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Invasive device-associated nosocomial infections of a teaching hospital in Turkey; four years' experience

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Aim: To determine our setting's IDAI rates, infecting microorganisms, and their resistance patterns to achieve standardization and make comparisons among other Turkish and developed country hospitals all over the world.

Materials and methods: The numbers of total patient days, ventilator days, central catheter days and, urinary catheter days in the ICUs were recorded and IDAI rates were calculated. Clinical specimens were obtained from patients, cultivated at appropriate culture media, and infecting microorganisms and resistance patterns were determined.

Results: Totally 1450 invasive device-associated infection episodes were determined (16.4% of patients) with a rate of 21.12/1000 days. Ventilator associated pneumonia rate was 22.05/1000 ventilator days and most common microorganism was *Acinetobacter baumannii*. Central catheter associated blood stream infection rate was 9.14/1000 central catheter days and the most common infecting organism was *A. baumannii*. Catheter associated urinary infection rate was 10.12/1000 urinary catheter days and the most common pathogen was *Candida* species. MRSA rate decreased from 89.6% in 2006 to 61.8% in 2009 ($P < 0.001$). ESBL production rates were between 70.7% and 45.6% in *Escherichia coli* and 66.7% and 55.9% in *Klebsiella pneumoniae* isolates. Vancomycin resistance among *Enterococci* was between 34.3% and 21.7% in these years.

Conclusion: Our hospital infection rates were found to be similar to those of country data but higher than those in developed nations. Considering the high infection and resistance rates to most of the available antibiotics, it is highly urgent that infection control measures be taken and more effective antibiotic control policies be adopted.

Key words: Device associated infection, nosocomial, resistance

Türkiye'deki bir hastanenin invazif araç ilişkili enfeksiyon hızları; dört yıllık deneyim

Amaç: Merkezimizdeki invazif araç ilişkili enfeksiyon hızlarının, etken mikroorganizmaların ve direnç paternlerinin tespit edilerek standardizasyon sağlanması ve Türkiye ile gelişmiş ülkelerdeki hastaneler ile karşılaştırma yapılması.

Yöntem ve gereç: Yoğun bakımlarda toplam hasta günü, ventilatör günü, santral kateter günü ve üriner kateter günleri kayıt edildi ve invazif araç ilişkili enfeksiyon hızları hesaplandı. Hastalardan klinik örnekler alınarak uygun ortama ekildi ve enfekte eden mikroorganizmalar ile direnç paternleri tespit edildi.

Bulgular: Toplam olarak % 16,4 oranında ve 12, 12/1000 hasta gününde 1450 invazif araç ilişkili enfeksiyon tespit edilmiştir. Ventilatör ilişkili pnömoni hızı 21, 12/1000 ventilatör günü ve en sık görülen patojen *Acinetobacter baumannii* idi. Santral kateter ilişkili kan dolaşım enfeksiyonu hızı 9,14/1000 kateter günü ve en sık izole edilen patojen *A. baumannii* idi. Kateter ilişkili üriner sistem enfeksiyon hızı ise 10,12/1000 kateter günü ve en sık karşılaşılan patojen *Candida* türleri idi. MRSA oranı 2006 yılında % 89.6'dan 2009 yılında % 61.8'e düştü ($P < 0,001$). ESBL oranları çalışma yıllarında *Escherichia coli*'de % 70,7 ve % 45,6 arasında, *Klebsiella pneumoniae*'de ise % 66,7 ve % 55,9 arasında idi. Enterokok türleri arasında vankomisin direnci % 34,3 ve % 21,7 arasındaydı.

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Sonuç: Hastanemiz enfeksiyon hızları ülke verileriyle benzer ancak gelişmiş ülkelere oranla yüksek bulundu. Bu yüksek enfeksiyon hızları ve antimikrobiyallere direnç oranları göz önüne alındığında enfeksiyon kontrol önlemlerine uyumun acil olarak arttırılması ve daha etkili antibiyotik kontrol politikaları geliştirilmesine ihtiyaç vardır.

Anahtar sözcükler: Araç ilişkili enfeksiyon, direnç, nozokomiyal

Introduction

Healthcare associated infections (HAI) result in increased mortality, morbidity, and costs (1). The Centers for Disease Control and Prevention (CDC) Study of the Efficacy of Nosocomial Infection Control (SENIC) has shown the efficacy of surveillance in helping to prevent healthcare acquired infections (HAIs) (2). Since the majority of the infections occur in intensive care units (ICU) and invasive device-associated infections (IDAIs) represent the greatest threat in the ICUs, targeted surveillance and calculation of IDAI rates per 1000 device-days, is used in hospitals in the US and other developed countries which allows benchmarking between similar institutions (3,4). ICUs also are often associated with resistant microorganisms (5).

There are several reports on invasive device-associated infections from Turkey. In this study our aim was to determine our setting's IDAI rates, infecting microorganisms, and their resistance patterns to achieve standardization and make comparisons among other Turkish and developed country hospitals all over the world.

Materials and methods

Setting

Our hospital is a referral hospital with 1020 beds, in the southern part of Turkey, which receives significant amount of migration from the southeast. Targeted surveillance performed at 4 ICU units started in January 2006; A: 10 bedded traumatic, general medical and surgical ICU, B: 13 bedded general medical ICU, C: 16 bedded neurosurgical ICU, D: 14 bedded pediatric medical and surgical ICU. The units have 2-4 isolation rooms each. Patient to nurse ratio is approximately 1:5.

