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(RESEARCH ARTICLE)

High Incidence and Fatality of Device-Associated Infections in Greek ICUs: Insights from a Two-Year Prospective Study

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Abstract

Device-associated infections (DAIs) are a major threat in intensive care units (ICUs), being linked with excess fatality, prolonged hospitalization and costs. We conducted a two-year prospective surveillance study (2022-2024) in three adult general ICUs n Athens to estimate the incidence of DAIs and their clinical impact, using CDC/NHSN case definitions. Among 500 eligible patients (>3 ICU days, 10,482 ICU patient-days in total), 268 (51,6%) developed 288 DAI episodes. The overall DAI incidence was 31.2 episodes per 1,000 ICU patient-days. Incidence by device was 19,2 per 1,000 ventilator-days for ventilator-associated events (VAE), 7,2 per 1,000 central line-days for central line-associated bloodstream infection (CLABSI) and 3,6 per 1,000 urinary catheter-days for catheter-associated urinary tract infection (CAUTI). The most frequent pathogens were *Klebsiella pneumoniae* (36.2%) and *Acinetobacter baumannii* (26.5%); among tested Gram-negative isolates, carbapenem resistance was universal. ICU fatality was 41,1% in patients with DAIs versus 23,2% without DAIs. Median ICU lengths of stay was 30 days (IQR 20-44) in patients with DAIs versus 11 days (IQR 8-19) in those without. The high burden of multidrug-resistant organisms and the excess fatality and length of stay support the urgent implementation of structured antimicrobial-resistance surveillance, antimicrobial-stewardship and device-specific prevention bundles in Greek ICUs.

Keywords: Device-Associated Infection; Healthcare-Associated Infection; Intensive Care Unit; Ventilator-Associated Events; CLABSI; CAUTI; Antimicrobial Resistance

1. Introduction

Invasive devices - central venous catheters, endotracheal or tracheostomy tubes, and urinary catheters - are indispensable in modern critical care but substantially increase the risk of healthcare-associated infections IHAIs). [1] Among these, device-associated infections (DAIs) account for a large share of preventable harm in ICUs and are consistently associated with adverse outcomes and substantial resource use. [2]

International bodies such as the World Health Organization and the U.S. Centers for Disease Control and Prevention (CDC) provide standardized case definitions and prevention bundles for DAIs. Despite the availability of effective strategies, DAI rates remain high in settings facing resource constraints and heavy antimicrobial pressure. [3] Greece has long reported some of the highest HAI prevalence and antimicrobial resistance (AMR) levels in Europe, with ICU patients being disproportionately affected.[4,5]

The Covid-19 pandemic further disrupted infection prevention, contributing to increases in certain HAIs in many countries.[6] Greece ranks first among European countries in the prevalence of healthcare-associated infections and

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reports some of the highest antimicrobial resistance (AMR) rates in Europe for specific bacterial strains. AMR rates in the country have increased compared with pre-COVID-19 years. According to the CDC, the COVID-19 pandemic adversely affected the incidence of HAIs, with notable increases in CLABSIs, VAEs, and CAUTIs during 2020. Similarly, findings from the International Nosocomial Infection Control Consortium (INICC) revealed substantial increases in overall fatality, length of stay, and rates of CLABSI and VAE in ICUs of low- and middle-income countries. [7,8]

In the United States, approximately 250,000 CLABSIs occur annually, resulting in about 28,000 ICU deaths and costing up to 2.3 billion dollars per year. A study conducted in four European countries found that the additional length of stay per CLABSI episode ranged from 4 to 14 days, with additional costs ranging from €4,200 to €13,030. For VAEs, attributable mortality has been estimated between 7% and 30%, and additional costs between €3,227 and $6,775 per case. For CAUTIs, fatality ranges from 3% to 28%, length of stay increases by 0.5 to 2.5 days, and costs range from $876 to $10,197 per episode. [9,10]

This study prospectively evaluated the incidence of VAEs, CLABSIs and CAUTIs and their clinical impact in three adult ICUs in Athens, and describes the microbiology and resistance patterns of causative organisms.

