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Major article

# Changes in the incidence of health care–associated pathogens at a university hospital from 2005 to 2011

JaHyun Kang PhD, MPH [a,*], Emily E. Sickbert-Bennett PhD, MS [b], Vickie M. Brown RN, MPH [b], David J. Weber MD, MPH [b,c], William A. Rutala PhD, MPH [b,c]

[a] School of Nursing, University of Pittsburgh, Pittsburgh, PA
[b] Department of Hospital Epidemiology, University of North Carolina Health Care, Chapel Hill, NC
[c] Division of Infectious Diseases, University of North Carolina School of Medicine, Chapel Hill, NC

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***Background:*** Data on health care–associated infections (HAIs) outside of intensive care units (ICU) are scarce. We assessed hospital-wide changes in the incidence of health care–associated pathogens by infection site and by service between 2005 and 2011.

***Methods:*** All data on health care–associated pathogens in 2005-2011 based on comprehensive hospital-wide surveillance were extracted from an electronic database. The incidence of HAI by pathogen was calculated per 1000 patient-days and per 1000 device-days. Regression analyses were conducted to estimate trend changes in the yearly incidence of pathogens for selected HAIs.

***Results:*** The majority (8784 of 10,070; 87.2%) of the HAIs recorded over the 7-year period had at least 1 pathogen; a total of 10,585 pathogens were isolated. Overall, across all major service categories (eg, ICU, medicine), significant trends toward decreasing incidence were observed for all pathogens except *Clostridium difficile*. The decrease in incidence was greatest for central line–associated bloodstream infections, less for catheter-associated urinary tract infections, and lowest for ventilator-associated pneumonias.

***Conclusions:*** This study showed significant decreases in incidence of the majority of HAIs caused by various pathogens, but significant increases in patient-days during the study period. Only HAIs due to *C difficile* showed a significantly increased incidence.



Monitoring changes in the incidence of health care–associated infections (HAIs) through surveillance is essential to planning, implementing, and evaluating infection control measures to prevent HAIs in the hospital setting. Incidence data on HAIs occurring outside of intensive care units (ICU) are scarce, however, ever since targeted (ie, priority-based) surveillance emerged as a cost-effective method, leading to the discontinuation of hospital-wide surveillance in the Centers for Disease Control and Prevention's National Nosocomial Infections Surveillance System (NNIS) in 1986.[1] In a recent study comparing the number of HAIs included in targeted surveillance (National Healthcare Safety Network [NHSN] surveillance) and hospital-wide surveillance, targeted surveillance detected only 77.7% of the bloodstream infections, 74.5% of the surgical site infections (SSIs), 62.3% of the urinary tract infections, and 18.6% of the respiratory tract infections (including 100% of the ventilator-associated pneumonia [VAP] cases) that were identified with hospital-wide surveillance.[2]

Information on pathogens isolated from HAIs has implications for both treatment and the implementation of infection control and prevention strategies. However, in contrast to the increasing focus on antimicrobial-resistant pathogens, there are few reports on HAI pathogens. The NHSN reports from 2006-2007 and 2009-2010 identified the 10 most common health care–associated pathogens during these time periods as coagulase-negative staphylococci (CoNS; 15.3% and 11.4%, respectively), *Staphylococcus aureus* (14.5% and 15.6%), *Enterococcus* spp (12.1% and 13.9%), *Candida* spp (6.8% and 9.5%), *Escherichia coli* (9.6% and 11.5%), *Pseudomonas aeruginosa* (7.9% and 7.5%), *Klebsiella pneumoniae/oxytoca* (5.8% and 8.0%), *Enterobacter* spp (4.8% and 4.7%), *Acinetobacter baumannii* (2.7% and 1.8%), and *Proteus* spp (not stated and 2.5%).[3,4] Changes in the spectrum of health care–associated pathogens may arise from

* Address correspondence to JaHyun Kang, PhD, MPH, 415 Victoria Building, 3500 Victoria Street, Pittsburgh, PA, 15261.
*E-mail address:* kangjh@pitt.edu (J. Kang).

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increasing numbers of immunocompromised patients, older patients with multiple comorbidities, and the increased use of broad-spectrum antibiotics and invasive procedures.[5]

There is no established framework for determining the incidence of HAI by pathogen based on hospital-wide surveillance data. Despite challenges (eg, potential imprecision if the population of patients at risk is small), hospital-wide surveillance has the strong advantage of providing comprehensive HAI data, including information about HAI pathogens isolated across hospital settings.[6] Thus, in this study we examined the incidence of HAIs by pathogen using comprehensive hospital-wide surveillance data at a university hospital.

