
Ahmet Dilek¹, Fatma Ülger¹, Şaban Esen², Musa Acar¹, Hakan Leblebicioğlu², Victor D. Rosenthal³

¹Department of Anesthesiology and Reanimation, Faculty of Medicine, Ondokuz Mayıs University, Samsun, Turkey
²Department of Clinical Microbiology and Infectious Diseases, Faculty of Medicine, Ondokuz Mayıs University, Samsun, Turkey
³International Nosocomial Infection Control Consortium, Buenos Aires, Argentina

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

Received: 15.09.2011 Accepted: 12.10.2011

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; 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
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 (CLABSI), 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 duration 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 (CLABSI), 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 duration 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 (CLABSI), 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 durat...
Efficacy of Process and Outcome Surveillance

Dilek et al.

NHSN and our results

Table 4. Comparison of the rates of DAI between INNIC, 2004 and 2007

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

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; DU, device utilization rate.

Bacterial resistance

Bacterial resistance rates changed during the study period in relation to micro-organisms. Ninety-one percent (95% CI 84.6-98.9) in 2004, and 78% (95% CI 60.0-90.7) in 2004 and rose to 94.4% (95% CI 84.6-98.9) in 2007.

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

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall bed days of patients without DA-HAI</td>
<td>442</td>
<td>655</td>
<td>1294</td>
<td>1730</td>
</tr>
<tr>
<td>Average Length of stay of patients without DA-HAI</td>
<td>5.1</td>
<td>6.3</td>
<td>9.8</td>
<td>9.2</td>
</tr>
<tr>
<td>(5.2-6.2)</td>
<td>(5.3-7.6)</td>
<td>(8.3-11.6)</td>
<td>(8.0-10.6)</td>
<td></td>
</tr>
<tr>
<td>Overall bed days of patients with DA-HAI</td>
<td>1593</td>
<td>1008</td>
<td>1121</td>
<td>419</td>
</tr>
<tr>
<td>Average Length of stay of patients with DA-HAI</td>
<td>25.7</td>
<td>25.2</td>
<td>22.9</td>
<td>18.2</td>
</tr>
<tr>
<td>(20.1-33.4)</td>
<td>(18.6-35.1)</td>
<td>(12.3-28.5)</td>
<td>(12.3-28.5)</td>
<td></td>
</tr>
</tbody>
</table>

DA-HAI, device-associated health care associated infection; CI, confidence interval.
Staphylococcal infections are declining in intensive care units. Piperacillin-Tazobactam increased in species Acinetobacter sequences of infection control measures. In contrast, resistance decreases the cross-transmission of DA-HAIs.

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, 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 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.

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.

Acknowledgments
The authors thank the many health care professionals at the hospital who assisted with conducting surveillance, including the surveillance nurses, clinical microbiology laboratory personnel, and the physicians and nurses providing care for the patients during the study; without their cooperation and generous assistance, this study would not have been possible. We also thank Mariano Vilar, Debora López Burgardt, and Alejandro Ponce de Leon, who work at INICC headquarters in Buenos Aires, for their hard work and commitment to achieving INICC goals; and the INICC Advisory Board (Carla J. Alvarado, Gary L. French, Nicholas Graves, William R. Jarvis, Patricia Lynch, Dennis Maki, Russell N. Olmsted, Didier Pittet, Wing Hong Seto, and William Rutala), who have so generously supported this unique international infection control network.

Conflict of Interest
No conflict of interest was declared by the authors.

References