2. Materials and Methods

2.1. Study Design

We carried out a prospective, active surveillance study in three adult general ICUs ofa tertiary hospital in Athens, Greece (nurse-to-patient ratio approximately 1:4) from 2022 to 2024. All consecutive adults hospitalized for more than 2 days were eligible; patients staying ≤2 days were excluded. Routine laboratory monitoring was performed, and microbiological sampling was obtained as clinically indicated. Patients were followed from ICU admission to discharge or death.

2.2. Incidence and Impact of Device-Associated Infections

DAIs were identified using the CDC/NHSN Patient Safety Component protocols: ventilator-associated events (VAE: VAC, IVAC, possible VAP), central line–associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI). Incidence densities were calculated as episodes per 1,000 ICU patient-days (overall) and per 1,000 device-days for each device. Device utilization was defined as device-days divided by ICU patient-days multiplied by 100.

Throughout the surveillance period, the incidence rate of device-associated infections (DAIs) was calculated. The incidence of VAEs was determined by dividing the number of VAEs by the number of ventilator-days and multiplying by 1,000. Similarly, CLABSI incidence was calculated based on central venous catheter-days, and CAUTI incidence based on urinary catheter-days. DAI rates were expressed as episodes per 1,000 device-days. [11,12]

The device utilization ratio was calculated by dividing the number of device-days for each device (mechanical ventilator, central venous catheter, urinary catheter) by the total ICU patient-days and multiplying by 100. Device-days represented the total days of exposure to each device for all patients during the surveillance period, while ICU patient-days represented the total ICU hospitalization days for all patients. [12,13]

To assess attributable mortality and length of stay, comparisons were made between patients with DAIs and those who were admitted without healthcare-associated infections (HCAIs) and did not acquire DAIs during their ICU stay. Crude excess fatality was defined as the difference in mortality between patients with and without DAIs. Similarly, crude excess length of stay was defined as the difference in mean ICU length of stay between the two groups. [14]

2.3. Statistical Analysis

DAIs were identified using the CDC/NHSN Patient Safety Component protocols: ventilator-associated events (VAE: VAC, IVAC, possible VAP), central line–associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI). Incidence densities were calculated as episodes per 1,000 ICU patient-days (overall) and per 1,000 device-days for each device. Device utilization was defined as device-days divided by ICU patient-days multiplied by 100.

3. Results

A total of 500 patients contributed 10,482 ICU patient-days. Overall, 268/500 patients (51,6%) developed 288 DAI episodes: 182 patients had one episode, 57 had two, and 29 had three. Compared with patients without DAIs (n=232), those with DAIs were more often medical admissions and had higher APACHE II scores on ICU admission. Duration of mechanical ventilation, central venous catheterization, urinary catheterization, and days on antimicrobials were significantly longer in patients with DAIs.

The overall DAI incidence density was 31.2 per 1,000 ICU patient-days. By device, the incidence was 19.2 per 1,000 ventilator-days for VAEs, 7.2 per 1,000 central line-days for CLABSIs, and 3.6 per 1,000 urinary catheter-days for CAUTIs.

Table 1 Baseline Clinical Characteristics and Exposure Variables Associated With DAIS