Surveillance

Infection control nurses and doctors visited all the ICUs regularly. Demographic data consisting of age, gender, underlying diseases, etc. were recorded. Patient records were examined for physical examination, blood counts, microbiology data, temperature, and treatment charts. The patient's doctors were also consulted. Center for Disease Control (CDC) definitions for hospital infections were used for diagnosis (6).

Total patient days, ventilator days, central catheter days, and urinary catheter days in the ICUs were recorded. The overall infection rates were calculated by dividing infection episodes by total patient days, multiplied by 1000. IDAI rates were calculated by dividing number of episodes by total device days, multiplied by 1000. Device utilization rates were also calculated; dividing device days by total patient days (7). Four years' surveillance data of 2006-2009 were extracted.

Microbiology

Clinical specimens were obtained from patient's peripheral blood and from indwelling catheters, tracheal and bronchial aspirates, and from urinary catheters. They were cultivated on appropriate culture media (obtained from bioMérieux, France) (8,9).

At least 2 sets of blood culture bottles were incubated in BACTEC 9240 (Becton Dickinson Microbiology System) at 35 °C for 7 days. When there was a positive culture signal the blood specimens were added to 5% sheep-blood agar, Chocolate agar, MacConkey agar, and Sabouraud dextrose agar (SDA) with antibiotics. SDA media were incubated at 37 °C for 7 days for fungus. Daily observation was made for positive culture. If there was a positive culture, Gram staining for direct microscopic examination was performed from colony suspensions and microorganism existence was investigated.

Identification of bacteria and yeast isolates was performed by using conventional methods and Gram Positive Identification (GP ID) and Gram Negative identification (GN ID) cards of the VITEK 2 system (bioMérieux, France).

Antimicrobial susceptibilities of the test organisms were determined using the VITEK 2 system (bioMérieux, France) according to the manufacturer's recommendations. Susceptibility testing was done by VITEK II system (bioMerieux, France) and API systems (bioMerieux, France). Clinical Laboratory Standards (CLSI) were used for interpretation of antimicrobial resistance patterns (10).

Detection of extended-spectrum beta-lactamase (ESBL) production was performed using the E-test (AB BIODISK, Solna, Sweden). The criterion for ESBL production was at least an 8-fold decrease in the MIC of ceftazidime with an addition of 4 mg/L clavulanic acid for *K. pneumoniae* and *E. coli* strains (10).

For *Staphylococcus* spp., susceptibility testing with the VITEK 2 system was performed. The current CLSI breakpoints for oxacillin susceptibility were used: MICs of ≤ 2 mg/L indicated susceptibility, and MICs of ≥ 4 mg/L indicated resistance.

For *Enterococcus* spp., determined MICs in the VITEK 2 system with Antimicrobial Susceptibility Testing card were confirmed using Vancomycin E-test strips (AB BIODISK, Solna, Sweden).

Multidrug resistance was defined as resistance to 3 or more groups of antimicrobials: cephalosporins, aminoglycosides, quinolones, piperacillin-tazobactam, and carbapenems. Extreme drug resistance was defined as resistance to all antibiotics available except colistin and tigecycline.

Results

Totally 6834 patients were admitted to our hospital ICUs; 1450 device-associated infections occurred in 68,425 patient days in 1118 patients with a rate of 16.4% and 21.12 per 1000 patient days. Distribution of IDAI rates and utilization ratios according to years are shown in Table 1.

Table 1. Distribution of invasive device-associated infection rates and utilization ratios according to years.

Years		VAP	CA-BSI	CA-UTI	IDAIR*
2006	**n /%**	185 / 48.4	73 / 19.1	124 / 32.5	**382**
	dd / rate	7942 / 23.3	7805 / 9.4	12,098 / 10.2	**17,283 / 22.20**
	DUR	46	45	70	
2007	**n /%**	181 / 50.7	67 / 18.8	109 / 30.5	**357**
	dd / rate	7898 / 22.92	7892 / 8.49	13,110 / 8.31	**17,783 / 20.08**
	DUR	44.4	44.4	73.7	
2008	**n /%**	149 / 40	77 / 20.6	147 / 39.4	**373**
	dd / rate	8101 / 18.39	8119 / 9.48	12,067 / 12.18	**17,453 / 21.37**
	DUR	46	46	69	
2009	**n /%**	166 / 49.1	66 / 19.5	106 / 31.4	**338**
	dd / rate	6949 / 23.89	7149 / 9.23	10,750 / 9.86	**15,906 / 21.25**
	DUR	43	44	67	
Total	**n /%**	681 / 47	283 / 19.5	486 / 33.5	**1450**
	dd / rate	30,890 / 22.05	30,965 / 9.14	48,025 / 10.12	**68,425 / 21.19**
	DUR	45	45	70	

dd: device days, **DUR:** Device utilization ratio, **Rate:** Calculated by dividing number of infections by device days multiplied by 1000, **VAP:** Ventilator associated pneumonia, **CA-BSI:** Catheter associated blood stream infection, **CA-UTI:** Catheter-associated urinary tract infection

***IDAIR:** Invasive device-associated infection rate-Calculated by dividing number of infections by patient days multiplied by 1000

Of the device-associated infections, 47% were ventilator-associated pneumonia (VAP), 19.5% were central venous catheter-associated blood stream infections (CA-BSIs), and 33.5% were urinary catheter-associated urinary tract infections (CA-UTIs) (Table 1).

