ORIGINAL PAPER
Polish Journal of Microbiology
2022, Vol. 71, No 3, 443–452
https://doi.org/10.33073/pjm-2022-039

Trends of Bloodstream Infections in a University Hospital During 12 Years

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Submitted 26 May 2022, accepted 27 July 2022, published online 19 September 2022

Abstract

This study aims to investigate trends in bloodstream infections and their antimicrobial susceptibility profiles over 12 years in our hospital. This retrospective study was carried out in the Bursa Uludag University Hospital, Turkey, during 2008–2019. Blood cultures from patients were performed using BACTEC System. Isolates were identified with Phoenix System until 2018 and "matrix-assisted laser desorption ionization time-of-flight mass spectrometry" (MALDI-TOF MS) in 2019. Antibiotic susceptibility testing was performed with Phoenix System. Patient data came from the BD EpiCenter™ data management system. *Escherichia coli* was found to be the most common Gram-negative (11.6%), and coagulase-negative staphylococci were the most common Gram-positive (10.1%) monomicrobial growth. Overall, there was a significant increase in rates of extended-spectrum β-lactamase positive *E. coli* ($p = 0.014$) and *Klebsiella pneumonia* ($p < 0.001$), carbapenem-resistant *E. coli* ($p < 0.001$), and *K. pneumoniae* ($p < 0.001$) and colistin-resistant *K. pneumoniae* ($p < 0.001$) and *Acinetobacter baumannii* ($p < 0.001$) over 12 years. Carbapenem and colistin resistance has increased dramatically in recent years. We believe that regular monitoring of the distribution of pathogens and antibiotic susceptibility profiles, especially in intensive care units, can contribute to evidence for the increase in resistant microorganisms and help prevent their spread with antimicrobial stewardship and infection control policies.

K e y w o r d s: bloodstream infections, antimicrobial resistance, blood culture

Introduction

Bloodstream infections (BSIs) are associated with high morbidity and mortality worldwide, in both developed and developing countries (Tian et al. 2019). They are among the top seven causes of death in Europe and North America, with more than two million episodes each year and a case fatality rate of 13–20%, resulting in 250,000 deaths annually. Approximately 30% of patients with BSI receive ineffective or delayed antimicrobial therapy, which in turn causes increased antimicrobial resistance and mortality (Pfaller et al. 2020). For this reason, in 2015, the World Health Organization published the Antimicrobial Resistance Global Action Plan to promote awareness and understanding of antimicrobial drug resistance (WHO 2015). In addition, studies conducted in the last decade have associated an increase in the incidence of BSI with a sharp rise in at-risk population numbers (elderly patients, those with chronic diseases or immunosuppression, etc.). These developments are central to the global spread of multiresistant bacteria. Therefore, monitoring changes in the rate of BSI caused by pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA) and extended-spectrum β-lactamase (ESBL) or carbapenemase-producing *Enterobacteriaceae* is key to improving their management and prevention, as well as ensuring the delivery of appropriate healthcare (Diekema et al. 2019; Sader et al. 2019; Martínez Pérez-Crespo et al. 2021).

This study aims to investigate the prevalence of pathogens responsible for BSI, and their antimicrobial susceptibility profiles, in patients at our tertiary care university hospital for 12 years. Understanding the disease burden of BSIs can provide a valuable indicator for healthcare providers.

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Experimental

Materials and Methods

This single-center study was conducted at an 880-bed tertiary care university hospital, per the principles of the Declaration of Helsinki. Our hospital was accredited by Joint Commission International two times (2007–2010 and 2012–2015) in the past. Approval was granted by the Ethics Committee (2021–11/6).

This study was a retrospective analysis of all data from blood cultures carried out by the Microbiology Laboratory from January 2008 to December 2019. We evaluated all BSI data without distinguishing between community-onset or hospital-acquired infections because separation in the BD EpiCenter™ data management system (Becton Dickinson, USA) is not very credible. Blood culture specimens from adult (> 18 years) patients from hospital wards and intensive care units (ICU) were evaluated. The study was divided into four-time intervals (2008–2010, 2011–2013, 2014–2016, 2017–2019) to track the distribution of microorganisms and changes in antimicrobial resistance and compare between periods during the 12 years. Patient data were obtained from the BD EpiCenter™ data management system. Our study did not include molecular data on resistance profiles. To avoid duplication from the same patient, if the same organism caused persistent BSIs, only one specimen from the first episode within 30 days, was included for each patient in the study. Each infection was considered individually if patients had two or more separate BSIs. Patients below 18 years of age and outpatients were excluded from the study (Zhu et al. 2018).