	All (n=500)	**DAIS (268)**	**No DAIS (232)**	**Pvalue**
Male sex, n (%)	298 (59.6)	172 (64.2)	126 (54.3)	0,101
Admission category, n (%)				
Medical	295 (59)	162 (60.4)	133 (57.3)	0,002
Surgical	199 (39.8)	87 (32.5)	112 (48.3)	
Reason for ICU admission, n (%)				
Infection	116 (23.2)	65 (24.3)	51 (22)	0,021
Post operative monitoring	87 (17.4)	64 (23.9)	23 (9.9)	0,001
Neurological disease	80 (16)	42 (15.7)	38 (16.4)	0,688
Pulmonary disease	76 (15.2)	52 (19.4)	24 (10.3)	0,662
Cardiovascular disease	36 (7.2)	20 (7.5)	16 (6.9)	0,490
Trauma	87 (17.4)	56 (20.9)	31 (13.4)	0,112
Other (poisoning,burn)	15 (3)	7(2.6)	8(3.4)	1,000
	All	DAIS	No DAIS	Pvalue
Invasive procedures, n(%)				
Central venous catheter	500 (100)	268 (100)	232(100)	NA
Urinary catheter	500 (100)	268 (100)	232 (100)	NA
Endotracheal tube	500 (100)	268 (100)	232 (100)	NA
Tracheostomy	181 (36.2)	132 (49.3)	49 (21.1)	0.001
Tune thoracostomy	39 (7.8)	23 (8.6)	16 (6.9)	0,739
Days in ICU	19 (9-33)	30 (20-44)	11 (8-19)	0.001
Days of mechanical ventilation	15 (7-27)	25 (16-37)	9 (5-16)	0.001
Days with central line	20 (10-33)	31 (19-45,1)	12 (7-19)	0.001
Days with urinary catheter	20 (10-33)	31 (19-44,2)	12 (7-19)	0.001
Days with antibiotics	18 (9-30)	29 (16-41)	10 (7-16)	0.001

Device utilization ratios were high: mechanical ventilation 75,2%, central venous catheters 96,4%, and urinary catheters 100%. Among 206 VAE episodes, 50,6% were ventilator-associated conditions (VAC), 29,7% infection-related vantilator-associated complications (IVAC), and 19,7% possible VAP (PVAP).

The median time from device initiation to infection onset was 8 days for VAEs (IQR: 4–14), 8 days for CLABSIs (IQR: 5–10), 11 days for CAUTIs (IQR: 5–15).

Poly-microbial infections accounted for 17.6% of all DAIs. The most frequently isolated organisms were *Acinetobacter baumannii* (26.5%), *Klebsiella pneumoniae* (36.2%) and *Pseudomonas aeruginosa* (18.2%).

Klebsiella pneumoniae was the most common pathogen in VAE and CLABSI cases (48.2%), whereas *Acinetobacter baumannii* predominated in CAUTIs (46.2%). Among tested Gram-negative isolates, carbapenem resistance was 100%.

Table 2 ICU Device Utilization and Burden of Device-Associated Infections

Type of DAI	No of Bed Days	Device Days	Device Utilization Ratio	No of Infections	DAI Rates
VAEs	12.524	10.121	80.8%	206	20.4
VACs	12.524	10.121	80.8%	104	10.3
IVACs	12.524	10.121	80.8%	65	6.4
PVAPs	12.524	10.121	80.8%	37	3.7
CLABSIs	12.524	12.516	100%	112	8.9
CAUTIs	12.524	12.524	100%	32	2.6

ICU fatality was 41.2% in patients with DAIs compared with 23.2% in those without. Median ICU length of stay was 30 days (IQR 20-44) for patients with DAIs versus 11 days (IQR 8-19) without.

Table 3 Fatality by DAI Type

Type of DAI	Mp of Deaths	Fatality	Crude Extra Fatality	Pvalue
None	59	23.2	-	-
DAIs	116	41.1	17.9	0,001
VAEs	95	44.1	20.9	0.001
CLABSIs	52	46.0	22.8	0.012
CAUTIs	16	45.7	22.5	0.242
VAEs and CLABSIs	32	50	26.8	0.012
VAEs and CAUTIs	12	46.2	23.0	0.186
CLABSIs and CAUTIs	8	42.1	18.9	0,576
VAEs, CLABSIs and CAUTIs	4	36.4	13.2	1.000

4. Discussion

In the point-prevalence study of healthcare-associated infections (HAIs) and antibiotic use conducted during 2022–2023, the prevalence of HAIs reached 12.1%, whereas the corresponding value in the 2016–2017 survey was 10.0%. [15,36] Antibiotic consumption in 2022–2023 remained comparable to 2016–2017 (55.4%) but was significantly higher than the European average. Greece has consistently ranked among the highest in Europe. [37] In 2011–2012, the crude European prevalence was 6.0% (range: 2.3%–10.8%), with Greece in 4th place, whereas in 2016–2017, the European prevalence was 5.9% (range: 2.9%–10.0%), with Greece ranking first. [16,17] During 2022–2023, the prevalence of infections in Greece ranged between 10% and 12% during hospitalization, while the European average was approximately 5–6%. In a sample of 9,707 hospitalized patients in Greece, 1,175 had at least one HAI (12.1% prevalence). [16,37]

