

1 **Impact of Education and Process Surveillance on Device-Associated Health**  
2 **Care-Associated Infection Rates in a Turkish ICU: International**  
3 **Nosocomial Infection Control Consortium's (INICC) Findings**

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19 **ABSTRACT**

20 **Objective:** The aim of this study was to analyze the impact of process and outcome  
21 surveillance on rates of device-associated health care-associated infections (DA-HAI) in an  
22 intensive care unit (ICU) in Turkey over a four-year period.

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24 **Patients and Methods:** An open label, prospective cohort, active DA-HAI surveillance study  
25 was conducted on 685 patients admitted to the ICU of a university hospital in Turkey from  
26 January 2004 to December 2007, implementing the methodology developed by the  
27 International Nosocomial Infection Control Consortium. DA-HAI rates were recorded  
28 according to Centers for Disease Control and Prevention (CDC) National Healthcare Safety  
29 Network (NHSN) definitions. We analyzed the rates of DA-HAI, mechanical ventilator-  
30 associated pneumonia (VAP), central line-associated bloodstream infection (CLA-BSI), and  
31 catheter-associated urinary tract infection (CAUTI), as well as microorganism profile, extra  
32 length of stay, and hand hygiene compliance. Pooled DA-HAI rates were calculated and  
33 compared by year.

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35 **Results:** The DA-HAI rate per 100 patients declined as follows: for 2004, the DA-HAI rate  
36 was 58.4%; for 2005, it was 38.9%; for 2006, it was 34.8%; and for 2007, it was 10.9%. The  
37 DA-HAI rate per 1,000 bed-days also declined: for 2004, it was 42.8, and for 2007 it was  
38 10.7. The rates decreased from 25.8 to 13.4 for VAP; from 29.9 to 25.0 for CLA-BSI; and  
39 from 9.2 to 6.2 for CAUTI cases per 1,000 device-days during the study period.

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41 **Conclusion:** Process and outcome surveillance of DA-HAI significantly reduced DA-HAI.

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43 **Key Words:** Health care-associated infection; ventilator-associated pneumonia; central line-  
44 associated bloodstream infection; catheter-associated urinary tract infection; outcome and  
45 process surveillance; hand hygiene; intensive care unit

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## INTRODUCTION

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50 Healthcare-associated infections from invasive medical devices in the intensive care  
51 unit (ICU), particularly central line-associated bloodstream infection (CLA-BSI), ventilator-  
52 associated pneumonia (VAP), and catheter-associated urinary tract infection (CAUTI), have  
53 been shown to pose the greatest threat to patient safety (1-7). Over the past decade, studies  
54 conducted in the industrialized western countries have shown that a systematized institutional  
55 approach, ensuring a very high level of compliance with essential infection control practices,  
56 has brought striking reductions in the incidence of device-associated health care-associated  
57 infections (DA-HAIs) in ICU patients (8-12).

58 The Institute for Healthcare Improvement (IHI) started 100,000 Lives Campaign in  
59 United States hospitals to improve patient care and prevent avoidable deaths in 2005.  
60 Eliminating VAP and CLA-BSI is the focus of two of the six interventions that have been  
61 widely implemented with great success. When done in concert, these interdependent steps,  
62 also called "bundles," typically result in significantly better outcomes than when implemented  
63 individually. The components of the bundles may be different from center to center (13).

64 In 2002, the International Nosocomial Infection Control Consortium (INICC) was  
65 established in countries of the developing world. INICC found that rates of DA-HAI in the  
66 ICUs of the hospitals in these countries, with very limited resources, were three to five times  
67 higher than the rates in North American ICUs (2-4, 14-17). Because of these resource  
68 limitations, INICC has focused its efforts on reducing the incidence of DA-HAI in these  
69 hospitals by implementing the following, on an educational basis: outcome surveillance,  
70 including rates of DA-HAI; process surveillance, including compliance with hand hygiene,  
71 compliance with prevention of VAP, CLA-BSI, and CAUTI with standardized checklists,

72 proven to reduce the incidence of DA-HAI; and performance feedback of each ICU's  
73 surveillance data to the healthcare personnel working in that unit (18).