## METHODS

This study was conducted at University of North Carolina (UNC) Health Care, an 806-bed academic facility, and was approved by UNC's Institutional Review Board. UNC Health Care has conducted comprehensive hospital-wide surveillance by trained full-time infection preventionists (IPs) since 1978. Hospital-wide surveillance has been actively performed through a chart review of each patient who had isolated pathogen(s) based on daily microbiology records.

All health care–associated pathogen (numerator) data, with information on the service, location (nursing station), HAI category, and multidrug resistance, were extracted from the UNC Health Care electronic epidemiology database for 2005-2011, because device-days (denominator) data have been collected from 2005. Isolated pathogens were grouped into 18 categories of related species based on previous studies at UNC Health Care.[5,7] For the incidence of multidrug-resistant (MDR) pathogens, 4 additional subgroups of MDR pathogens were created: methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), MDR-*Acinetobacter*, and MDR-*Pseudomonas*. Patient-day data were extracted from the hospital census database for the study period (2005-2011) to calculate the service-associated incidence. To calculate the incidence of device-associated HAIs, device-days (eg, ventilator-days, central line-days, and Foley catheter-days) were extracted for 2006-2011 because of incomplete data for 2005, when UNC Health Care first mandated the daily recording of device-days by nursing station.

To analyze the incidence of isolated pathogens in device-associated HAI, we sorted all pathogens related to device utilization according to infection site information and then classified them into 5 major categories: central line–associated bloodstream infection (CLABSI), catheter-associated urinary tract infection (CAUTI), VAP, SSI, and other infections (eg, endocarditis, osteomyelitis, meningitis), following NHSN definitions.[8] To analyze the pathogen incidence according to service type, all cases (regardless of infection site) and all locations where pathogens were isolated (nursing station and inpatient hospital service) were classified into 6 major service categories: 2 acuity-based categories (ICU and non-ICU) and 4 service-based categories (Medicine, Surgery, Pediatrics, and Other [eg, dermatology, gynecology, psychiatry, rehabilitation medicine]). Step-down units (SDUs) were categorized as non-ICU, because the HAI rates in SDUs were closer to the rates in the general wards than to rates in the ICUs.[9] Denominator data (device-days and patient-days) were classified into the same major infection site and service categories as the numerator (pathogens) data.

SAS version 9.2 (SAS Institute, Cary, NC) was used to compute descriptive statistics of the yearly incidence of HAI for the study period for each category of analysis. The incidence of HAI according to the health care–associated pathogen in each category were calculated as the number of HAIs per 1000 patient-days or device-days. Simple linear regression was used to test for overall changes in patient-days during the study period, because HAI pathogen incidence may be associated with the number of patients admitted or the patients' length of hospital stay.

For estimating trend changes in the yearly incidence of HAIs according to pathogen across the study period, Poisson regression analysis was used to determine goodness of fit and adjust for overdispersion. When the Poisson regression result was statistically significant ($P < .05$), a logistic regression analysis for linear fit was conducted to estimate the incidence difference between the first and last years of the study and to examine the trend change across the study years. The estimated incidence difference and the relative incidence difference were used to summarize the changes in incidence difference over time and were calculated using following formulas:

Estimated incidence difference (EID) = Exp (log odds of incidence of last study year)/[1 + Exp (log odds of incidence of last study year)] − Exp (log odds of incidence of study year 1)/[1 + Exp (log odds of incidence of study year 1)]

Relative incidence difference (RID) = [(estimated incidence of study year 1 − incidence of last study year)/incidence of study year 1] × 100.

## RESULTS

Overall, at least 1 pathogen was isolated for 8784 of the 10,070 HAIs (87.2%) that occurred during the 7-year study period. Because some HAIs involved multiple pathogens, a total of 10,585 pathogens were isolated (Table 1); the mean number of pathogens per HAI was 1.21. The number of total patient-days per year increased significantly during the study period ($P < .05$). Although our top 10 pathogens are similar to those reported by the NHSN,[5] the rank order is somewhat different. Among our top 10 pathogens, the incidence of *E coli*, *Enterococcus* spp, CoNS, *Candida* and other yeasts, *Enterobacter* spp, and other streptococci decreased significantly, whereas the incidence of *Clostridium difficile* increased significantly per 1000 patient-days (Table 1 and Fig 1). The estimated incidence of *C difficile* increased by 0.42 per 1,000 patient-days between 2005 and 2011; the RID was 159% during that period.