For the period 2023–2024, the available DAI data from ICUs in Greece indicate a very high incidence compared to Europe (27.4 infections per 1,000 patient-days) and a significant increase in ICU mortality and length of stay (44.9%). [35]

The highest prevalence of HAIs was recorded among ICU patients, where 45.7% of hospitalized individuals developed at least one infection. More than half of all hospitalized patients (55.4%) received at least one antimicrobial agent. These proportions have remained relatively stable compared with previous prevalence studies but remain significantly higher than the European average. Greece ranked first in Europe in both preceding point-prevalence surveys. [18,19]

The mean incidence of central line–associated bloodstream infections (CLABSIs) in Greece is 6.4 per 1,000 catheter-days, a rate substantially higher than international benchmarks. The risk of CLABSI increases significantly with longer catheter duration. Antimicrobial resistance (AMR) rates are generally higher among bacterial isolates recovered from ICU patients compared with those from general wards. [20,21]

4.1. Antimicrobial Resistance Trends

4.1.1. Klebsiella pneumoniae

Among *K. pneumoniae* isolates from ICU patients during 2018–2021, resistance rates increased over time third-generation cephalosporins: from 79.5% (2018) to 88.6% (2021), aminoglycosides: from 62.4% to 72.8%, carbapenems: from 75.5% to 84%, fluoroquinolones: from 81.2% to 89.6%. [22,23]

Resistance among *Pseudomonas aeruginosa* isolates has shown a slightly increasing trend in general wards, while ICU rates remained stable. An exception is aminoglycoside resistance in ICU isolates, which declined considerably from 33.5% (2018–2019) to 28.2% (2020) and 23.5% (2021). [24]

Resistance levels of *Acinetobacter baumannii* recovered from ICUs and wards during 2018–2021 consistently exceeded 85%, with the highest values observed in 2020 and 2021. [26]

4.2. Interpretation of Current Findings

Our study highlights the significant burden of device-associated infections (DAIs) in Greek ICUs, with nearly half of ICU patients developing at least one DAI and an incidence rate of 27.4 episodes per 1,000 ICU patient-days. According to the 2022–2023 European Centre for Disease Prevention and Control (ECDC) point-prevalence survey, the incidence of HAIs in European ICUs was 20.5%, a value lower than that observed in our study but comparable to the 45.7% reported in Greek ICUs. Our incidence values differ from two earlier Greek studies reporting 18.3 and 34.1 DAI episodes per 1,000 ICU patient-days.

The DAI incidence observed in our study was notably higher than that reported in Cyprus (19 per 1,000 ICU patient-days), the United States (0.9–4.4 episodes), and the INICC reports from 45 countries (9.0–10.1 episodes). Factors contributing to these differences may include the country's socioeconomic context, absence of a national surveillance system, limited resources for infection prevention, and low adherence to prevention measures. [25]

The device utilization ratio is a critical indicator when combined with DAI measurement, as it reflects exposure risk. In our study, device utilization was high: 75.2% for mechanical ventilation, 96.4% for central venous catheters, and 100% for urinary catheters—figures substantially higher than those reported by NHSN and INICC. Increased device usage is associated with higher colonization risk by multidrug-resistant organisms (MDROs). [27]

Previous studies indicate that the most important risk factors for acquiring MDROs include prior antibiotic use, ICU hospitalization, and the presence of invasive devices. Measuring colonization risk is essential for developing targeted infection-control strategies. [28,29]

4.3. Common Pathogens and Resistance Patterns

The predominant pathogens in the three ICUs were *Acinetobacter baumannii* and *Klebsiella pneumoniae*, consistent with findings from systematic reviews. European studies indicate increasing carbapenem resistance among these organisms. Greece remains among the countries with the highest AMR levels. [29,30]

Carbapenem resistance in Greece is approximately *Pseudomonas aeruginosa*: 61.5%, *Klebsiella pneumoniae*: 81% and *Acinetobacter baumannii*: ~90%.

