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Major article

# Evaluation of the effectiveness of an infection control program in adult intensive care units: A report from a middle-income country

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***Background:*** The rates of hand hygiene improvement and health care–associated infections (HAIs) were evaluated after the introduction in 2004 of an infection surveillance and prevention program at a university teaching hospital in a low- to middle-income country.

***Methods:*** Data on hand hygiene compliance, HAI rate, multiresistant organisms, and antibiotic consumption in 4 adult intensive care units (ICUs; medical, general surgery, anesthesiology and reanimation, and neurosurgery) were collected retrospectively for each year from 2004 to 2012. Negative binomial regression modeling with a log link was used to adjust for overdispersion in observations, and the first year of observations served as the baseline for comparing changes in incidence rate ratio (IRR) over the subsequent years.

***Results:*** Total hand hygiene compliance improved from 30.5% in 2004 to 43.5% by 2010 (IRR, 1.3; $P < .0001$) and reached 63.8% by 2012 (IRR, 1.9; $P < .0001$). The HAI rate was 42.6/1,000 patient-days at baseline and increased significantly thereafter until 2012, when it decreased by 20% to 33.6/1,000 patient-days (IRR, 0.8; $P = .001$). The rate of central line–associated bloodstream infection was 7.85 (95% confidence interval [CI], 5.89-10.26)/1,000 catheter-days in 2004 and increased to 12.4 (95% CI, 9.98-14.39)/1,000 catheter-days in 2012 (IRR, 1.5; $P = .024$). The rate of ventilator-associated pneumonia remained stable from the 2004 baseline rate of 31.66/1,000 ventilator-days to the 2012 rate of 24.04/1,000 ventilator-days (IRR, 0.88; $P = .574$). The rate of catheter-associated urinary tract infection remained relatively stable between 2004 and 2012 (from 7.92/1,000 catheter-days to 4.97/1,000 catheter-days; $P = .101$). The rate of methicillin-resistant *Staphylococcus aureus* infection was 6.24/1,000 patient-days at baseline and decreased significantly to 0.73/1,000 patient-days by 2007 (IRR, 0.13; $P < .001$) and continued to remain below 2/1,000 patient-days for the next 5 years. The rate of *Pseudomonas aeruginosa* infection decreased significantly from 8.66/1,000 patient-days in 2004 to 6.09/1,000 patient-days in 2010 (IRR, 0.72; $P = .026$) and to 5.44/1,000 patient-days by 2012 (IRR, 0.63; $P = .002$). The rate of *Acinetobacter baumannii* infection was 14.3/1,000 patient-days at baseline, decreased significantly by 2005 (IRR, 0.73; $P = .012$), fluctuated between 2006 and 2010, and then decreased significantly to 10.44/1,000 patient-days in 2011 (IRR, 0.74; $P = .007$) and then to 7.6/1,000 patient-days in 2012 (IRR, 0.53; $P < .001$). Antibiotic consumption did not decrease noticeably over the 9-year study period.

***Conclusions:*** Hand hygiene improved in all of the ICUs evaluated. Measuring changes in HAI rates in a single health care setting can be statistically challenging, and a bias in the detection rates is not uncommon in the early years of a new infection prevention program. Here, for the first time, implementation of an infection surveillance and prevention program was associated with a reduction in HAI rate.



Health care-associated infections (HAIs) are a serious patient safety issue in hospitals worldwide. HAIs affect approximately 5%-10% of admitted patients and can be life-threatening for patients in intensive care units (ICUs) even in high-income countries.[1] The burden of HAIs is greater in hospitals in low- to middle-income

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countries, with >25% of patients acquiring at least 1 HAI during hospital admission.[2] In high-resource health care settings, an estimated two-thirds of HAIs are considered preventable when effective infection control measures are implemented.[1] The applicability of preventive programs to low- to middle-income countries is unknown, owing to the limited available surveillance data.[2] In the present study, we examined hand hygiene compliance and HAI rate data collected during our 9-year survey for changes after the introduction of a national surveillance program in a university hospital in a middle-income country.

## METHODS

### *The institution and infection control program*

The World Bank classifies Turkey as a middle-income country.[3] In the mid-1980s, individual nonstandardized infection control programs were developed by Turkish hospitals in response to increased HAI rates. In 2000, the Turkish Society of Hospital Infection and Control began developing standardized guidelines and infection control training courses for nurses and doctors. In 2005, the Turkish Ministry of Health prioritized infection control by requiring hospitals to collect HAI rates and document infection control activities. The Turkish national surveillance system was then rolled out in 2006.[4]

Erciyes University Hospital provides tertiary referral care in the Central Anatolian region of Turkey. The hospital was established in 1976 with 126 beds and has since grown to its current capacity of 1,300 beds. The hospital serves approximately 5 million people and has 65,000 admissions annually. It has 55 intensive care beds across 4 level III adult ICUs; 18 in a medical ICU (MICU), 12 in an anesthesiology and reanimation ICU (ARICU), 12 in a general surgery ICU (GSICU), and 13 in a neurosurgery ICU (NSICU). Renovations to the hospital started in 2004. The ICUs were renovated in 2010; changes included bed spacing >1.5 m; 1 isolation room for every 6 beds; handwashing facilities in each ICU room, with 1 sink for every 2 beds and at the ICU nursing stations; and alcohol-based hand rub (ABHR) located at every bedside and available in the nurses' treatment and dressing rooms. Pocket-sized bottles of ABHR were not available.