### *Service*

The incidence of HAIs by pathogen and service category are summarized in Table 2. Overall, across service categories, trends toward decreasing incidence were observed for all pathogens except *C difficile*. *C difficile* was the most frequently occurring health care–associated pathogen in Medicine, and it had a significantly increased incidence in all service categories except Pediatrics. *S aureus* was the most common pathogen identified in Other service categories, and its incidence was significantly lower in Medicine and ICU settings. A significantly decreased incidence of *E coli* was seen in Medicine and non-ICU settings. The incidences of CoNS and of *Candida* and other yeast were significantly decreased in all service categories, the incidences of *Enterococcus* spp and of *P aeruginosa* were significantly decreased in Medicine, the incidence of *Enterobacter* spp was significantly decreased in Medicine and ICU settings, and the incidences of other streptococci were significantly decreased in Pediatrics and non-ICU settings.

### *Device-associated HAIs*

Overall and across service categories, all device-associated HAIs by pathogen showed significant decreases or no significant change in incidence per 1000 device-days (Table 3). The decreases in incidences of specific pathogens were greatest for CLABSI, less for CAUTI, and lowest for VAP.

**Table 1**
Overall incidence (per 1000 patient-days) of health care–associated pathogens over a 7-year period (2005-2011)

| Pathogen group | Total, 2005-2011 | | Incidence per 1000 patient-days | | | | | | | Incidence, mean (range) | EID | RID, % | *P* value* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rank | No. | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | | | | |
| *S aureus* | 1 | 1743 | 1.26 | 1.06 | 0.86 | 1.16 | 1.23 | 1.07 | 1.09 | 1.10 (0.86-1.26) | NS | — | .8883 |
| *E coli* | 2 | 1149 | 0.74 | 0.80 | 0.95 | 0.71 | 0.53 | 0.69 | 0.68 | 0.73 (0.53-0.95) | −0.18 | 8 | .0054 |
| *Enterococcus* spp | 3 | 1114 | 0.73 | 0.79 | 0.79 | 0.70 | 0.63 | 0.61 | 0.70 | 0.70 (0.61-0.79) | −0.13 | 4 | .0471 |
| CoNS | 4 | 849 | 0.77 | 0.74 | 0.57 | 0.50 | 0.51 | 0.41 | 0.30 | 0.54 (0.30-0.77) | −0.47 | 61 | <.0001 |
| *Candida* and other yeast | 5 | 792 | 0.80 | 0.59 | 0.55 | 0.35 | 0.39 | 0.46 | 0.41 | 0.50 (0.35-0.80) | −0.34 | 49 | <.0001 |
| *P aeruginosa* | 6 | 747 | 0.53 | 0.56 | 0.43 | 0.49 | 0.42 | 0.43 | 0.46 | 0.47 (0.42-0.56) | NS | — | .0557 |
| *C difficile* | 7 | 685 | 0.32 | 0.33 | 0.37 | 0.30 | 0.29 | 0.55 | 0.83 | 0.43 (0.29-0.83) | 0.42 | 159 | <.0001 |
| *Klebsiella* spp | 8 | 608 | 0.40 | 0.42 | 0.44 | 0.35 | 0.38 | 0.38 | 0.33 | 0.38 (0.33-0.44) | NS | — | .1435 |
| *Enterobacter* spp | 9 | 563 | 0.49 | 0.35 | 0.36 | 0.40 | 0.30 | 0.32 | 0.30 | 0.36 (0.30-0.49) | −0.14 | 39 | .0019 |
| Other streptococci | 10 | 292 | 0.26 | 0.21 | 0.19 | 0.17 | 0.12 | 0.17 | 0.19 | 0.18 (0.12-0.26) | −0.07 | 27 | .0239 |
| *Proteus* spp | 11 | 224 | 0.14 | 0.12 | 0.17 | 0.16 | 0.10 | 0.13 | 0.16 | 0.14 (0.10-0.17) | NS | — | .8654 |
| *Serratia* spp | 12 | 193 | 0.15 | 0.08 | 0.11 | 0.12 | 0.14 | 0.14 | 0.11 | 0.12 (0.08-0.15) | NS | — | .7278 |
| *Acinetobacter* spp | 13 | 176 | 0.05 | 0.07 | 0.12 | 0.20 | 0.18 | 0.12 | 0.05 | 0.11 (0.05-0.20) | NS | — | .3487 |
| Group B streptococcus | 14 | 94 | 0.07 | 0.07 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 (0.05-0.07) | NS | — | .6269 |
| *Haemophilus* spp | 15 | 92 | 0.11 | 0.03 | 0.03 | 0.05 | 0.05 | 0.07 | 0.07 | 0.06 (0.03-0.11) | NS | — | .6862 |
| *Bacteroides* spp | 16 | 91 | 0.05 | 0.05 | 0.06 | 0.05 | 0.07 | 0.06 | 0.06 | 0.06 (0.05-0.07) | NS | — | .4250 |
| *Citrobacter* spp | 17 | 83 | 0.08 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.02 | 0.05 (0.02-0.08) | NS | — | .1113 |
| Other | 18 | 1,090 | 0.76 | 0.74 | 0.67 | 0.70 | 0.59 | 0.60 | 0.77 | 0.69 (0.59-0.77) | NS | — | .1968 |
| Total pathogens isolated | 10,585 | | 1581 | 1505 | 1535 | 1495 | 1386 | 1486 | 1597 | | | | |
| Total patient-days | 1,582,872 | | 205,390 | 213,709 | 226,723 | 230,016 | 229,971 | 234,389 | 242,674 | | | | |

