	22.4	11.8
CAUTI	5702	0.95	24	11.7	8.2	4.2

Abbreviations: CAUTI, catheter-associated urinary tract infection; CLABSI, central catheter-associated bloodstream infection; VAP, ventilator-associated pneumonia.

Table 3
Mortality rates for device-associated health care–associated infections

	Mortality, %		Relative risk		
Type of infection	Crude	Crude excess	Mean	95% CI	*P*
None	31.2	—	—	—	—
VAP	44.3	13.0	1.47	0.96-2.25	.07
CLABSI	51.9	20.6	1.72	1.05-2.83	.03
CAUTI	50.0	18.7	1.66	0.70-3.96	.25
VAP and CLABSI	51.6	20.3	1.72	1.06-2.77	.03
VAP and CAUTI	40.0	8.7	1.33	0.58-3.05	.50
CLABSI and CAUTI	25.0	-6.2	0.83	0.14-4.70	.84
VAP, CAUTI, and CLABSI	50.0	18.7	1.66	0.59-4.69	.33

Abbreviations: CAUTI, catheter-associated urinary tract infection; CLABSI, central catheter–associated bloodstream infection; VAP, ventilator-associated pneumonia.

(51.9%) and patients with both VAP and CLABSI (51.6%) were significantly higher than the crude ICU mortality rate for patients admitted without HAI who did not acquire a DA-HAI in the ICU (31.2%), yielding overall crude excess mortality rates of 20.6% (relative risk, 1.72; 95% CI, 1.05-2.83; $P = .03$) and 20.3% (relative risk, 1.72; 95% CI, 1.06-2.77, $P = .03$), respectively. We calculated the crude mortality and the crude excess mortality rate for the coinfections (Table 3) despite the small numbers because of the high prevalence of antimicrobial resistance in Greece.

Microorganisms' Profile and Antimicrobial Resistance

The distribution of pathogens by site of infection varies. Forty-three (21%) of the DA-HAIs were polymicrobial. The 4 most frequently isolated pathogens were *Acinetobacter baumannii* (47%), *Klebsiella pneumoniae* (19.8%), *Pseudomonas aeruginosa* (12.6%), and *Candida* spp (7.5%). Overall, 89.0% of *A baumannii*, 83.3% of *K pneumoniae*, and 65.6% of *P aeruginosa* isolates were resistant to carbapenem.

Both *K pneumoniae* (23.5%) and *P aeruginosa* (22.6%) were common in patients with VAP (n = 115), whereas *A baumannii* (37.8%) and *K pneumoniae* (34.8%) were more prevalent in CLABSI (n = 66), and *Candida* spp (66.7%) and *A baumannii* (12.5%) were more prevalent in patients with CAUTI (n = 24).

The crude ICU mortality for patients with only VAP due to carbapenem-resistant *A baumannii* and carbapenem-resistant *K pneumoniae* (75%) was significantly higher than that (31.2%) for patients admitted without HAI who did not acquire a DA-HAI in the ICU (relative risk, 2.50; 95% CI, 1.29-4.82, $P = .006$).

The crude ICU mortality rates for patients with only CLABSI due to carbapenem-resistant *A baumannii* (63.6%) and for patients with only CLABSI due to carbapenem-resistant *K pneumoniae* (75%) were significantly higher than that (31.2%) for patients admitted without an HAI who did not acquire a DA-HAI in the ICU, yielding overall crude excess mortality rates of 32.4% (relative risk, 2.12; 95% CI, 1.21-3.70, $P = .008$) and 43.7% (relative risk, 2.50; 95% CI, 1.29-4.82; $P = .006$), respectively.

Discussion

Our results show that DA-HAIs are a significant problem in the 3 Greek ICUs studied, occurring in 51.7% of patients (at a density rate of 34.1 DA-HAIs per 1000 ICU days), which is considerably higher than the rates reported in an NHSN report[21] for 2006 to 2007 (22.7%), a previous report[18] from Greece (25.2%), and a previous report[22] from Egypt (19.3%). However, our results are comparable to results reported for Turkish ICUs.[23] These differences could be attributed to many things: disease severity, lack of a well-established national infection surveillance system, limited funds and resources for infection control and prevention, insufficient numbers of experienced health care workers, and insufficient compliance among staff with hand hygiene recommendations, the importance of which has been demonstrated in many studies.[8,9,24,25]