Guidelines from the Center for Disease Control and Prevention (CDC) were followed to distinguish true BSI agents from contamination. Causative agents for BSIs were considered to be either pathogenic microorganism growth detected in one or more blood cultures or the identical skin microbiota isolates [diphtheroids (*Corynebacterium* spp. not *Corynebacterium diphtheriae*), *Bacillus* spp. (not *Bacillus anthracis*), coagulase-negative staphylococci (CoNS) including *Staphylococcus epidermidis*, viridan group streptococci, *Aerococcus* spp. *Micrococcus* spp. and *Rhodococcus* spp.] seen in two or more blood cultures at different times; otherwise, the findings were considered contamination (CDC 2020). The contamination rate was calculated as the ratio of blood culture bottles considered contaminated to the total number of blood cultures collected during the study period (CLSI 2007; Alnami et al. 2015).

Microbiological procedures. All blood cultures throughout the study were monitored using the BACTEC™ 9240 System (Becton Dickinson, USA). Positive bottles were removed, and Gram staining was performed; blood samples were inoculated on 5% sheep blood agar and eosin methylene blue agar and incubated at 37°C for 24–48 hours. Species identification was performed using conventional methods: Phoenix™ 100 System (Becton Dickinson, USA) until 2018, and matrix-assisted laser desorption ionization time-of-flight mass spectrometer (MALDI-TOF MS) (Bruker Daltonics, Germany) in 2019. Antibiotic susceptibility testing was performed using the Phoenix™ 100 System, Kirby-Bauer Disk Diffusion (Oxoid, UK), and gradient diffusion methods (bioMérieux, France). The recommendations of the Clinical and Laboratory Standards Institute (CLSI) until 2014 (CLSI 2013), and European Committee on Antimicrobial Susceptibility Testing (EUCAST) since 2014 (EUCAST 2020) were observed. Isolates were tested for susceptibility to vancomycin and teicoplanin using the gradient diffusion method. According to CDC recommendations, *Enterobacteriaceae* and *Acinetobacter baumannii* isolates were defined as carbapenem-resistant when showing resistance to at least one of the following agents: ertapenem, meropenem, imipenem, or doripenem (Goodman et al. 2016). MRSA and ESBL assays from the Phoenix™ 100 System were used to classify MRSA and ESBL-positive samples. ESBL-positive *Escherichia coli* and *Klebsiella pneumoniae* isolates were determined according to the Phoenix™ 100 System. *S. aureus* ATCC® 29213™, *E. coli* ATCC® 25922™, and *Pseudomonas aeruginosa* ATCC® 27853™ were quality control strains.

Statistical analysis. Statistical analysis was performed using IBM SPSS 23.0 (IBM SPSS Statistics, USA). The categorical descriptive data were presented as frequency distribution and percentages (%). Long-term trends in the distribution of agents and resistance rates isolated from both wards and ICUs were evaluated using linear regression. The incidence of bacteremia was expressed as the ratio of cases per 10,000 hospital/unit bed days and per 1,000 hospital/unit admissions, with information obtained from the hospital management database. Changes in annual incidence rates (per unit and total), were analyzed with Spearman correlation analysis, in which the strength of the relationship increases as it approaches ± 1 and decreases as it approaches 0. Antibiotic resistance patterns against ceftriaxone, cefotaxime, cefepime, imipenem, meropenem, ertapenem, piperacillin-tazobactam, amikacin, gentamicin, colistin, and ciprofloxacin as treatment for *E. coli*, *K. pneumoniae*, *A. baumannii,* and *P. aeruginosa* in hospital wards and ICUs were compared using the chi-square method. The same method was also used to compare antibiotic resistance against daptomycin, oxacillin, vancomycin, teicoplanin, and linezolid for *S. aureus*, CoNS, and vancomycin, teicoplanin, linezolid, penicillin, and high-level gentamicin for *Enterococ-*

cus faecalis, and *Enterococcus faecium*. A *p*-value equal to or less than 0.05 was considered significant in all statistical analyses.