*EID*, estimated incidence difference; *RID*, relative incidence difference; *NS*, not significant.
*Based on Poisson regression.

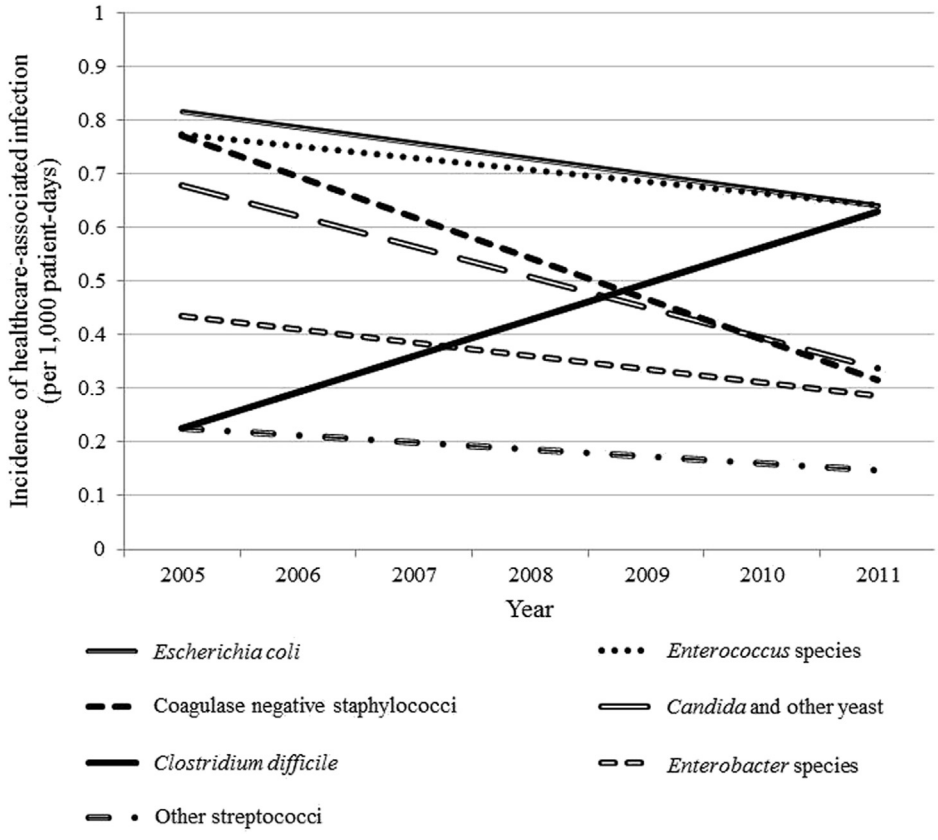


**Fig 1.** HAI pathogens with significant changes in incidence trends over 7-year period (2005-2011).

Overall, the incidence of CLABSI decreased significantly for most pathogens, with the exception of *E coli*. Of note, the incidences of CoNS and *Candida* and other yeast in CLABSI were significantly decreased across all service categories. Areas of significant decreases for each pathogen were as follows: *S aureus*, overall and in Medicine and non-ICU settings; *Enterococcus* spp, overall and in Medicine, Surgery, and non-ICU settings; *Klebsiella* spp, overall and in Surgery and non-ICU settings; *Enterobacter* spp, overall and in Pediatrics, and ICUs; and other streptococci, overall.