DA-HAI rates and device utilization ratios should be examined together, so that preventive measures can be targeted appropriately.[26] The device utilization ratios for mechanical ventilators (95%), central catheters (94%), and urinary catheters (95%) in the ICUs we studied were all much higher than the 90th percentiles reported in all types of ICUs participating in the NHSN report[26] for the year 2010 (46%, 64%, and 84%, respectively), the International Nosocomial Infection Control Consortium (INICC) report[27] (38%, 53%, and 56%, respectively), and Egyptian studies[22] (12%, 11%, and 19%, respectively). Those ratios were, however, similar to the device utilization ratios previously reported in Greek ICUs[18] (81%, 95%, and 98%, respectively). In previous studies,[28] device utilization was the major risk factor for acquiring VAP, CLABSI, and CAUTI and for mortality. The extent of device utilization in our ICUs requires further investigation. More common use of noninvasive methods of ventilation and earlier removal of invasive devices should be encouraged. The high rates of DA-HAIs may reflect the higher device utilization ratios.[28]

Moreover, the incidence density rates in the 3 ICUs were all much higher than the 90th percentiles reported in medical-surgical ICUs participating in the NHSN report: for VAP, 20 versus 4 infections per 1000 ventilator-days; for CLABSI, 11.8 versus 3.4 infections per 1000 catheter-days; and for CAUTI, 4.2 versus 3.2 infections per 1000 catheter-days.[26] The implementation of a multidisciplinary approach and a comprehensive infection control program ("bundle") is the key to reducing DA-HAI rates and improving patient safety.[29,30]

Unlike the situation in the medical-surgical ICUs participating in the NHSN,[21] the major pathogens in the 3 Greek ICUs studied here, especially in patients with VAP, were *A baumannii, K pneumoniae,* and *P aeruginosa.* Only 1.7% of VAP isolates were *Staphylococcus aureus.* In CAUTIs, *Candida* spp were the most frequent isolates, followed by *P aeruginosa* and *A baumannii.* The leading pathogen for CLABSI was *A baumannii,* followed by *K pneumoniae.* Our results are consistent with results of previous studies in Egypt[22] and Turkey.[23]

To our knowledge, this is the first study that uses the definitions and procedures standardized by the CDC to explore antimicrobial resistance rates of organisms causing DA-HAIs in ICUs in Greece. Surveillance studies indicate that the percentage of carbapenem-resistant isolates has gradually increased in Europe, North America, and Latin America.[31] In Greece, the proportion of imipenem-resistant *A baumannii* isolates from ICUs patients in tertiary care hospitals increased from 0% to 85.1% between 1996 and 2007; in 2007, the proportions of imipenem-resistant *P aeruginosa* and *Klebsiella* spp were 58% and 65%, respectively (Greek System for Surveillance of Antimicrobial Resistance: http://www.mednet.gr/whonet/). In our study, isolated pathogens showed higher rates of carbapenem resistance than the rates reported by NHSN[21] and INICC.[27] Our resistance rate for *A baumannii* was 89.0% versus 30.6% reported by NHSN and 55.3% reported by INICC; for *K pneumoniae,* our resistance rate was 83.3% versus 10.8% reported by NHSN and 7.9% reported by INICC; and for *P aeruginosa,* our resistance rate was 65.6% versus 23.0% reported by NHSN and 47.2% reported by INICC. Our high resistance rates are similar to the rates reported for Egyptian ICUs.[22]

> Implementation of a multidisciplinary approach and a comprehensive infection control program is key to improving patient safety.

The most interesting microbiological finding of this study was that carbapenem-resistant *A baumannii, K pneumoniae,* and *P aeruginosa* are endemic in our ICUs. According to the EUROBACT International Cohort Study,[32] these are the most common bloodstream isolates in southern European countries. The presence of these pathogens in excess numbers might be attributed to the lack of appropriate policies and guidelines related to antibiotic use in most Greek hospitals. More efforts are required to implement consensus standards such as the 13+13 set of performance indicators for the prevention and control of HAIs and antimicrobial resistance in Greek ICUs.[33]

Another interesting finding in the present study was the high ICU mortality rate in the patients admitted without HAI who did not acquire a DA-HAI in

the ICU. We know of no previous reports of data on mortality associated with DA-HAIs in Greece. In accordance with results of studies in Cuba,[34] the high crude ICU mortality in these patients (33% in the Cuban study and 31.2% in our study) suggests a possible relationship between mortality and severity of underlying disease, presence of shock on admission, and hemodialysis during hospitalization.