Results

In our hospital, from 2008 to 2019, a total of 136,030 blood cultures were processed for 34,782 patients from wards and ICUs. Of these, 11,542 isolates identified in 10,584 blood culture bottles from 7,096 patients were included in this study, while 11,443 isolates identified in 10,232 blood culture bottles from 4,460 patients were deemed contaminated according to CDC criteria and therefore were excluded from the study. Our contamination rate (10,232/136,030) was calculated to be 7.5%.

In our study, 8,891 BSI episodes occurred among 7,096 (4,016 – 56.6% male and 3,080 – 43.3% female) patients. Proportions of species are shown in Table I. 80.4% of samples were collected from wards, and 19.6% from ICUs. The overall rate of polymicrobial episodes was 19.4%, with significantly higher numbers in ICUs (27.7%) compared to hospital wards (17.3%) (chi-square; $p < 0.001$).

In the analysis of monomicrobial growths, *E. coli* was the most commonly seen Gram-negative (11.6%) and CoNS the most common Gram-positive (10.1%) agent. The most commonly found fungi were *Candida parapsilosis* (2.7%) and *Candida albicans* (2.5%). In polymicrobial growth analysis, although *E. coli* was the most common accompanying agent in the wards and overall, *A. baumannii* was the most frequent in ICU patients. When we evaluated polymicrobial and monomicrobial growth together, CoNS (12%) emerged as the most common pathogen, followed by *E. coli* (11.8%), *K. pneumoniae* (8.9%), *S. aureus* (8.6%), *A. baumannii* (7.6%), and *P. aeruginosa* (5%).

Fig. 1 and 2 show the frequency of microorganisms within all positive blood cultures. There was a significant decrease in the overall frequency of polymicrobial and CoNS isolates over the study period; the frequency of *K. pneumoniae* isolates increased significantly on the

Table I
Distribution of microorganisms in bloodstream infections in the wards and intensive care units.

Bloodstream infection episodes		Wards n (%)	Intensive care units n (%)	Overall n (%)
Monomicrobial	Gram-negative	3,065 (42.8%)	710 (40.9%)	3,775 (42.5%)
	Escherichia coli	971 (13.6%)	57 (3.3%)	1,028 (11.6%)
	Klebsiella pneumoniae	529 (7.4%)	146 (8.4%)	675 (7.6%)
	Acinetobacter baumannii	261 (3.6%)	186 (10.7%)	447 (5.0%)
	Pseudomonas aeruginosa	275 (3.8%)	65 (3.7%)	340 (3.8%)
	Gram-positive	2,289 (32.0%)	441 (25.4%)	2,730 (30.7%)
	Coagulase-negative staphylococci	717 (10%)	184 (10.6%)	901 (10.1%)
	Staphylococcus aureus	717 (10%)	96 (5.5%)	813 (9.1%)
	Enterococcus faecalis	188 (2.6%)	57 (3.3%)	245 (2.8%)
	Enterococcus faecium	191 (2.7%)	38 (2.2%)	229 (2.6%)
	Fungi	559 (7.8%)	106 (6.1%)	665 (7.5%)
	Monomicrobial (Total)	5,913 (82.7%)	1,257 (72.3%)	7,170 (80.6%)
Polymicrobial		1,240 (17.3%)	481 (27.7%)	1,721 (19.4%)
Total		7,153 (100%)	1,738 (100%)	8,891 (100%)