The overall VAP rate was 22.05 per 1000 ventilator days varying between 18.39 and 23.89 per 1000 ventilator days in different years. Device utilization ratio (DUR) was 45% overall. The most frequent isolates were *Acinetobacter baumannii* 40% (n = 493), followed by *Pseudomonas aeruginosa* 18.8% (n = 232), *Staphylococcus aureus* 13.8% (n = 170), and *Klebsiella pneumoniae* 9.1% (n = 112).

CA-BSI rate was 9.14 per 1000 central venous catheter days varying in different ICUs between 8.49 and 9.48 per 1000 catheter days. Central venous catheter utilization ratio was 45% overall. The most frequently isolated microorganisms were *A. baumannii* 19.1% (n = 134), *Enterococcus faecium* 10.6% (n = 74), coagulase negative staphylococci (CNS) 8.4% (n = 59), and *S .aureus* 8.4% (n = 59).

CA-UTI rate was 10.12 per 1000 urinary catheter days and varied between 8.31 and 12.18 per 1000 catheter days. Urinary catheter utilization ratio was 70%. The most frequent infecting microorganisms were *Candida* spp. 31.6% (n = 284), *Escherichia coli* 17.9% (n = 161), *Enterococcus* spp. 8.9% (n = 80), and *K. pneumonia* 7.8% (n = 70).

Totally 3269 microorganisms were isolated and 65.3% of these microorganisms were gram negative and 13.9% were *Candida* spp. (Table 2). The most common infecting microorganism was *A. baumannii* (25.5%, n = 835), followed by *P. aeruginosa* (14.2%, n = 465), *K. pneumoniae* (8.6%, n = 280), *E. coli* (8.5%, n = 279), and *S. aureus* (8%, n = 260).

The resistance patterns of the selected microorganisms to antimicrobials are summarized in Table 3. Resistance to antimicrobials in *Acinetobacter* and *Pseudomonas* strains increased where MRSA rate decreased significantly from 89.6% to 61.8% ($P < 0.001$).

Discussion

Most of the ICU acquired infections are related to invasive devices and these infections are associated with isolates of resistant microorganisms. In order to decrease the healthcare associated infections, surveillance and particularly the surveillance of invasive device-associated infections is essential. Our overall infection rate was similar to that of hospitals in developing countries and Turkey; 14.7% and 22.5 infections per 1000 ICU days in a multi-center study by Rosenthal et al. involving the rates of 8 developing countries (11), and 38.3% and 33.9 IDAI per 1000 patient days (INICC Turkish branch) in Leblebicioğlu et al.'s study (4). İnan et al. found overall infection rates of 29.1% and 34.2 per 1000 patient days (12). In a study investigating the nosocomial infection surveillance of a center for 10 years between 1997 and 2006, infection rates were found 20.8 per 1000 patient days in the ICU, which was also similar to our rates (13).

In this study, most common device-associated infection was VAP (49.5%), followed by CA-UTI (31.5%) and CA-BSI (18.9%). This was similar to the results in other developing countries; Rosenthal et al. found that the most common infection was VAP (41%, n = 1277), followed by CA-UTI (30%, n = 930) and CA-BSI (29%, n = 888) (11). In the Turkish branch of this study, VAP consisted 47.4% of all IDAIs, followed by CA-BSI with 30.4% and CA-UTI with 22.2% where VAP ratio was similar and CA-BSI ratio was significantly higher than our study (4). İnan et al. also showed a similar distribution of IDAIs 38.7% VAP, 38.7% CA-UTI, and 22.6% CA-BSI (12). Doğru et al. found a similar distribution; VAP was 53.6% where CA-BSI and CA-UTI were 25.9% and 21.5%, respectively (14).

There was a decreasing trend in IDAI rates from 2006 to 2009 (Table 1) with overall VAP rate of 23.11 per 1000 ventilator days, CA-BSI rate of 8.92 per 1000 catheter days, and CA-UTI rate of 9.24 per 1000 catheter days. When these rates were compared with those in National Healthcare Safety Network (NHSN) report, all IDAI rates were over the 90th percentile while device utilization ratios were between the 25th and 50th percentiles, which means infection control practices should be more intensively applied (15). Similarly, when compared with German Nosocomial

Table 2. Distribution of the microorganisms causing invasive device-associated infections.