74           The aims of this study were to determine the DA-HAI rates in an INICC member  
75 university hospital ICU in Turkey and to perform a time-sequence analysis of the efficacy of  
76 education and process surveillance to controlling DA-HAIs.

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**PATIENTS AND METHODS**

A prospective study was conducted on patients hospitalized in a tertiary medical-surgical ICU in Ondokuz Mayıs University Hospital, Turkey. The study was carried out between January 2004 and December 2007 in a 900-bed teaching hospital. At the beginning of the study, only eight beds were actively occupied. During the last two years of the study period, the ICU wards were distributed into two services, each with five beds, plus one isolation room. The unit runs two shifts per day, with two full-time anesthesia specialists and three anesthesia residents on the day shift and two anesthesia residents on the night shift. The average nurse-to-patient ratio is one nurse per three patients. Throughout the study, the patients were consulted by an infectious diseases specialist on a daily basis. Data was collected by infection-control nurses based on standard surveillance charts. Infection control measures and guidelines for the prevention of nosocomial infections were applied according to national and Centers for Disease Control and Prevention (CDC) guidelines (12, 19-25).

The hand hygiene program was reviewed in January 2005, after a baseline intervention period of INICC study. Compliance with hand hygiene recommendations improved significantly by following a hospital-wide education program, which was mainly based on a colorful education paper and hand hygiene techniques with a generalized use of alcohol hand rubs and soap-and-water hand-washing.

Isolation precautions were strictly applied, according to national and international guidelines (26, 27). ICU staff (doctors, residents, and nurses) and infection-control teams met on a weekly basis to evaluate the hand hygiene education program and results of the DA-HAI rates in the ICU.

103           **Definitions**

104           Within the hospital, standard laboratory methods were used to identify and test the  
105           susceptibility of microorganisms, and standardized CDC definitions were used for central  
106           line-associated bloodstream infection (CLA-BSI), ventilator-associated pneumonia (VAP),  
107           and catheter-associated urinary tract infection (CAUTI) (28).

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109           **Outcome and Process Surveillance**

110           Outcome Surveillance includes rates of CLA-BSI, VAP, and CAUTI per 1000 device-  
111           days. Process Surveillance includes compliance rates for hand hygiene and selected infection  
112           control measures for the prevention of CLA-BSI, CAUTI, and VAP (18). Hand hygiene  
113           compliance by healthcare workers, based on the frequency of hand hygiene practices when  
114           clearly indicated, was monitored by the hospital infection-control practitioner (ICP) during  
115           randomly selected one-hour observation periods, three times per week. Healthcare workers  
116           were aware that hand hygiene practices would be monitored, but they were not informed of  
117           the schedule during which observations would take place. Vascular-catheter care compliance  
118           was assessed and incorporated in a standardized form designed by the INICC (18). Placement  
119           of gauze on intravenous device (IVD) insertion sites, marking the date on the intravenous  
120           administration set, and condition of the sterile gauze or transparent sterile dressing were  
121           assessed by the ICP in the study ICU five days per week. The condition of the gauze was  
122           evaluated by monitoring the presence or absence of moisture or blood, as well as grossly  
123           soiled conditions. Urinary catheter care compliance was monitored and incorporated in a  
124           standardized form designed by the INICC (18). The aspects analyzed were the following:  
125           presence of the catheter on the thigh, presence of the urine collection bag below bladder level,  
126           and no floor contact. Mechanical ventilator care compliance was monitored and incorporated  
127           in a standardized form designed by the INICC (18). Some aspects that were evaluated were

128 absence of liquid in the tubules, absence of mucus in the tubules, position of the head of the  
129 patient's bed at 30-45 degrees, absence of a sub-droplet lake, and a well-inflated intratracheal  
130 balloon, among others.

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### 132 **Statistical Analysis**

133 Epi-Info version 6.04b (CDC, Atlanta, GA) and SPSS version 16.0 (SPSS Inc. [an  
134 IBM company], Chicago, IL) were used for data analysis. Length of stay, bacterial resistance,  
135 hand hygiene compliance, and features of intervention were analyzed by year and compared  
136 using 95% confidence intervals (CI).