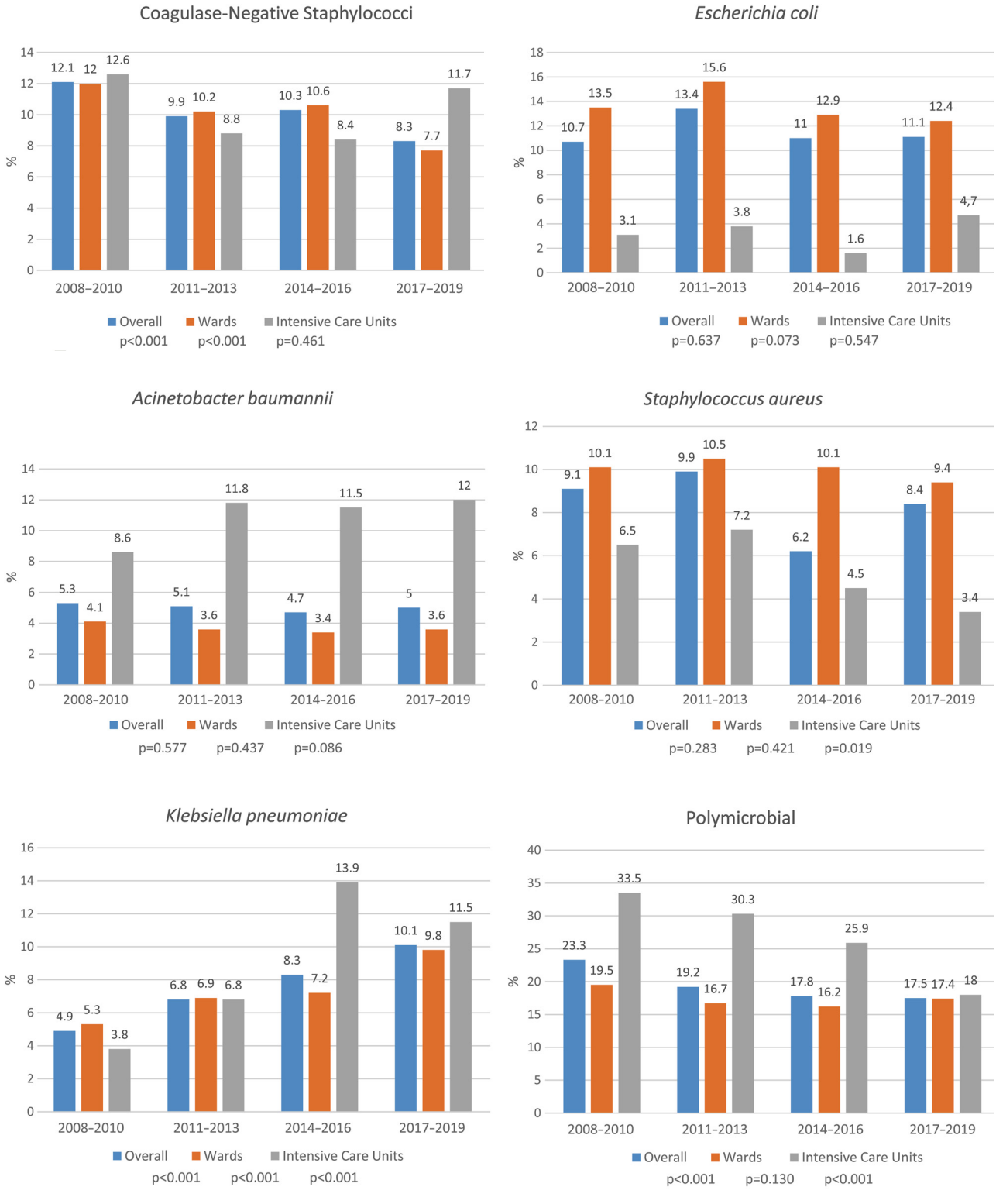


Fig. 1. The most common microorganisms in all positive blood cultures over the 12 years.

wards and in ICUs, whereas the frequency of *S. aureus* isolates decreased significantly in ICUs (Fig. 1).

Fig. 2 shows the frequency of resistant strains within all positive blood cultures. Vancomycin-resistant enterococcus (VRE) rates in both wards and ICUs have remained unchanged over the 12 years, while the rate of MRSA in ICUs has decreased significantly. Overall, ESBL-positive *E. coli* and *K. pneumoniae*, carbapenem-resistant *E. coli* and *K. pneumoniae*, and colistin-resistant *K. pneumoniae* and *A. baumannii* have all increased significantly over the years.

Tables II and III show the resistance rates of the most common bacteria at different points during the 12 years. In *E. coli*, we found that resistance against