	2006 N /%	**2007 N /%**	**2008 N /%**	**2009 N /%**	**Total N /%**
Acinetobacter baumannii	153 / 28.4	219 / 25.9	235 / 23.2	228 / 26.1	835 / 25.5
Pseudomonas aeruginosa	71 / 13.2	115 / 13.6	144 / 14.2	135 / 15.5	465 / 14.2
Stenotrophomonas maltophilia	18 / 3.3	18 / 2.1	11 / 1.1	5 / 0.6	52 / 1.6
Burkholderia cepacia	2 / 0.4	3 / 0.4	9 / 0.8		14 / 0.4
Pseudomonas spp	1 / 0.2	6 / 0.7	7 / 0.7	16 / 1.8	30 / 0.9
Acinetobacter spp.		4 / 0.5		8 / 0.9	12 / 0.4
Escherichia coli	41 / 7.6	71 / 8.4	92 / 9.1	75 / 8.6	279 / 8.5
Klebsiella pneumoniae	30 / 5.6	83 / 9.8	102 / 10.1	65 / 7.4	280 / 8.6
Enterobacter cloacae	6 / 1.1	11 / 1.3	14 / 1.4	15 / 1.7	46 / 1.4
Morganella morganii	3 / 0.6		3 / 0.3	3 / 0.3	9 / 0.3
Serratia marcescens	3 / 0.6	7 / 0.8	18 / 1.8	9 / 1	37 / 1.1
Klebsiella oxytoca	2 / 0.4	4 / 0.5	7 / 0.7	7 / 0.8	20 / 0.6
Citrobacter spp.	1 / 0.2	4 / 0.5	4 / 0.4	4 / 0.5	13 / 0.4
Proteus spp.	1 / 0.2	6 / 0.7	8 / 0.8	8 / 0.9	23 / 0.7
Other gram negatives	2 /	2 / 0.2		15 / 1.7	19 / 0.6
Gram negatives					**2134 / 65.3**
Enterococcus faecium	21 / 3.9	46 / 5.4	39 / 38	42 / 4.8	148 / 4.5
Enterococcus faecalis	9 / 1.7	18 / 2.1	27 / 2.7	24 / 2.8	78 / 2.4
Enterococcus gallinarum/casseliflavus	2 / 0.4	1 / 0.1	1 / 0.1	3 /0.3	7 / 0.2
Enterococcus other	3/ 0.6	1 / 0.1	3 / 0.3	1 / 0.1	8 / 0.2
Staphylococcus aureus	77 / 14.3	66 / 7.8	78 / 7.7	39 / 4.5	260 / 8
Coagulase negative staphylococci	19 / 3.5	23 / 2.7	47 / 4.6	45 / 5.2	134 / 4.1
Streptococcus spp.	5/ 0.9	14 / 1.6	14 / 1.4	10 / 1.2	43 / 1.3
Other gram positives				2 / 0.2	2 / 0.1
Gram positives					**680 / 20.8**
Candida albicans	33 / 6.1	54 / 6.4	38 / 3.8	37 / 4.2	162 / 5
Candida glabrata	9 / 1.7	16 / 1.9	27 / 2.7	10 / 1.2	62 / 1.9
Candida tropicalis	6 / 1.1	18 / 2.1	33 / 3.3	16 / 1.8	73 / 2.2
Candida parapsilosis	5 / 0.9	16 / 1.9	33 / 3.3	31 / 3.6	85 / 2.6
Candida kefyr		5 / 0.6	4 / 0.4		9 / 0.3
Candida krusei		8 / 1.0			8 / 0.2
Other *Candida* spp.	16 / 3.0	7 / 0.8	14 / 1.4	19 / 2.2	56 / 1.7
Candida					**455 / 13.9**
Total	**539 / 100**	**846 / 100**	**1012 / 100**	**872 / 100**	**3269 / 100**

Table 3. Distribution of resistance patterns of etiological agents through 2006 and 2009.

	2006 % (n)	2007 % (n)	2008 % (n)	2009 % (n)	P value*
Pseudomonas aeruginosa					
meropenem R	49.3 (35)	64.3 (73)	67.9 (95)	57.5 (77)	>0.05
amikacin R	45.7 (32)	66.1 (74)	26.8 (38)	28.6 (38)	<0.001
ciprofloxacin R	59.2 (42)	54 (61)	49.6 (70)	45.7 (59)	>0.05
piperacillin-tazobactam R	49.3 (35)	38.7 (43)	46.1 (65)	69 (89)	<0.001
Acinetobacter baumannii					
meropenem R	44 (66)	71.9 (156)	85.2 (195)	90.8 (206)	<0.001
amikacin R	86 (129)	82.5 (174)	51.3 (118)	63.4 (144)	<0.001
tobramycin R	27.1 (41)	37.4 (80)	70.9 (161)	49.3 (101)	<0.001
Enterococus spp.					
ampicillin R	62.9 (22)	82.5 (52)	55.7 (38)	68.6 (48)	>0.05
vancomycin R	22.8 (8)	21.7 (13)	34.3 (24)	31.4 (22)	>0.05
MRSA rate	89.6 (69)	93.6 (58)	84.42 (65)	61.8 (21)	<0.001
ESBL rate					
Escherichia coli	70.7 (29)	53.5 (38)	45.6 (42)	64.6 (42)	>0.05
Klebsiella pneumonae	56.7 (17)	62.6 (52)	55.9 (57)	66.7 (50)	>0.05

***R:** resistance*
**: trend analysis is performed*

Infection Surveillance System (KISS), all of the IDAI rates in the present study were also over the 90th percentile (16).