Another Greek study reported resistance rates of 98% for *A. baumannii*, 75% for *K. pneumoniae*, and 46% for *P. aeruginosa*. In our study, resistance reached 100%, underscoring the endemic nature of AMR in Greek ICUs. [30,31,37]

High resistance rates are attributed to inadequate antimicrobial stewardship (AMS). In the 2022–2023 ECDC point-prevalence survey, Greece had the highest antimicrobial use in Europe: 55.3% of hospitalized patients received at least one antimicrobial, with an average of 1.67 antibiotics per patient, and 90% of antimicrobials administered parenterally. [33,37]

Carbapenems are frequently used in empirical treatment of non-severe infections, limiting therapeutic options. National legislation mandates the presence of infectious-disease specialists and AMS committees in hospitals, but staffing variability and limited dedicated time undermine their effectiveness. [31,32]

4.4. Impact of DAIs on Outcomes

Our findings demonstrate that the development of a DAI nearly doubles mortality, while multiple DAIs increase crude excess mortality beyond 25%. ICU length of stay increases twofold for patients with one DAI and may triple or quadruple for those with multiple DAIs. [34]

Low nurse-to-patient ratios remain a major barrier to effective infection prevention. In the three ICUs studied, the ratio was 1:3. Although several risk factors contribute to DAI acquisition, insufficient staffing likely impedes optimal infection-control practices. [4]

The high crude mortality attributable to DAIs underscores the importance of active surveillance, early identification of high-risk patients, detection of gaps in infection-control practices, continuous staff training, and targeted quality-improvement interventions. [35]

Abbreviations

- ICU : Intensive Care Unit
- DAIs : Device - Associated Infections
- CDC/NHSN : Centers for Disease Control and Prevention/National Healthcare Safety Network
- VAE : Ventilator - Associated Events
- CLABSI: Central Line - Associated Bloodstream Infection
- CAUTI : Catheter - Associated Urinary Tract Infection
- AMR : Antimicrobial Resistance
- VAC : Ventilator-Associated Condition
- IVAC: Infection-Related Ventilator-Associated Complication
- PVAP: Possible Ventilator-Associated Pneumonia

5. Conclusions

This study documents a heavy burden of device-associated infections in Greek ICUs, driven by high device exposure and endemic multidrug resistance. Implementing comprehensive prevention bundles, antimicrobial stewardship, and continuous monitoring should be prioritized to reduce DAIs, improve outcomes, and optimize resource use.

The findings of this study highlight the critical importance of monitoring device-associated infections (DAIs) in ICU patients. The increased DAI incidence, the extensive use of invasive devices, and the high levels of antimicrobial resistance among isolated pathogens underscore the need for implementing comprehensive infection-control strategies.

Active surveillance of antimicrobial resistance, together with the implementation of antimicrobial stewardship (AMS) programs and structured care bundles for ventilators, central venous catheters, and urinary catheters, is essential for reducing the risk of DAIs.

Staff education, internal audits, continuous feedback, and initiatives that promote a culture of safety—emphasizing hand hygiene, minimizing device use, and applying antibiotic-rotation strategies—can effectively reduce the impact of DAIs and enhance patient safety and quality of care in the ICU.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

Informed ethical approval was obtained from all individual participants included in the study.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Blot S, Ruppé E, Harbarth S, Asehnoune K et al. Healthcare-associated infections in adult intensive care unit patients: Changes in epidemiology, diagnosis, prevention and contributions of new technologies. *Intensive Crit.* Care Nurs. 2022, 70, 103227.

[2] Centers for Disease Control and Prevention. 2020. Available online: https://archive.cdc.gov/www_cdc_gov/hai/data/archive/ 2020-HAI-progress-report.html (accessed on 10 January 2025).

[3] Rosenthal V D, Myatra S N, Divatia J V, Biswas S et al. The impact of CO,,3VID-19 on health care–associated infections in intensive care units in low- and middle-income countries: International Nosocomial Infection Control Consortium (INICC) findings. Int. J. Infect. Dis. 2022, 118, 83–88.