**Table 2**
Overall incidence (per 1000 patient-days) of the top 10 health care–associated pathogens by service category over a 7-year period (2005-2011)

| Pathogen group (overall top 10) | Service-based category | | | | | | | | | | | | Acuity-based category | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Medicine | | | | Surgery | | | | Pediatrics | | | | ICU | | | | Non-ICU | | | |
| | R | Mean | EID | RID, % | R | Mean | EID | RID, % | R | Mean | EID | RID, % | R | Mean | EID | RID, % | R | Mean | EID | RID, % |
| *S aureus* | 4 | 0.62 | −0.26* | 48 | 1 | 2.57 | NS | — | 1 | 0.77 | NS | — | 1 | 1.64 | −0.67† | 34 | 1 | 0.97 | NS | — |
| *E coli* | 3 | 0.64 | −0.37† | 39 | 3 | 1.34 | NS | — | 4 | 0.47 | NS | — | 4 | 1.11 | NS | — | 2 | 0.63 | −0.23† | 17 |
| *Enterococcus* spp | 2 | 0.65 | −0.29† | 15 | 2 | 1.39 | NS | — | 3 | 0.50 | NS | — | 3 | 1.12 | NS | — | 3 | 0.60 | NS | — |
| CoNS | 6 | 0.41 | −0.59† | 71 | 5 | 0.94 | −0.42† | 48 | 2 | 0.67 | −0.71† | 67 | 6 | 0.96 | −1.11† | 67 | 4 | 0.43 | −0.30† | 58 |
| *Candida* and other yeast | 5 | 0.61 | −0.60† | 64 | 6 | 0.86 | −0.36* | 37 | 8 | 0.36 | −0.32† | 52 | 2 | 1.26 | −1.15† | 59 | 7 | 0.30 | −0.13* | 40 |
| *P aeruginosa* | 7 | 0.24 | −0.19* | 38 | 4 | 1.09 | NS | — | 5 | 0.44 | NS | — | 5 | 1.11 | NS | — | 6 | 0.31 | NS | — |
| *C difficile* | 1 | 0.71 | 0.87† | 262 | 9 | 0.52 | 0.47† | 164 | 9 | 0.23 | NS | — | 9 | 0.49 | 0.62† | 224 | 5 | 0.42 | 0.38† | 145 |
| *Klebsiella* spp | 8 | 0.24 | NS | — | 8 | 0.76 | NS | — | 6 | 0.41 | NS | — | 8 | 0.77 | NS | — | 8 | 0.29 | NS | — |
| *Enterobacter* spp | 9 | 0.14 | −0.12* | 63 | 7 | 0.80 | NS | — | 7 | 0.40 | NS | — | 7 | 0.92 | −0.48† | 42 | 9 | 0.21 | NS | — |
| Other streptococci | 10 | 0.14 | NS | — | 10 | 0.37 | NS | — | 11 | 0.13 | −0.16† | 50 | 12 | 0.20 | NS | — | 10 | 0.18 | −0.08* | 29 |

*R*, rank within the category; *EID*, estimated incidence difference; *RID*, relative incidence difference; *ICU*, intensive care unit.
*01 ≤ $P$ < .05.
†$P$ < .01.