Despite these unpromising figures, when compared with developing countries' and some European data, our IDAI rates were not very high. VAP rates were similar to the rates in the INICC study and even better than some of the countries' (overall rate of 24.1 and range between 10.0 and 52.7 cases per 1000 ventilator days) (11). In a Dutch study VAP rate was found to be 25 infections per 1000 ventilator days (17). Some other studies reported such rates as 20.4 and 19.3 infections per 1000 ventilator days by Orsi et al. from Italy (18), 21 infections per 1000 patient days by Lizan-Garcia et al. from Spain (19), and 12.1 infections per 1000 ventilator days by Dima et al from Greece (20). The reason for higher rates in Spanish and Italian studies may be the study periods' being earlier than ours. Another reason can be the need for more intense and complicated infection control implementations for handling this kind of infection.

Limited number of Turkish studies also report similar VAP rates; 26.5 infections per 1000 ventilator days by Leblebicioğlu et al. in Turkish branch of INICC (4), 20.76 infections per 1000 ventilator days by İnan et al. (12), 22.6 infections per 1000 ventilator days by Erdem et al. (21), 27.1 infections per 1000 ventilator days by Doğru et al. (14), and a higher rate of 59.7 infections per 1000 ventilator days from a small university hospital by Turgut et al., saying that smaller hospitals can also have higher nosocomial infection rates, emphasizing the urgent need of the implementation of infection control guidelines (22). According to our national surveillance data, our VAP rates were generally between the 25th and 50th percentiles (23).

In contrast with the NHSN report, when compared with those in other developing country and some European rates, CA-BSI rates in the present study were considerably low; 12.5 infections per 1000 catheter days (ranging between 7.8 and 18.5 infections) in INICC study (11), 19.1 and 16.6 infections per 1000 catheter days in the study by Orsi et al. (18), 12.1 infections per 1000 catheter days from Greece (20), 30 infections per 1000 catheter days from Spain (19), 30.3 infections per 1000 catheter days from Argentina by Roshental et al. (24), and 12.0 infections per 1000 catheter days from Israeli by Finkelstein et al. (25).

The Turkish data available on CA-BSI were very diverse; in the biggest study by Leblebicioğlu et al. (Turkish branch of INICC) CA-BSI rate was found as 17.6 infections per 1000 catheter days (4); İnan et al. (12), Yılmaz et al. (26), and Doğru et al. (14) found similar rates to ours (9.69, 9.6, and 11.8 infections per 1000 catheter days, respectively), whereas the study by Turgut et al. showed relatively low rates (4.1 infections per 1000 catheter days), probably because of lower device utilization ratios (22). But considering the biggest and the only multicenter study and national surveillance data, the rates in the present study appear to be similar to and lower than Turkish average, possibly because of the education given in our center and infection control practices in this field, Surveillance is the first step to decrease health-care associated infections. In our setting starting with surveillance we stressed the importance of infection control, but there are still some institutional and national deficiencies. There are no standards for invasive procedures including catheter insertion, ventilator associated procedures, sterilization, and disinfection. Understaffing is another important factor for high infection rate. Nurse and cleanup personnel shortage at the night shifts and weekends could also be another source. What is more, the government does not provide enough support for infection control at university hospitals (23,27-29). All these may account for the figures in infection control similar to or slightly better than those in some countries but not as good as those in developed countries.

CA-UTI rates were similar with the rates in other developing country, ranging between 1.7 and 12.8 infections per 1000 catheter days in the INICC study, and 1.3 and 9 infections per 1000 catheter days in different European countries; whereas rates in individual developing countries were significantly higher (11,18-20). Turkish data were similar in this case, possibly because of CA-UTI's being the first area of improvement in infection control practices in most of the centers, and because of its being relatively easier to lower this kind of infection (4,12,14,22). These relatively low rates of CA-UTI can also be the result of our educational and infection control programs in our institution. However, the absence of routine usage of closed catheterization systems, lack of adequate number of trained personnel, and limited resources for infection control practices make the difference with the developed countries.

Microorganisms causing VAP in the INICC study was similar to ours with small differences, i.e. *P. aeruginosa,* Enterobacteriaceae, *A. baumannii*, and *S. aureus* being the leading causative agent (11). In a study from Turkey, *P. aeruginosa* was the leading microorganism, followed by *Acinetobacter* spp. and *Candida* spp. (14). Studies from Europe were generally similar except for a small number (Table 4).

The major causative agents in CA-BSIs were CNS and *Acinetobacter* spp. in most of the studies (Table 4). *S. aureus*, *P. aeruginosa*, and *Enterococcus* spp. were also frequently isolated from these kinds of infections in the majority of the hospitals. *S. maltophilia* also attracted attention in one of the studies by an incidence rate of 10.9% (18).

CA-UTIs were mainly caused by *Candida* species in most of the centers in Turkey (12,14,22), but the causative distribution of the European hospitals were quite different and diverse (Table 4) (18,20). The difference from Europe may be due to the unnecessary and prolonged urinary catheterization, use of broad spectrum antibiotics in consequence of resistance, prolonged hospitalization in ICU, and underlying diseases like diabetes mellitus, cancer, and septicemia.

High resistance rates among gram negative bacteria as well as gram positive bacteria were one of the remarking results of our study. When we compare the results with NNIS data where MRSA, VRE, ciprofloxacin, and carbapenem resistant *P. aeruginosa*,

Table 4. Comparison of the most frequent microorganisms isolated from infection sites in selected studies and the present study.