On the other hand, crude excess ICU mortality rates in patients with CLABSI and patients with VAP and CLABSI were significantly higher than the rate in patients admitted without HAI who did not acquire a DA-HAI in the ICU. In our study, the excess mortality for VAP (13.0%) was similar to that reported by INICC[27] (15.2%) and in an Egyptian study[22] (12.9%), and the excess mortality for CLABSI (20.6%) was higher than that reported by INICC[27] (14.7%) and lower than that reported in the Egyptian study[22] (45.7%). Likewise, excess mortality for CAUTI (18.7%) was higher than that reported by INICC[23] (7.3%) and lower than that reported in the Egyptian study[22] (47.9%). Increasing evidence suggests that VAP has statistically little effect on nosocomial mortality but proportionately greater impact on the length of hospital stay and duration of mechanical ventilation.[35] In a previous study[28] in 19 hospitals in the Netherlands, the crude mortality was significantly higher in patients with CLABSI and patients with CAUTI but was lower in patients with VAP. However, neither VAP, CLABSI, or CAUTI was associated with excess mortality when adjusted for other risk factors.[28]

Finally, we estimated the clinical impact of VAP and CLABSI due to carbapenem-resistant *A baumannii, K pneumoniae,* and *P aeruginosa* on ICU mortality, because of the high prevalence of those pathogens. Data for clinical outcomes of infections and antimicrobial resistance are conflicting.[36] A more recent cohort study[37] that was supported by the European Commission revealed that the additional effect of the most common antimicrobial resistance patterns is comparatively low. We found that VAP due to carbapenem-resistant *A baumannii* and *K pneumoniae* is associated with increased ICU mortality, as reported in other studies.[38,39] The crude mortality was significantly higher in patients with CLABSI due to carbapenem-resistant *A baumannii* and *K pneumoniae* than in patients admitted without HAI who did not acquire a DA-HAI in the ICU. This difference may be due to the delay in getting effective treatment,[40] as half of the patients (50%) initially received inappropriate antibiotic therapy (data not shown). Our findings will provide clinicians with the necessary information to optimize the initial antimicrobial therapy and manage CLABSIs caused by carbapenem-resistant *A baumannii* appropriately, as well as to revise the antimicrobial prescribing policies.[41]

ICU health care professionals have been educated through focused seminars about the risk factors and the adequate measures for preventing HAIs in their units. A multidisciplinary team has been developed that consists of the medical and nursing directors, the supervisors, the head of the nursing staff, and physiotherapists from the ICUs. Educational materials (including scientific articles on the use of care bundles for VAP and CLABSI prevention, checklists for infection control, and leaflets on hand hygiene and the appropriate use of antibiotics) have been distributed to all the trainees. Additionally a focused training session has been conducted for the hospital's cleaning staff. The medical and nursing directors were delegated to assess periodically the compliance of the staff with standard precautions. The high workload and the low nurse to patient ratio have been recognized by the medical and nursing directors, the nurses, and the supervisors as barriers to the use of all the precautions for infection prevention in their ICUs. In each of the 3 ICUs, the nurse to patient ratio was 1 to 3. In a recent study[42] conducted in 27 ICUs in 9 European countries, univariate analysis revealed that the VAP rate in units with nurse to patient ratios of 1 to 3 was the highest, but after adjustment for covariates, this difference was no longer significant. Although there are several risk factors for VAP onset, suboptimal nurse staffing levels may be a barrier to the elimination of DA-HAIs in our ICUs. Our new approach will be based on the presentation of these results in an effort to motivate the staff to improve their compliance with standard precautions.

Study Limitations

The strengths of our study were the cohort design and the sound selection of controls from the appropriate population at risk. Potential sources of bias were the same as those related to any voluntary surveillance system. Furthermore, diagnoses could be misclassified. However, the use of a common protocol with standard definitions of DA-HAIs provided by the CDC's NHSN and the prospective data collection limit the possibility of systematic bias having affected our clinical outcomes. The study also had several potential limitations. First, our study did not include enough patients for detailed estimates of clinical outcomes for DA-HAIs to be computed. Additionally, the study was performed at 3 ICUs in Athens, and the results should not be generalized to other settings. Despite those limitations, our

findings provide clinicians with information about the epidemiology of DA-HAIs that will facilitate informed decisions and the discussion of prognoses with patients and their families.

Conclusion

Our study confirms the importance of DA-HAI surveillance in ICU patients. The high rates of DA-HAIs, device utilization ratios, and levels of antimicrobial resistance of pathogens identified in this study, compared with international benchmarks, highlight the importance of establishing antimicrobial stewardship and an active surveillance program, developing a comprehensive education program on evidence-based approaches for all health care workers, and decreasing device utilization and the implementation of care bundles, which will contribute to reducing the burden of DA-HAIs and improve the quality of care and patient safety in Greek ICUs.

FINANCIAL DISCLOSURES
None reported.

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