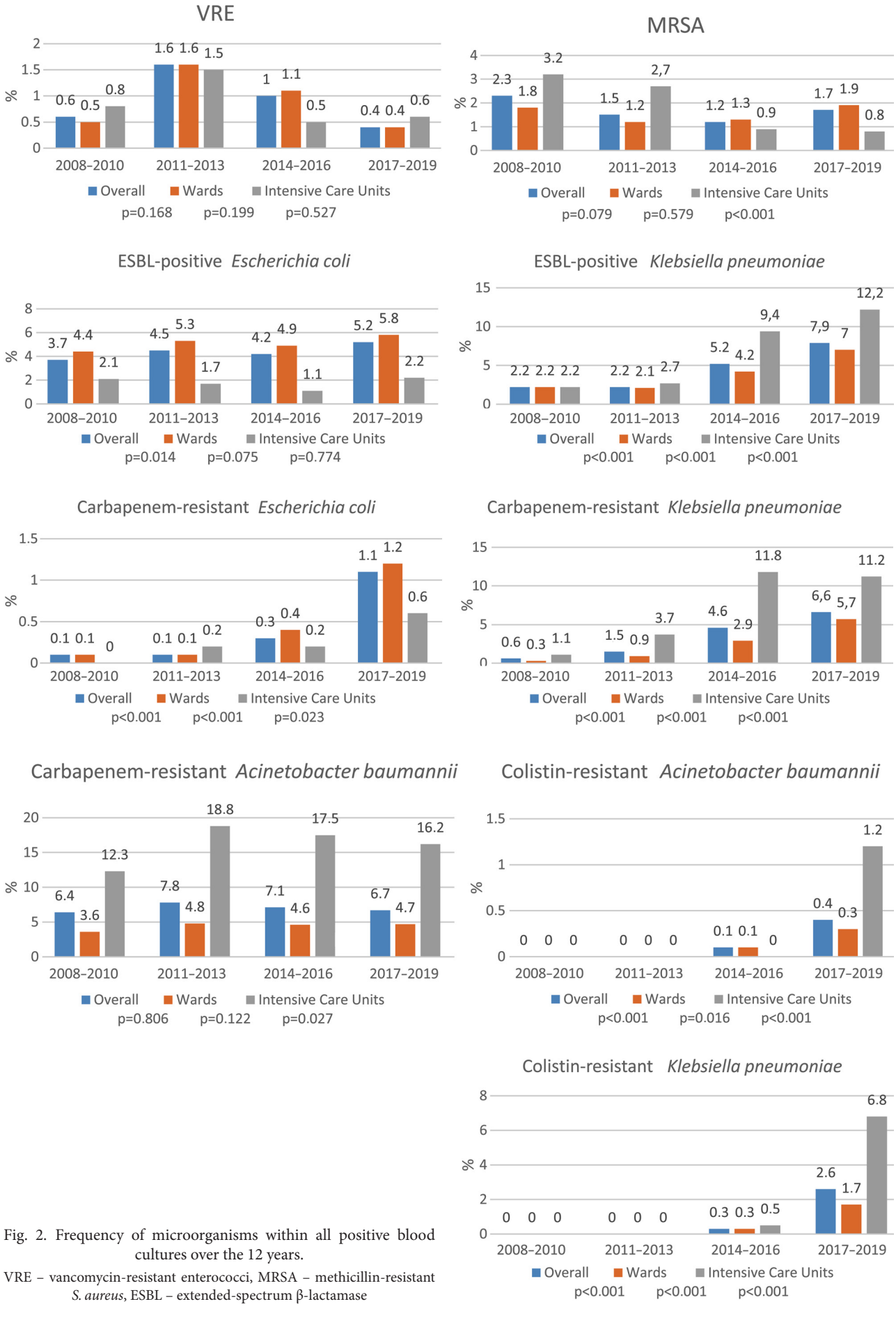


Fig. 2. Frequency of microorganisms within all positive blood cultures over the 12 years.

VRE – vancomycin-resistant enterococci, MRSA – methicillin-resistant *S. aureus*, ESBL – extended-spectrum β-lactamase

Table II
Antibiotic resistance rates of the most common Gram-negative bacteria in blood cultures.

