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Impact of Education and Process Surveillance on Device-Associated Health Care-Associated Infection Rates in a Turkish ICU: Findings of the International Nosocomial Infection Control Consortium (INICC)

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ABSTRACT

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

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

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

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

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

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Introduction

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

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

In 2002, the International Nosocomial Infection Control Consortium (INICC) was established in countries of the developing world. INICC found that rates of DA-HAI in the ICUs of the hospitals in these countries, with very limited resources, were three to five times higher than the rates in North American ICUs (2-4, 14-17). Because of these resource limitations, INICC has focused its efforts on reducing the incidence of DA-HAI in these hospitals by implementing the following, on an educational basis: outcome surveillance, including rates of DA-HAI; process surveillance, including compliance with hand hygiene, compliance with prevention of VAP, CLA-BSI, and CAUTI with standardized checklists, proven to reduce the incidence of DA-HAI; and performance feedback of each ICU's surveillance data to the healthcare personnel working in that unit (18).

The aims of this study were to determine the DA-HAI rates in an INICC member university hospital ICU in Turkey and to

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perform a time-sequence analysis of the efficacy of education and process surveillance in controlling DA-HAIs.

Material and Methods

A prospective study was conducted on patients hospitalized in a tertiary medical-surgical ICU in Ondokuz Mayis 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 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.

Definitions

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

Outcome and Process Surveillance

Outcome Surveillance includes rates of CLA-BSI, VAP, and CAUTI per 1000 device-days. Process Surveillance includes compliance rates for hand hygiene and selected infection control measures for the prevention of CLA-BSI, CAUTI, and VAP (18). Hand hygiene compliance by healthcare workers, based on the frequency of hand hygiene practices when clearly indicated, was monitored by the hospital infection-control practitioner (ICP) during randomly selected one-hour observation periods, three times per week. Healthcare workers were aware that hand hygiene practices would be monitored, but they were not informed of the schedule during which observations would take place. Vascular-catheter care compliance was assessed and incorporated in a standardized form designed by the INICC (18). Placement of gauze on intravenous device (IVD) insertion sites, marking the date on the intravenous administration set, and the condition of the sterile gauze or transparent sterile dressing were assessed by the ICP in the study ICU five days per week. The condition of the gauze was evaluated by monitoring the presence or absence of moisture or blood, as well as grossly soiled conditions. Urinary catheter care compliance was monitored and incorporated in a standardized form designed by the INICC (18). The aspects analyzed were the following: presence of the catheter on the thigh, presence of the urine collection bag below bladder level, and no floor contact. Mechanical ventilator care compliance was monitored and incorporated in a standardized form designed by the INICC (18). Some aspects that were evaluated were absence of liquid in the tubules, absence of mucus in the tubules, position of the head of the patient's bed at 30-45 degrees, absence of a sub-droplet lake, and a well-inflated intratracheal balloon, among others.

Statistical analysis

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

Results

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

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

The number of bed-days, DA-HAI rate per 100 patients, central line days, central line duration, CLABSI per 1000 central line days, mechanical ventilation (MV) duration, VAP per 1000 MV days, rate (95% CI), urinary catheter (UC), UC dura-

Table 1. Characteristics of patients at baseline and during the intervention period

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

ASIS, average severity illness score

Table 2. Hand hygiene compliance stratified by year

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

tion, CAUTI per 1000 UC days, rate (95% CI) are shown stratified by year in Table 3.

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

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

Bacterial resistance

Bacterial resistance rates changed during the study period in relation to micro-organisms. Ninety-one percent (95% CI 83.2-96.1) of *Staphylococcus aureus* were methicillin-resistant in 2004, and 62.5% (95% CI 40.5-81.23) were resistant in 2007. Ceftazidime-resistant *Pseudomonas* represented 51.6% (95% CI 38.7-64.3) of all *Pseudomonas* in the first year of study and 20.8% (95% CI 7.1-42.2) in 2007. Thirty-seven percent (95% CI 25.7-50.0) of *Pseudomonas* sp. were resistant to imipenem in 2004, and 7.7% (95% CI 8.7-25.2) were resistant in 2007. Eighty-one percent (95% CI 72.6-87.5) of *Coagulase-Negative Staphylococci* were resistant to methicillin in 2004, and 78.0% (95% CI 64.0-88.5) were resistant in 2007. There was no *E. coli* resistance to imipenem during the entire period. Finally, *Acinetobacter* sp. resistance to Piperacillin-Tazobactam was 78% (95% CI 60.0-90.7) in 2004 and rose to 94.4% (95% CI 84.6-98.9) in 2007.

Table 3. Device utilization rate in the ICU by year, between 2004 and 2007

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

ICU, intensive care unit; DA-HAI, device associated health care associated infection; CLABSI, central line associated bloodstream infection; CL, central line; MV, mechanical ventilator; VAP, ventilator associated pneumonia; CI, confidence interval; UC, urinary catheter; CAUTI, catheter associated urinary tract infection; DU, device utilization rate

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

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

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

Discussion

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).

Table 5. Bed days by years for ICU patients with and without DA-HAI in 2004 and 2007

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

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

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

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

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

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

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

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

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Conflict of Interest

No conflict of interest was declared by the authors.

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