[4] Yepez E S, Bovera M M, Rosenthal V D et al. Device-associated infection rates, mortality, length of stay and bacterial resistance in intensive care units in Ecuador:International Nosocomial Infection Control Consortium's findings. *World J. Biol. Chem.* 2017, *8*, 95–101.

[5] Chovanec K, Arsene C, Gomez C, Brixey M. Association of CLABSI with Hospital Length of Stay, Readmission Rates, and Mortality: A Retrospective Review. *Worldviews Evid.-Based Nurs.* 2021, *18*, 332–338.

[6] Pathak R, Gangina S, Jairam F, Hinton K. A vascular access and midlines program can decrease hospital-acquired central line-associated bloodstream infections and cost to a community-based hospital. *Ther. Clin. Risk Manag.* 2018, *14*, 1453–1456.

[7] Alotaibi N H, Barri A, Elahi M A. Length of Stay in Patients with Central Line-Associated Bloodstream Infection at a Tertiary Hospital in the Kingdom of Saudi Arabia. *Cureus* 2020, *12*, e10820.

[8] He Q, Wang W, Zhou S. The epidemiology and clinical outcomes of ventilator-associated events among 20,769 mechanically ventilated patients at intensive care units: An observational study. *Crit. Care* 2021, *25*, 44.

[9] Hollenbeak C,Schilling A. The attributable cost of catheter-associated urinary tract infections in the United States: A systematic review. *Am. J. Infect. Control* 2018, *46*, 751–757.

[10] Abrantes-Figueiredo J I, Ross J W, Banach D B. Device Utilization Ratios in Infection Prevention: Process or Outcome Measure? *Curr. Infect. Dis. Rep.* 2018, *20*, 8.

[11] Mishra A, Aggarwal A, Khan F. Medical Device-Associated Infections Caused by Biofilm-Forming Microbial Pathogens and Controlling Strategies. *Antibiotics* 2024, *13*, 623.

[12] Pandey V K, Srivastava K R, Ajmal G. Differential Susceptibility of Catheter Biomaterials to Biofilm-Associated Infections and Their Remedy by Drug Encapsulated Eudragit RL100 Nanoparticles. *Int. J. Mol. Sci.* 2019, *20*, 5110.

[13] Sharma S, Mohler J, Mahajan S D. Microbial Biofilm: A Review on Formation, Infection, Antibiotic Resistance, Control Measures, and Innovative Treatment. *Microorganisms* 2023, *11*, 1614.

[14] Kim E J, Kwak Y G, Park S H. Trends in device utilization ratios in intensive care units over 10-year period in South Korea: Device utilization ratio as a new aspect of surveillance. *J. Hosp. Infect.* 2018, *100*, e177.

[15] Gade N, Burri R, Sujiv A. Promoting Patient Safety: Exploring Device-Associated Healthcare Infections and Antimicrobial Susceptibility Pattern in a Multidisciplinary Intensive Care Units. *Cureus* 2023, *15*, e50232.

[16] Schinas G, Polyzou E, Spernovasilis N.Preventing Multidrug-Resistant Bacterial Transmission in the Intensive Care Unit with a Comprehensive Approach: A Policymaking Manual. *Antibiotics* 2023, *12*, 1255.

[17] Wang Y, Yang J, Qiao F. Compared hand hygiene compliance among healthcare providers before and after the COVID-19 pandemic: A rapid review and meta-analysis. *Am. J. Infect. Control* 2022, *50*, 563–571.

[18] Spernovasilis N, Ierodiakonou D, Spanias C. Doctors' Perceptions, Attitudes and Practices towards the Management of Multidrug-Resistant Organism Infections after the Implementation of an Antimicrobial Stewardship Programme during the COVID-19 Pandemic. *Trop. Med. Infect. Dis.* 2021, *6*, 20.

[19] Mandelli G, Dore F, Langer M et al. Effectiveness of a Multifaced Antibiotic Stewardship Program: A Pre-Post Study in Seven Italian ICUs. *J. Clin. Med.* 2022, *11*,

[20] Lutufyo T, Qin W, Chen X. Central Line Associated Bloodstream Infection in Adult Intensive Care Unit Population-Changes in Epidemiology, Diagnosis, Prevention, and Addition of New Technologies. *Adv. Infect. Dis.* 2022, *12*, 252–280.