	Escherichia coli (%) (n = 1,360)			*p*	*Klebsiella pneumoniae* (%) (n = 1,031)			*p*	*Acinetobacter baumannii* (%) (n = 864)			*p*	*Pseudomonas aeruginosa* (%) (n = 580)			*p*
	Wards	ICU	Overall		Wards	ICU	Overall		Wards	ICU	Overall		Wards	ICU	Overall	
Ceftriaxone	25.7	23.8	25.6	0.664	38	50.4	41.1	< 0.001	38.2	28.5	33.4	0.002	–	–	–	–
Cefotaxime	11.3	23.8	12.3	< 0.001	10.7	20.2	13.1	< 0.001	32.6	43.5	38	0.001	–	–	–	–
Cefepime	36.9	49.5	37.9	0.010	46.8	67.2	52	< 0.001	47.7	62.5	55	< 0.001	19.3	38.2	24.8	< 0.001
Imipenem	1.4	1	1.3	0.589	25.1	48.9	31.1	< 0.001	74.9	88.7	81.7	< 0.001	23.9	39.4	28.4	< 0.001
Meropenem	0.9	1	0.9	0.620	24.7	48.9	30.8	< 0.001	74.7	90.7	82.6	< 0.001	17.8	34.1	22.6	< 0.001
Ertapenem	2.9	4.8	3.1	0.219	25.6	46.6	30.9	< 0.001	76	74.3	75.2	0.558	77.3	77.1	77.2	0.946
Piperacillin-Tazobactam	23.8	25.7	24	0.663	50.5	72.5	56.1	< 0.001	50	66.7	58.2	< 0.001	15.6	31.2	20.2	< 0.001
Amikacin	1.4	1.9	1.4	0.438	5.6	21	9.5	< 0.001	70.4	76.2	73.2	0.053	5.4	8.2	6.2	0.265
Gentamicin	26.1	36.2	26.8	0.024	23.3	42.7	28.2	< 0.001	62.2	75.2	68.6	< 0.001	12.2	26.5	16.4	< 0.001
Colistin	0.2	1	0.3	0.275	6	14.1	8.1	< 0.001	2.3	1.4	1.8	0.477	0.7	1.2	0.9	0.633
Fosfomycin	0	0	0	–	0.8	1.1	0.9	0.411	1.6	0.9	1.3	0.570	–	–	–	–
Ciprofloxacin	44.6	44.8	44.6	0.978	37.2	69.8	45.5	< 0.001	81.2	96.8	88.9	< 0.001	11.2	20	13.8	0.008
ESBL	36.6	43.8	37.1	0.086	45.9	56.9	48.7	0.001	–	–	–	–	–	–	–	–
Carbapenem-resistant	3.3	4.8	3.5	0.294	29.8	58.4	37.1	< 0.001	90.5	93.8	92.1	0.080	83.4	88.2	84.8	0.162

ESBL – extended-spectrum β-lactamase, - – not tested

Table III
Antibiotic resistance rates of the most common Gram-positive bacteria in blood cultures.

	Staphylococcus aureus (%) (n = 996)			*p*	*Coagulase-negative staphylococci* (%) (n = 1,382)			*p*	*Enterococcus faecalis/ Enterococcus faecium* (%) (n = 1,036)			*p*
	Wards	ICU	Overall		Wards	ICU	Overall		Wards	ICU	Overall	
Daptomycin	0	0	0	–	0	0	0	–	–[1]	–[1]	–[1]	–
Oxacillin	16.6	37.7	19.7	< 0.001	82.9	90.1	84.7	0.001	–[1]	–[1]	–[1]	–
Vancomycin	0	0	0	–	0	0	0	–	10.9	8.1	10.1	0.185
Teicoplanin	0.8	0.7	0.8	0.668	6.5	9	7.1	0.155	10.4	8.1	9.7	0.273
Linezolid	0	0	0	–	0.7	0.6	0.7	0.624	1	1.1	1.1	0.587
Penicillin	–[1]	–[1]	–[1]	–	–[1]	–[1]	–[1]	–	38.8	26	35.4	< 0.001
High-level gentamicin	–[2]	–[2]	–[2]	–	–[2]	–[2]	–[2]	–	43.5	48	44.7	0.202

[1] – not determined, [2] – not tested

cefotaxime, cefepime, and gentamicin was significantly more common in the isolates from ICU patients than in the wards (Table II). ESBL-positive *E. coli* bacteremia rate was 37.1%, and there was no statistically significant difference between ICU and non-ICU settings. In patients with *K. pneumoniae* infection, resistance rates for all antibiotics were found to be significantly higher in ICU patients. ESBL-positive *K. pneumoniae* bacteremia rate was 48.7% and carbapenem-resistant *K. pneumoniae* bacteremia rate was 37.1%. The resistance rate was significantly higher in the ICU setting. *A. baumannii*, resistance to cefotaxime, cefepime, imipenem, meropenem, piperacillin-tazobactam, gentamicin, and ciprofloxacin was significantly higher in ICU patients. Regarding *P. aeruginosa*, resistance to cefepime, imipenem, meropenem, piperacillin-tazobactam, gentamicin, and ciprofloxacin was also found to be significantly higher in ICU patients than in the wards (Table II).