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138           **RESULTS**

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140           Overall, 685 patients were hospitalized during the four years of the study. The  
141 patients' characteristics are shown in Table 1.

142           In 2004, hand hygiene compliance was 68.9% [95% CI 65.7-72.1]; it increased in  
143 2005, remaining high until the end of the study (2007: 91.2% [95% CI 88.5-93.4]) (Table 2).

144           The number of bed-days, DA-HAI rate per 100 patients, central line days, central line  
145 duration, CLABSI per 1000 central line days, mechanical ventilation (MV) duration, VAP per  
146 1000 MV days, rate (95% CI), urinary catheter (UC), UC duration, CAUTI per 1000 UC  
147 days, rate (95% CI) are shown stratified by year in Table 3.

148           The DA-HAI rates were compared with INICC and NHSN. In 2004 and 2007, the  
149 results of CLABSI, VAP, and CAUTI rates in our ICU decreased from 29.9 to 25.0, from  
150 25.8 to 13.4, and from 9.2 to 6.2, respectively (Table 4).

151           The average length of stay (LOS) of patients without DA-HAI remained similar during  
152 the entire study period. The average LOS of patients with DA-HAI was higher than that of  
153 non-infected patients (Table 5).

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155           **Bacterial Resistance**

156           Bacterial resistance rates changed during the study period in relation to micro-  
157 organisms. Ninety-one percent (95% CI 83.2–96.1) of *Staphylococcus aureus* were  
158 methicillin-resistant in 2004, and 62.5% (95% CI 40.5–81.23) were resistant in 2007.  
159 Ceftazidime-resistant *Pseudomonas* represented 51.6% (95% CI 38.7–64.3) of all  
160 *Pseudomonas* in the first year of study and 20.8% (95% CI 7.1–42.2) in 2007. Thirty-seven  
161 percent (95% CI 25.7–50.0) of *Pseudomonas* sp. were resistant to imipenem in 2004, and  
162 7.7% (95% CI 8.7–25.2) were resistant in 2007. Eighty-one percent (95% CI 72.6–87.5) of

163 *Coagulase-Negative Staphylococci* were resistant to methicillin in 2004, and 78.0% (95% CI  
164 64.0–88.5) were resistant in 2007. There was no *E. coli* resistance to imipenem during the  
165 entire period. Finally, *Acinetobacter* sp. resistance to Piperacillin-Tazobactam was 78% (95%  
166 CI 60.0–90.7) in 2004 and rose to 94.4% (95% CI 84.6–98.9) in 2007.

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## DISCUSSION

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The present study is the first report on time-sequence analysis of DA-HAI rates in ICUs in our country. Our results show that the DA-HAI rate per 1000 bed-days declined from 42.8 to 10.7 ( $p<0.01$ ). We also showed that education on infection control procedures, including hand hygiene, was successfully performed during the study period.

Most limited-resource countries do not have laws mandating DA-HAI control programs, and hospital accreditation is rarely required. In 2005, a regulation requiring a DA-HAI control program and a reporting system for each hospital in Turkey was introduced. After this regulation was adopted in developing countries, the quality of data and compliance with infection control procedures started to increase on a yearly basis (29). Funds and resources for infection control are very limited, nurse-to-patient staffing ratios are far lower on average than in ICUs of developed countries, and there are larger proportions of inexperienced nurses, all conditions that have been shown to be powerfully associated with increased risk of DA-HAI (30, 31). In addition, healthcare workers (HCW) can easily spread microorganisms from patient to patient with their hands. Our ICU was designed and constructed according to ICU standards in 2004. Patient staffing ratios were not low, but the nurse-to-patient ratio was lower on average than in ICUs in developed countries (31, 32). Hospitals participating in the INICC program were expected to communicate the results of DA-HAI surveillance to physicians, nurses, and hospital administrators, with the expectation that these data would fuel efforts to improve compliance with hand hygiene and other basic infection-control practices being promoted at the time, ultimately reducing the incidence of DA-HAIs in patients.