The hospital's Infection Control Committee was established in 1997 with 1 part-time infection control nurse (ICN) to perform surveillance in the ICUs. The hospital currently employs 7 full-time equivalent (FTE) trained ICNs. Since 2006, all ICNs must be certified in infection control. Physicians have received infection control training since 2004.

Surveillance is performed using internationally accepted definitions.[5] Infection control procedures developed and implemented throughout the hospital since 2004 include routine multimodal hand hygiene promotion campaigns for all health care workers, including education programs, posters, distribution of ABHR and chlorhexidine (CHG)-containing soap, hand hygiene compliance audits, and staff compliance feedback. Audits of hand hygiene compliance were started in 2009 using direct observation performed by trained ICNs in accordance with the World Health Organization's (WHO) "My Five Moments for Hand Hygiene" campaign (http://www.who.int/gpsc/tools/Five_moments/en/). ICNs were trained to use the WHO audit tool by an accredited hand hygiene auditor.[6]

Infection control activities focused primarily on the ICUs to produce monthly HAI rates and quarterly feedback to staff. In 2011, infection control prevention bundles were introduced into the ICUs through training sessions run by the ICNs for all physicians and nurses. These bundles included central line–associated bloodstream infections (CLABSIs), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infections (CAUTIs). In 2004, daily chlorhexidine bathing of ICU patients was introduced. Since 2004, all ICU patients have been routinely screened for vancomycin-resistant enterococci and carbapenem-resistant enterobactericae. The ICUs do not practice any other decolonization strategy. Antibiotic prescribing in Turkish hospitals has been regulated by the government since 2003, requiring an infectious diseases specialist to prescribe extended-spectrum cephalosporins, beta-lactam/beta-lactamase inhibitors, quinolones, carbapenems, glycopeptides, and linezolid.

### *Data collection*

All surveillance data were collected as a quality and safety activity of the hospital, and institutional approval was given for reporting the data. Data were collected retrospectively for the years 2004-2012 from 4 level III adult ICUs: a MICU, an ARICU, a GSICU, and an NSICU. Patient data provided by the hospital's Admissions Department included patient-days, length of stay, and nurse-to-patient ratio, derived from 24-hour patient census data. Data provided by the Infection Control Department included HAIs per 1,000 patient-days, device utilization and device-associated infection rates per 100 patients, incidence of multiresistant microorganisms (MROs), and hand hygiene compliance. Data on consumption of hand hygiene products, expressed as liters per 1,000 patient-days, was provided by the hospital pharmacy. The nursing workload was determined based on the 24-hour nurse-to-patient ratio (ie, total number of nurses during a 24-hour period divided by the daily patient census). Data on the number of ICNs, hospital bed capacity, ICU admissions, and the purchase of hand hygiene products between 2008 and 2012 were retrieved from the hospital's accounting system. Data on patient-days and length of stay in the MICU, GSICU, and NSICU were unavailable for 2004 and 2005. Data on HAI rate, microorganisms detected, and hand hygiene compliance were obtained from the Infection Control Committee's annual reports. The pharmacy provided data on antimicrobial use (reported as defined daily dose [DDD], the average maintenance dose per day for each drug), normalized per 1,000 patient-days, in accordance with methodology of the WHO Collaborating Centre for Drug Statistics.

A microorganism was classified as a multiresistant organism (MRO) if it proved resistant to more than 3 classes of antibiotics, including aminoglycosides, antipseudomonal penicillins, carbapenems, cephalosporins, beta-lactam/beta-lactamase inhibitor, quinolones, colistin, and tigecycline; the latter 2 agents were tested infrequently.[7] The most prevalent MROs reported included *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, extended-spectrum beta-lactamase *Klebsiella pneumoniae, Escherichia coli*, methicillin-resistant *Staphylococcus aureus* (MRSA), and ampicillin-resistant *Enterococcus* spp. The infections by microorganisms were aggregated across all ICUs and presented as rates of infection by year and by gram-negative bacilli and as MRSA infections per 1,000 patient-days. The most commonly prescribed antibiotics, reported as DDD, included ceftriaxone, beta-lactam/beta-lactamase inhibitors, carbapenem, aminoglycoside, glycopeptide, linezolid, metronidazole, quinolones, colistin, tigecycline, and fluconazole.

OpenEpi was used to calculate proportions and 95% confidence intervals (CIs) around proportions. A generalized linear model, using SPSS version 21 (IBM, Armonk, NY), was used to estimate incidence rate ratios (IRRs) and *P* values for changes in rates of HAI, CLABSI, CAUTI, VAP, and microorganisms using patient-days as the offset variable while controlling for type of ICU and occupancy rates. Alpha was set at the 5% level.

## RESULTS

The 24-hour nurse-to-patient ratio was 0.7:1 in 2004 and increased to 0.9:1 in 2012. The ratio of ICNs to admissions