When we investigated Gram-positive bacteremia, daptomycin, vancomycin, and linezolid-resistant *S. aureus* were not detected. However, oxacillin-resistant *S. aureus* (an indicator of MRSA) was significantly higher in ICU patients. While daptomycin and vancomycin resistance was not detected in CoNS, oxacillin resistance (indicating MRCoNS) was also found to be significantly higher in ICU patients. In the *E. faecalis* and *E. faecium* isolates, penicillin resistance was found to be significantly higher in non-ICU patients (Table III).

The incidence of BSI episodes per year and over 12 years was calculated as a ratio of 10,000 hospital bed days and 1,000 hospital admissions. The incidence of BSI in our hospital over the 12 years was 20.8/10,000 bed days, and 10.2/1,000 admissions. An inverse correlation was demonstrated for MRSA isolates in 10,000 bed days ($r = -0.978$, $p = 0.022$) and 1,000 admissions ($r = -0.977$, $p = 0.023$) when calculating annual incidence rates. In other resistant strains, no significant correlation (direct or inverse) was found per 10,000 hospital/unit bed days or 1,000 hospital/unit admissions.

Discussion

Our study is important for highlighting changes and trends in the frequency of bacteremia isolates and their antibiotic resistance detected in our hospital over a long period. CLSI guidelines advocate a target of < 3% contamination rate in blood cultures (CLSI 2007). However, in studies from different geographical regions and countries with diverse socioeconomic levels, a higher rate of 3.8–10.4% has been reported, which is similar to our results of 7.5% (Chukwuemeka and Samuel 2014; Abu-Saleh et al. 2018). A German study reported a 2.8% contamination rate in blood cultures (Schöneweck et al. 2021).

Our hospital is a tertiary care hospital with low staffing levels, a heavy workload, and an increasing frequency of invasive procedures. All these contribute to the cross-infection with microorganisms from patient to patient. It may account for our high contamination rate (7.5%). However, we found a significant decrease in the overall frequency of CoNS isolates in samples, related to the contamination rate.

S. aureus is the leading cause of Gram-positive bacteremia worldwide, while *E. coli* is the most significant cause of Gram-negative bacteremia (Hattori et al. 2018; Tian et al. 2019; Pfaller et al. 2020). In a study conducted in Iran, CoNS was found to be the most common Gram-positive pathogen while the most common Gram-negative bacteria was *P. aeruginosa* (Keihanian et al. 2018). In two other studies conducted in our country, the most common Gram-positive pathogen were *E. faecalis* (Satılmış and Aşgın 2019) and *S. epidermidis*

(Bıçak et al. 2020), with *E. coli* the most common among Gram-negative bacteria. In our study, CoNS was found frequently in Gram-positive bacteria, a result of our high contamination rate. Meanwhile, similar to the literature, *E. coli* was the most common Gram-negative bacterium.

The prevalence of polymicrobial infection in BSI episodes is reported to vary between 8–32% (Yo et al. 2019). Similarly, in our study, this rate was 19.4%. According to the international EUROBACT study, which examined BSIs in 162 ICUs; monomicrobial growth was reported in 88% of the patients (58.3% Gram-negative, 32.8% Gram-positive, 7.8% fungal, 1.2% anaerobic), while polymicrobial growth was reported in 12% (Tabah et al. 2012). Similar to these results and those of other studies, we found Gram-negative bacteria to be the most common etiological agents for BSI in the ICUs, and Gram-positive bacteria emerged as the second most common cause (Tabah et al. 2012; Chaturvedi et al. 2021; Kallel et al. 2021).

Changing trends in the prevalence of pathogens caused by BSI have also been recorded. The SENTRY study group and two other studies have described an increase in the prevalence of *K. pneumoniae* in BSIs over time (Li et al. 2020; Pfaller et al. 2020; Tsuzuki et al. 2021). A study from Greece, our neighboring country, noted using data from WHONET that although the prevalence of *K. pneumoniae* in hospital wards has decreased in past years, it has increased in ICUs (Polemis et al. 2020). In contrast, in our study, we saw a significant increase in the prevalence of *K. pneumoniae* – overall in hospital wards and ICUs. One SENTRY study (Pfaller et al. 2020) found the prevalence of MRSA to be decreasing over time, while another SENTRY study (Diekema et al. 2019) noted an increase in ESBL-positive *E. coli* and *K. pneumoniae,* and carbapenem-resistant *Enterobacteriaceae*. Studies conducted in China reported the increasing incidence of carbapenem-resistant *K. pneumoniae* (Tian et al. 2019; Mineau et al. 2018) and MRSA in hospital wards (Tian et al. 2019), but a decrease in MRSA and ESBL-positive *K. pneumoniae* in ICUs (Tian et al. 2019). Meanwhile, ESBL-positive *E. coli* has increased in ICUs in Toronto (Mineau et al. 2018), while the prevalence of MRSA has decreased in Spain (Martínez Pérez-Crespo et al. 2021). In our study, we noted a significant decrease in the prevalence of MRSA in our ICUs over the study period, while overall, the prevalence of all other phenotypic resistant Gram-negative bacteria increased significantly.