VAP and CAUTI rates in 2007 in our ICU were similar to those presented in the INICC report (14). However, as previously shown and reaffirmed in the INICC report, which

193 includes our ICU data, ICUs in developing countries have rates of CLABSI, VAP, and  
194 CAUTI three to five times higher than the rates reported in North American ICUs (15-17, 33).  
195 Although our survey showed a decreasing trend in the CLABSI rate, we must show a more  
196 concerted effort to reduce this rate.

197         According to many published related studies, DA-HAI has a positive correlation with  
198 average length of ICU stay, with DA-HAI rates increasing with increased length of ICU stay  
199 (3, 5, 6, 31, 34). During the study period, the average length of hospital stay with DA-HAI  
200 ranged from 18.2 to 25.7 days. These results show that patients had an increased risk of DA-  
201 HAI during their stay in the ICU. As a consequence of these facts, well-designed infection  
202 control programs and successful efforts of the HCWs decreased LOS in the ICU. Therefore,  
203 good use of the capacity of ICU beds might decrease the risks of DA-HAI and the rate of  
204 mortality, thereby improving the quality of health care. However, having infection control  
205 guidelines without outcome and process surveillance is not enough to prevent DA-HAI. The  
206 efforts of the ICP, good communication with HCWs, the use of educational tools (posters),  
207 and the evaluation of feedback improve compliance and can decrease the cross-transmission  
208 of DA-HAIs.

209         Resistance to methicillin declined in *Staphylococcus aureus* during the study period. It  
210 is one of the expected consequences of infection control measures. In contrast, resistance to  
211 Piperacillin-Tazobactam increased in *Acinetobacter* species. Staphylococcal infections are  
212 declining in intensive care units in Turkey. However, multi-drug-resistant *Acinetobacter*  
213 infections have been increasing in recent years. Our ICU, which admits critically ill patients  
214 from various local hospitals, is a reference center in our region. We think that insufficient  
215 isolation and screening of patients during admission to our unit is an important cause of  
216 increasing resistance. Another cause of this condition may be the transmission of  
217 microorganisms from patient to patient.

218           This study has some limitations. We cannot exclude the possibility that the observed  
219 decline in DA-HAIs after joining INICC simply represented a spontaneous downward trend in  
220 the incidence of DA-HAI, unrelated to the activities of the institutional ICP and the  
221 continuous feedback of institutional data from the central INICC office. However, we think  
222 this is unlikely, as there has been only a modest decline in the baseline rate of DA-HAIs of  
223 new hospitals joining INICC, over the development of the program to date, far less than the  
224 striking reductions seen in each cohort analyzed over the first 12-month intervention period.  
225 Another limitation is that the study design does not permit an accurate determination of the  
226 epidemiologic mechanisms responsible for the striking decline in DA-HAIs during the  
227 intervention period.

228           Hospitals worldwide may participate for free in the non-profit International  
229 Nosocomial Infection Control Consortium (INICC) network, which was created out of an  
230 understanding of the paramount need for developing countries to significantly prevent,  
231 control, and reduce DA-HAI and their adverse consequences. In INICC, not only are  
232 investigators freely provided with training and methodological tools to conduct outcome and  
233 process surveillance, but through the publication of these confidentially collected data,  
234 relevant scientific evidence-based literature is fostered as well.

235           In conclusion, this study has shown that by providing basic education in infection  
236 control, conducting surveillance of DA-HAI, and providing continuous performance feedback  
237 in the ICU, substantial improvements in infection rates have been achieved. These findings  
238 were paralleled by an 89% decline in the rate of DA-HAI per 100 patients by the third year of  
239 active participation in INICC.