**Table 3**
Overall incidence change in device-associated HAIs caused by the top 10 pathogens per 1000 device-days over a 6-year period (2006-2011)

| Pathogen group (overall top 10) | CLABSI | | | | CAUTI | | | | VAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Incidence, median (range) | EID | RID, % | Stratified analyses* | Incidence, median (range) | EID | RID, % | Stratified analyses* | Incidence, median (range) | EID | RID, % | Stratified analyses* |
| *S aureus* | 0.31 (0.10-0.38) | −0.25 | 73 | M, NI | 0.07 (0.05-0.15) | NS | — | — | 0.95 (0.64-1.23) | −0.5 | 48 | S |
| *E coli* | 0.19 (0.08-0.23) | NS | — | — | 1.00 (0.48-1.59) | −1.01 | 51 | M, S, NI | 0.16 (0.11-0.27) | NS | — | — |
| *Enterococcus* spp | 0.49 (0.32-0.71) | −0.36 | 55 | M, S, NI | 0.63 (0.58-1.06) | −0.34 | 25 | M, NI | 0.10 (0.10-0.21) | NS | — | — |
| CoNS | 0.63 (0.29-1.00) | −0.71 | 71 | M, S, P, I, NI | 0.09 (0.03-0.25) | −0.19 | 88 | S, NI | 0.10 (0.06-0.11) | NS | — | — |
| *Candida* and other yeast | 0.22 (0.10-0.53) | −0.34 | 81 | M, S, P, I, NI | 0.64 (0.48-1.02) | −0.36 | 36 | P, I | 0.06 (0.05-0.11) | NS | — | — |
| *P aeruginosa* | 0.12 (0.01-0.16) | −0.09 | 93 | — | 0.45 (0.23-0.62) | −0.26 | 26 | S, NI | 0.71 (0.50-0.86) | NS | — | — |
| *C difficile* | — | — | — | — | — | — | — | — | - | - | — | — |
| *Klebsiella* spp | 0.17 (0.13-0.26) | −0.15 | 46 | S, NI | 0.37 (0.14-0.60) | −0.4 | 69 | M, S, NI | 0.29 (0.11-0.32) | NS | — | S† |
| *Enterobacter* spp | 0.19 (0.06-0.26) | −0.21 | 77 | P, I | 0.21 (0.16-0.33) | −0.17 | 47 | S, NI | 0.31 (0.26-1.02) | NS | — | — |
| Other streptococci | 0.09 (0.05-0.18) | −0.09 | 44 | — | 0.03 (0.02-0.03) | — | — | — | 0.15 (0.05-0.24) | NS | — | — |

*CLABSI*, central line-associated bloodstream infection; *CAUTI*, catheter-associated urinary tract infection; *VAP*, ventilator-associated pneumonia; *EID*, estimated incidence difference; *RID*, relative incidence difference; *M*, medicine; *S*, surgery; *P*, pediatrics; *I*, intensive care unit; *NI*, non–intensive care unit.
*Only statistically significant associations are shown; direction of change (ie, increase or decrease) was always consistent with overall EID except in *Klebsiella* spp in VAP.
†Significant decrease.

**Table 4**
Overall incidence of HAIs by MDR pathogen per 1000 patient-days over a 7-year period (2005-2011)

| MDR pathogen | n | Incidence per 1000 patient-days | | | | | | | Incidence, median (range) | EID | RID, % | *P* value* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | | | | |
| MRSA | 798 | 0.56 | 0.52 | 0.39 | 0.51 | 0.54 | 0.46 | 0.54 | 0.52 (0.39-0.56) | NS | — | .9746 |
| VRE | 212 | 0.09 | 0.12 | 0.17 | 0.14 | 0.14 | 0.10 | 0.16 | 0.14 (0.09-0.17) | NS | — | .2123 |
| MDR *Acinetobacter* | 95 | 0.00 | 0.00 | 0.07 | 0.13 | 0.10 | 0.11 | 0.00 | 0.07 (0.00-0.13) | NS | — | — |
| MDR *Pseudomonas* | 21 | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 (0.00-0.03) | NS | — | — |

*MDR*, multidrug-resistant; *MRSA*, methicillin resistant *Staphylococcus aureus*; *VRE*, vancomycin-resistant Enterococci.
*Based on Poisson regression.

The overall incidence of CAUTI showed significant decreases in all of the top 10 pathogens except *S aureus* and other streptococci. According to service category, the significantly decreased pathogens were as follows: *E coli* and *Klebsiella* spp, overall and in Medicine, Surgery, and non-ICU settings; *Enterococcus* spp, overall and in Medicine and non-ICU settings; CoNS, *P aeruginosa*, and *Enterobacter* spp, overall and in Surgery and non-ICU settings; and *Candida* and other yeast, overall and in Pediatrics and ICU settings.

For VAP incidence, only *S aureus* showed a significant decrease overall. In Surgery, there was a significant decrease in the incidence of VAP caused by *S aureus* and *Klebsiella* spp.