According to the SENTRY study, BSIs caused by MRSA were seen among patients in the non-ICU setting, while VRE, ESBL-positive *Klebsiella* sp., carbapenem-resistant *Klebsiella* sp., and *E. coli* were more common among patients in ICUs (Pfaller et al. 2020). In the US, the prevalence of MRSA was higher in ICU patients (Ham et al. 2020). In our study, there was no statistically significant difference in the prevalence of VRE, although MRSA was significantly more common in ICUs than in the hospital wards. Our study found the rate of antibiotic-resistant isolates to be generally higher in ICUs than in hospital wards. ICUs are units where resistant infectious species and critical patients are monitored and treated; furthermore, these dedicated areas frequently require invasive interventions. Therefore, the likelihood of encountering resistant bacteria here is higher than in other hospital wards.

In a study conducted in the USA, the incidence of MRSA per 10,000 bed days was reported to have decreased (Jernigan et al. 2020). In a study from China, the incidence of Gram-positive microorganisms in BSI per 1,000 admissions had decreased (Zhu et al. 2018). In another study from China, a detected increase in the incidence of Gram-negative microorganisms was not considered statistically significant (Zhu et al. 2021). The incidence density increased linearly in a medical-surgical intensive care unit during 2005–2007 in Turkey (from 3.57 to 9.60 per 1,000 patient-days) (Erdem et al. 2009). The incidence of BSI in our hospital over the 12 years was 20.8/10,000 bed days and 10.2/1,000 admissions. In our study, the correlation of phenotypically resistant bacteria with 10,000 hospital bed days and 1,000 hospital admissions was examined, and an inverse correlation was found in MRSA isolates only for both 10,000 bed days and 1,000 admissions.

In conclusion, although our study was conducted at only one healthcare center, our hospital is a tertiary hospital and the largest in the South Marmara region of Turkey. While our contamination rate is high, the prevalence of polymicrobial growth and CoNS has decreased significantly over the years. However, although the frequency of *S. aureus* and MRSA has decreased significantly in ICUs, the prevalence of *K. pneumoniae* increased. The most important finding of this study was the dramatic increase in carbapenem and colistin resistance in recent years. Our infection control committee has been operating since 1995. We have blood culture collection procedures, and we use regular educational interventions for proper blood culture specimen collection for physicians, nurses, and phlebotomists. We have a hand hygiene policy, infection control education and procedures, and antimicrobial stewardship policies (restriction for broad-spectrum antibiotics, cumulative antibiogram, following usage of antibiotics by defined daily doses, de-escalation, and stop order). In order to prevent the spread of *K. pneumoniae* and other resistant bacteria, we are trying to increase hand hygiene compliance rates by constantly repeating hand hygiene training. Physicians can use broad-spectrum antibiotics (such as carbapenems and polymyxins) only with the approval of infectious diseases and clinical microbiologists (restriction policy). We believe we need

to re-evaluate our hospital's hand hygiene policy, infection control procedures, and antimicrobial stewardship. On the other hand, physicians should be aware of the increasing drug resistance, such as ESBL and carbapenem resistance, and choose their empiric treatment according to susceptibility patterns. We believe that monitoring the distribution of pathogens and antibiotic susceptibility profiles at regular intervals, especially in ICUs, will contribute to our understanding of the increase of resistant microorganisms and help prevent their spread with antimicrobial stewardship and infection control policies.

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Declarations

This manuscript was presented at the National Turkish Society of Microbiology Congress as an oral presentation (Evaluation of Blood Culture Growth Between 2007–2019) on 25–27 December 2020.

Author contributions

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by all of the authors. The first draft of the manuscript was written by NÜT and all authors commented on previous versions of the manuscript. Writing – review and editing were performed by CÖ, BE, and HA. All authors read and approved the final manuscript.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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