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361 **Table 1.** Characteristics of Patients at Baseline and During the Intervention Period

<b>Year</b>	<b>N° of patients</b>	<b>Sex (male), n (%)</b>	<b>Age (mean)</b>	<b>ASIS score, (mean)</b>
<b>2004</b>	149	79 (53)	49.0	3.59
<b>2005</b>	144	82 (57)	42.7	3.62
<b>2006</b>	181	102 (56)	46.9	3.78
<b>2007</b>	211	147 (70)	44.3	3.56

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ASIS, average severity illness score

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368 **Table 2.** Hand Hygiene Compliance Stratified by Year

	<b>HH compliance</b>	<b>95% CI</b>
<b>2004</b>	68.9% (577/837)	65.7 - 72.1
<b>2005</b>	84.3% (665/789)	81.5 - 86.8
<b>2006</b>	88.0% (641/728)	85.5 - 90.3
<b>2007</b>	91.2% (516/566)	88.5 - 93.4

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372 **Table 3.** Device Utilization Rate in the ICU by Year, between 2004 and 2007

<b>Year</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>Bed Days</b>	2035	1663	2415	2149
<b>DA-HAI per 100 patients, rate (95% CI)</b>	58.4% (50.1 – 66.4)	38.9% (30.9 – 47.4)	34.8% (27.9 – 42.2)	10.9% (7.02 – 15.9)
<b>Central Line days</b>	1338	1189	817	400
<b>Central Line Duration</b>	0.66	0.71	0.34	0.19
<b>CLABSI per 1000 CL days, rate (95% CI)</b>	29.9% (21.4 – 40.5)	15.1% (8.9 – 23.8)	23.3% (14.0 – 36.1)	25.0% (12.0 – 45.6)
<b>Mechanical Ventilator</b>	1164	1234	1305	746
<b>MV Duration</b>	0.57	0.74	0.54	0.35
<b>VAP per 1000 MV days, rate (95% CI)</b>	25.8% (17.4 – 36.6)	21.9% (14.5 – 31.7)	21.5% (14.3 – 30.9)	13.4% (6.4 – 24.6)
<b>Urinary catheter</b>	1851	1603	1702	480
<b>UC Duration</b>	0.91	0.96	0.70	0.22
<b>CAUTI per 1000 urinary catheter days, rate (95% CI)</b>	9.2% (5.4 – 14.7)	6.9% (3.4 – 12.3)	9.4% (5.4 – 15.2)	6.2% (1.3 – 18.2)

373 ICU, intensive care unit; DA-HAI, device associated health care associated infection;  
374 CLABSI, central line associated bloodstream infection; CL, central line; MV, mechanical  
375 ventilator; VAP, ventilator associated pneumonia; CI, confidence interval; UC, urinary  
376 catheter; CAUTI, catheter associated urinary tract infection.

379 **Table 4.** Comparison of the rates of DAI between INNIC, NHSN and our results

<b>Study and Period</b>	<b>CLABSI rate</b>	<b>VAP rate</b>	<b>CAUTI rate</b>
<b>INICC (2003-2008)</b>	7.6	13.6	6.3
<b>NHSN (2006-2007)</b>	2.0	3.0	3.0
<b>Present study (2004-2007)</b>	25.0	13.4	6.2

380 INICC, International Nosocomial Infection Control Consortium; NHSN, National Healthcare  
381 Safety Network; ICU, intensive care unit; CLABSI, central line-associated bloodstream  
382 infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract  
383 infection

386 **Table 5.** Bed Days by Years for ICU Patients with and without DA-HAI in 2004 and 2007

<b>Year</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>Overall bed days of patients without DA-HAI</b>	442	655	1294	1730
<b>Average Length of Stay of patients without DA-HAI (95% CI)</b>	5.1 (4.2 – 6.2)	6.3 (5.3 – 7.6)	9.8 (8.3 – 11.6)	9.2 (8.0 – 10.6)
<b>Overall bed days of patients with DA-HAI</b>	1593	1008	1121	419
<b>Average Length of Stay of patients with DA-HAI (95% CI)</b>	25.7 (20.1 – 33.4)	25.2 (18.6 – 35.1)	22.9 (17.4 – 30.8)	18.2 (12.3 – 28.5)

387 DA-HAI, device-associated health care associated infection; CI, confidence interval