Study	VAP	CA-BSI	CA-UTI
Present study	*A.baumannii* 40% *P.aeruginosa* 18.8% *S.aureus* 13.8% *K.pneumoniae* 9.1%	*A.baumannii* 19.1% *E.faecium* 10.6% CNS 8.4% *S.aureus* 8.4%	*Candida* spp. 31.6% *E.coli* 17.9% *Enterococcus* spp. 8.9% *K.pneumoniae* 7.8%
Dima et al. (20) **Greece, 2007**	*Acinetobacter* spp. 28% *Pseudomonas* spp. 23.2% *S.aureus* 13.6%	CNS 25.4% *Acinetobacter* spp. 20.7% *K.pneumoniae* 14.5% *Enterococcus* spp. 13%	*Streptococcus* spp. 17% *Enterococcus* spp. 17% *Pseudomonas* spp. 14.9% *Klebsiella* spp. 17.8%
***Orsi et al. (18)** **Italy, 2005**	*P.aeruginosa* 38.3% *S.aureus* 22.3% *A.baumannii* 11.7%	CNS 21.9% *P.aeruginosa* 17.2% *S.aureus* 17.2% *S. maltophilia* 10.9%	*P.aeruginosa* 63.6%
Rosenthal et al. (11) **INICC, 2006**	*Enterobacteriaceae* 26% *P.aeruginosa* 26% *S.aureus* 22% *Acinetobacter* spp. 20%	*Enterobacteriaceae* 27% *S.aureus* 25% CNS 18% *Acinetobacter* spp. 13%	E*nterobacteriaceae* 42% *Candida* spp. 30% *P.aeruginosa* 13%
İnan et al. (12) **Turkey, 2006**	*Pseudomonas* spp. 38.3% *Acinetobacter* spp. 27.3% *Klebsiella* spp. 13.4%	CNS 20% *Acinetobacte*r spp. 13.4% *S.aureus* 13.1% *Enterococcus* spp. 12.8%	*Candida* spp. 37.1% *Pseudomonas* spp. 16.5% *E.coli* 12.1%
Turgut et al. (22) **Turkey, 2008**	*Acinetobacter* spp. 26% *Pseudomonas* spp. 24% *E.coli* 11%	CNS 50% *S.aureus* 40%	*Candida* spp. 41% *E.coli* 22% *Pseudomonas* spp. 10%
Doğru et al. (14) **Turkey, 2010**	*P.aeruginosa* 25% *Acinetobacter* spp. 23%	CNS 26.5% *Pseudomonas* spp. 16.3%	*E.coli* 38% *Candida* spp. 41%
****EPIC study (32)** **Europe, 1996**	*Enterobacteriaceae* 34.4% *S. aureus* 30.1% *P. aeruginosa* 28.7% CNS 19.1% Fungi 17.1%		
****HELICS-ICU (33)** **Europe, 2007**	*S. aureus* 19.6% *P. aeruginosa* 18.8% *E. coli* 8.5% *Klebsiella* spp. 8.1%		

VAP: Ventilator associated pneumonia, **CA-BSI:** Catheter associated blood stream infection,
CA-UTI: Catheter-associated urinary tract infection, **CNS:** coagulase negative staphylococci
*The mentioned infections are not device associated. They are nosocomial pneumonia, blood stream infection, and urinary tract infection.
** The mentioned infections are not device associated. Given isolates represent overall results.

rates were 52.4%, 13.9%, 34.8%, and 19.1%, respectively, all our rates were very high and over the 90th percentile (1). Resistance data extracted from the German Nosocomial Infection Surveillance System for ICUs showed lower rates; MRSA and VRE rates were 28.8% and 0.9%, respectively (30). Other resistance surveillance studies from Europe and America also showed significantly lower resistance rates than ours (31-33).

When compared with the rates in developing countries, our rates were similar except for the high VRE rates in our study. In the INICC study MRSA, ceftriaxone-resistant *Enterobactericeae*, Ciprofloxacin-resistant *P. aeruginosa*, and VRE rates were 84%, 55%, 59%, and 5%, respectively (11). A study from Thailand also reported similar resistance rates: MRSA, imipenem resistant *P. aeruginosa*, ceftazidime-resistant *A. baumannii*, third generation cephalosporine resistant *K. pneumoniae*, and ciprofloxacin-resistant *E. coli* rates were 68.8%, 30.9%, 68.8%, 44.6%, and 38.3%, respectively (34).

There are only few Turkish studies reporting the resistance data of IDAIs. One is the report of Turkish branch of the INNIC by Leblebicioğlu with an MRSA rate of 89.2%, and ceftriaxone, ceftazidime, and piperacillin-tazobactam resistant *Enterobactericeae* rates of 48.2%, 52.0%, and 33.2%, respectively. Imipenem and piperacilin-tazobactam resistant *P. aeruginosa* rates were 38.7% and 30.0%, whereas VRE and piperacilin-tazobactam resistant *A. baumannii* rates were 1.9% and 87.1%, respectively (4). A VAP study from İstanbul, Turkey, reports ceftazidime, imipenem, ciprofloxacin, and amikacin resistant *A. baumannii* rates of 90%, 64%, 80%, and 43%, and ceftazidim, piperacilin-tazobactam, imipenem, ciprofloxacin, and amikacin resistant *P. aeruginosa* rates were 59%, 41%, 32%, 62%, and 16%, respectively (35). According to recently published national data, our rates were over the 90th percentile, except MRSA, which decreased significantly in 2009 to the 50th-75th percentiles. All these high resistance rates were linked to lack of infection control practices and the decrease in MRSA rates was thought to be the result of decreased cross-contamination via decreased *S. aureus* rates among causatives (from 14.5% in 2006 to 4.5% in 2009).