[21] Peleg A Y, Seifert H, Paterson D L. Acinetobacter baumannii: Emergence of a successful pathogen. *Clin. Microbiol. Rev.* 2008, *21*, 538–582.

[22] Barmpouni M, Gordon J.P, Miller R.L. Clinical and Economic Value of Reducing Antimicrobial Resistance in the Management of Hospital-Acquired Infections with Limited Treatment Options in Greece. *Infect. Dis. Ther.* 2023, *12*, 1891–1905.

[23] 23. European Centre for Disease Prevention and Control. 2024. Available online: https://www.ecdc.europa.eu/sites/default/files/documents/AMR_country_visit_report_Greece.pdf (accessed on 30 December 2024).

[24] Ture Z, Güner R, Alp E. Antimicrobial stewardship in the intensive care unit. *J. Intensive Med.* 2022, *3*, 244–253.

[25] Karagiannidou S, Zaoutis T, Maniadakis N. Attributable length of stay and cost for pediatric and neonatal central line-associated bloodstream infections in Greece. *J. Infect. Public Health* 2019, *12*, 372–379.

[26] Karagiannidou S, Kourlaba G, Zaoutis T. Attributable Mortality for Pediatric and Neonatal Central Line-Associated Bloodstream Infections in Greece. *J. Pediatr. Intensive Care* 2021, *13*, 174–183.

[27] Danielis M, Destrebecq A L L, Terzoni S. Nursing care factors influencing patients' outcomes in the intensive care unit: Findings from a rapid review. *Int. J. Nurs. Pract.* 2022, *28*, e12962.

[28] Gasparetto J, Tuon F F. Intravenous-to-oral antibiotic switch therapy: a cross-sectional study in critical care units. BMC Infect Dis. 2019 Jul 22;19(1):650.

[29] Zaha D C, Kiss R. Recent Advances in Investigation, Prevention, and Management of Healthcare-Associated Infections (HAIs): Resistant Multidrug Strain Colonization and Its Risk Factors in an Intensive Care Unit of a University Hospital. Biomed Res Int. 2019 Jun 20;2019.

[30] Yakusheva O, Costa D K. Variability in catheter-associated asymptomatic bacteriuria rates among individual nurses in intensive care units: An observational cross-sectional study. PLoS One. 2019 Jul 10;14(7).

[31] Ribeiro Á, Crozatti M. Pseudomonas aeruginosa in the ICU: prevalence, resistance profile, and antimicrobial consumption. Rev Soc Bras Med Trop. 2019 Dec 20.

[32] Chamchod F, Palittapongarnpim P. Effects of the proportion of high-risk patients and control strategies on the prevalence of methicillin-resistant Staphylococcus aureus in an intensive care unit. BMC Infect Dis. 2019 Dec 3;19(1).

[33] Cui Y, Dong D. Risk factors for Clostridioides difficile infection and colonization among patients admitted to an intensive care unit in Shanghai, China. BMC Infect Dis. 2019 Nov 11;19(1).

[34] Liang J, Li Z, Dong H. Prognostic factors associated with mortality in mechanically ventilated patients in the intensive care unit: A single-center, retrospective cohort study of 905 patients. Medicine (Baltimore). 2019 Oct;98(42).

[35] Kafazi A, Apostolopoulou E. Device-Associated Infections in Adult Intensive Care Units: A Prospective Surveillance Study. ***Acta Microbiol. Hell.*** 2025, ***70***(2), 15.

[36] Iordanou S, Papathanasoglou E. Device-associated health care-associated infections:The effectiveness of a 3-year prevention and control program in the Republic of Cyprus.Nurs Crit Care. 2022 Jul;27(4):602-611.

[37] Αποτελέσματα Επιτήρησης Μικροβιακής Αντοχής, Κατανάλωσης Αντιβιοτικών και Λοιμώξεων που Σχετίζονται με Φροντίδα Υγείας. ΕΟΔΥ. Αύγουστος 2023.