The remarkable resistance rates among gram negative and gram positive bacteria in our institute, particularly the VRE rate, represent the lack of infection control practices along with antibiotic control policies. Since 2006, when the national surveillance system was established and surveillance became mandatory in this country, all of the hospitals around Turkey have been reporting their hospital infection rates to the Ministry of Health. However, the outcome of infection control practices was not as good as expected. Possible reasons for this may be the lack of administrative and financial support, lack of feedback, personnel shortage, patient overload due to the fact that it is a reference and training hospital in this region, ineffective compliance to infection control practices, and lack of adequate legislative control. The government also started quality control studies among public hospitals. Unfortunately university hospitals are not included in this implementation and are left to their fate, which can be another cause contributing to the high IDAI and resistance rates.

In conclusion, our hospitals' IDAI rates were similar with the rates in this country and those in neighboring countries but significantly higher than the rates in developed countries. Regarding the increase at resistance rates to most of the available antibiotics, there is an urgent need for implementing infection control measures and more effective antibiotic control policies.

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References

1. National Nosocomial Infections Surveillance System. National Nosocomial Infections Surveillance (NNIS) System report, data summary from January 1992 through June 2004. Am J Infect Control 2004; 32: 470-485.
2. Haley RW, Culver DH, White JW, Morgan WM, Emori TG, Munn VP, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985; 121: 182-205.
3. Weber DJ, Sickbert-Bennett EE, Brown V, Rutala WA. Comparison of hospitalwide surveillance and targeted intensive care unit surveillance of healthcare-associated infections. Infect Control Hosp Epidemiol 2007; 28(12): 1361-1366
4. Leblebicioğlu H, Rosenthal V.D, Arikan OA, Ozgültekin A, Yalcin AN, Koksal I, et al. Device-associated hospital-acquired infection rates in Turkish intensive care units. Findings of the International Nosocomial Infection Control Consortium (INICC). Journal of Hospital Infection 2007; 65: 251-257
5. Vincent JL, Bihari DJ, Suter PM, Bruining HA, White J, Nicolas-Chanoin MH et al. The prevalence of nosocomial infection in intensive care units in Europe. Results of the European Prevalence of Infection in Intensive Care (EPIC) Study. EPIC International Advisory Committee. JAMA 1995; 274: 639-644
6. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections, 1988. Am J Infect Control 1988; 16: 128-140.
7. Jarvis WR, Edwards JR, Culver DH, Hughes JM, Horan T, Emori TG et al. Nosocomial infection rates in adult and pediatric intensive care units in the United States. National Nosocomial Infections Surveillance System. Am J Med 1991; 91(Suppl 3B): 185-191.
8. Thomson RB, Miller JM. Specimen collection, transport and processing: Bacteriology. In Murray PR editors. Manuel of Clinical Microbiology, 8th ed. American Society for Microbiology, Washington D.C.: 2003 P.286-330.
9. Sutton DA. Specimen collection, transport and processing: Mycology. In Murray PR editors. Manual of Clinical Microbiology, 8th ed. American Society for Microbiology, Washington D.C: 2003; 1659-1667.
10. Clinical and Laboratory Standards Institute (CLSI). Performance standard for antimicrobial susceptibility testing. Fifteenth informational supplement. Document M100-S15 (2005) CLSI, Wayne, PA, USA.
11. Rosenthal VD, Maki DG, Salomao R, Moreno CA, Mehta Y, Higuera F et al. Device-associated nosocomial infections in 55 intensive care units of 8 developing countries. Ann Intern Med 2006; 145: 582-591.
12. İnan D, Saba R, Yalcin AN, Yılmaz M, Ongut G, Ramazanoğlu A et al. Device-associated nosocomial infection rates in Turkish medical-surgical intensive care units. Infect Control Hosp Epidemiol 2006; 27: 343-348.
13. Geyik MF, Hosoğlu S, Ayaz C, Celen MK, Ustun C. Surveillance of Nosocomial Infections in Dicle University Hospital: a Ten-Year Experience. Turk J Med Sci 2008; 38: 587-593.
14. Doğru A, Sargın F, Çelik M, Sağıroğlu AE, Göksel MM, Sayhan H. The rate of device-associated nosocomial infections in a medical surgical intensive care unit of a training and research hospital in Turkey: one-year outcomes. Jpn J Infect Dis 2010; 63: 95-98.
15. Edwards JR, Peterson KD, Andrus ML, Tolson JS, Goulding JS, Dudeck MA et al. National Healthcare Safety Network (NHSN) Report, data summary for 2006, issued June 2007. Am J Infect Control 2007; 35: 290-301.
16. Gastmeier P, Geffers C, Sohr D, Dettenkofer M, Daschner F, Rüden H. Five years working with the German nosocomial infection surveillance system (Krankenhaus Infektions Surveillance System). Am J Infect Control 2003; 31: 316-321.
17. van der Kooi TI, de Boer AS, Manniën J, Wille JC, Beaumont MT, Mooi BW et al. Incidence and risk factors of device-associated infections and associated mortality at the intensive care in the Dutch surveillance system. Intensive Care Med 2007; 33: 271-278.
18. Orsi GB, Raponi M, Franchi C, Rocco M, Mancini C, Venditti M. Surveillance and infection control in an intensive care unit. Infect Control Hosp Epidemiol 2005; 26: 321-325.
19. Lizan-Garcia M, Peyro R, Cortina M, Crespo MD, Tobias A. Nosocomial infection surveillance in a surgical intensive care unit in Spain, 1996-2000: a time-trend analysis. Infect Control Hosp Epidemiol 2006; 27: 54-59.
20. Dima S, Kritsotakis EI, Roumbelaki M, Metalidis S, Karabinis A, Maguina N et al. Device-associated nosocomial infection rates in intensive care units in Greece. Infect Control Hosp Epidemiol 2007; 28: 602-605.
21. Erdem I, Ozgultekin A, Sengoz InanA, Dincer E, Turan G, Ceran N et al. Incidence, etiology, and antibiotic resistance patterns of gram-negative microorganisms isolated from patients with ventilator-associated pneumonia in a medical-surgical intensive care unit of a teaching hospital in Istanbul, Turkey (2004-2006). Jpn J Infect Dis 2008; 61: 339-342.
22. Turgut H, Sacar S, Okke D, Kavas ST, Asan A, Kutlu SS. Evaluation of device-associated infection rates in intensive care units of Pamukkale university hospital. Infection 2008; 36: 262-265.
23. Türkiye Hastane Enfeksiyonları Sürveyans Raporu 2006-2007. Turk J Hosp Infect 2009; 13(4): 215-269.
24. Rosenthal VD, Guzmán S, Crnich C. Device-associated nosocomial infection rates in intensive care units of Argentina. Infect Control Hosp Epidemiol 2004; 25: 251-255.
25. Finkelstein R, Rabino G, Kassis I, Mahamid I. Device-associated, device-day infection rates in an Israeli adult general intensive care unit. J Hosp Infect 2000; 44: 200-205.

26. Yılmaz G, Caylan R, Aydin K, Topbaş M, Köksal I. Incidence and Risk Factors for Intravascular Catheter-Related Infections. FLORA 2009; 14: 118-127.

27. Fridkin SK, Pear SM, Williamson TH, Galgiani JN, Jarvis WR. The role of understaffing in central venous catheter-associated bloodstream infections. Infect Control Hosp Epidemiol 1996; 17: 150-158.

28. Vicca AF. Nursing staff workload as a determinant of methicillin-resistant Staphylococcus aureus spread in an adult intensive therapy unit. J Hosp Infect 1999; 43: 109-113.

29. Andersen BM, Lindemann R, Bergh K, Nesheim BI, Syversen G, Solheim N et al. Spread of methicillin-resistant Staphylococcus aureus in a neonatal intensive unit associated with understaffing, overcrowding and mixing of patients. J Hosp Infect 2002; 50: 18-24.

30. Kohlenberg A, Schwab F, Geffers C, Behnke M, Rüden H, Gastmeier P. Time-trends for Gram-negative and multidrug-resistant Gram-positive bacteria associated with nosocomial infections in German intensive care units between 2000 and 2005. Clin Microbiol Infect 2008; 14: 93-96.

31. Jones RN. Global epidemiology of antimicrobial resistance among community-acquired and nosocomial pathogens: a five-year summary from the SENTRY Antimicrobial Surveillance Program (1997-2001). Semin Respir Crit Care Med 2003; 24: 121-134.

32. Vincent JL, Bihari DJ, Suter PM, Bruining HA, White J, Nicolas-Chanoin MH et al. The prevalence of nosocomial infection in intensive care units in Europe. Results of the European Prevalence of Infection in Intensive Care (EPIC) Study. EPIC International Advisory Committee. JAMA 1995; 274: 639-644.

33. Suetens C, Morales I, Savey A, Palomar M, Hiesmayr M, Lepape A et al. European surveillance of ICU-acquired infections (HELICS-ICU): methods and main results. J Hosp Infect 2007; 65 S2: 171-173.

34. Thongpiyapoom S, Narong MN, Suwalak N, Jamulitrat S, Intaraksa P, Boonrat J et al. Device-associated infections and patterns of antimicrobial resistance in a medical-surgical intensive care unit in a university hospital in Thailand. J Med Assoc Thai 2004; 87: 819-824.

35. Erdem I, Ozgultekin A, Sengoz Inan A, Dincer E, Turan G, Ceran N et al. Incidence, etiology, and antibiotic resistance patterns of gram-negative microorganisms isolated from patients with ventilator-associated pneumonia in a medical-surgical intensive care unit of a teaching hospital in Istanbul, Turkey (2004-2006). Jpn J Infect Dis 2008; 61: 339-342.