### *MDR pathogens*

All MDR pathogens showed no significant change in the overall HAI incidence (Table 4). When stratified by service (other data not shown), only MRSA showed a significantly increased incidence in Pediatrics (EID, 0.29; RID, 264%). When stratified by device-associated HAI, only CLABSI due to MRSA showed significant decreases overall (EID, −0.20; RID, 75%) and decreases in Medicine (EID, −0.33; RID, 94%), Surgery (EID, −0.27; RID, 44%), and non-ICU settings (EID, −0.34; RID, 92%). For the other device-associated HAIs (CAUTI and VAP), there was no significant trend in incidence in any MDR pathogens.

## DISCUSSION

This study found significant changes in HAI incidence by pathogen for each category studied and provided data on HAI incidence across categories. Overall and across all service categories, trends toward decreasing incidence of HAIs per 1000 patient-days were observed for all pathogens except *C difficile*, and

all device-associated HAIs by pathogen showed significant decreases or no significant change in incidence per 1000 device-days.

This study used HAI data from hospital-wide surveillance, based on daily microbiology laboratory reports. This approach has advantages (eg, evaluates the hospital-wide magnitude of HAI incidence) and disadvantages (eg, time-consuming), as do other types of surveillance with different perspectives: scope (hospital-wide vs targeted) and approach (patient-based vs laboratory-based).[6] Although the Centers for Disease Control and Prevention has not recommended hospital-wide surveillance for efficiency reasons (ie, too labor-intensive) for NNIS/NHSN since 1986,[1] and most hospitals have adopted targeted surveillance, UNC Health Care has retained hospital-wide surveillance to provide comprehensive surveillance and feedback to all hospital units.

This study has several strengths. First, it provides unique information on the hospital-wide magnitude of HAI by pathogen during the study period based on prospective, comprehensive hospital-wide surveillance, an uncommon approach in US hospitals. In the absence of a hospital-wide surveillance system, point-prevalence survey methods have been used in US hospitals to estimate the magnitude of the HAI burden.[10] However, some reported point-prevalence data can be criticized as an undefined mixture of both prevalence and incidence and are subject to overestimation related to the calculation method used (eg, number of HAIs on the visit day/number of beds visited), and findings might not be generalizable over time, even in the institutions studied.[6] Thus, the present study fills a need by evaluating the comprehensive magnitude of hospital-wide HAIs in a way that point-prevalence studies and targeted surveillance do not.

Second, this study supports the stratified incidences of HAI pathogens by service (eg, ICU, Medicine) as an advantage of hospital-wide surveillance.[6] This incidence analysis of HAI according to pathogen and across service categories was made possible through comprehensive hospital-wide surveillance. In contrast, targeted surveillance does not detect any HAIs outside of selected units or priority areas (eg, specific infections/sites). One study reported that approximately 50% of HAIs were missed when targeted surveillance method results were compared with the results of comprehensive, hospital-wide surveillance.[2]

Third, in this study, we used incidence data based on person-days at risk (eg, patient-days, central line-days) by pathogen as the representative measure of HAI rate. To our knowledge, few studies to date have reported incidence rates according to pathogen; thus, our results may serve as reference data for pathogen-categorized HAI incidence.

In summary, this study provides data on HAI incidence by person-days at risk by pathogen across each category (eg, service and device-related HAIs), thus providing information not available in previous HAI studies.

This study has some limitations as well. First, the changes in the incidence of specific health care–associated pathogens at our hospital might not be representative of all acute care university hospitals in the United States. Second, the incidences based on hospital-wide surveillance cannot be compared with incidences from targeted (priority-based, eg, SSI) surveillance, which is common at most hospitals; surveillance studies that differ in their scope and approach cause variations in the sensitivity and specificity of HAI case findings.[6] Third, we did not examine the causative factors behind the changes in the HAI pathogen spectrum (eg, changes in the number of orders placed for *C difficile* tests). Most likely, the decreasing incidence of many pathogens was related to dramatic decreases in the incidence of HAIs, including CLABSI, CAUTI, and VAP. Other factors may have included changes in the hospitalized patients' underlying diseases and changes in antimicrobial use, such as the defined daily dose per 1000 beds recommended by the World Health Organization's Alliance for the Prudent Use of Antibiotics.[11] The association between the significant increase in *C difficile* incidence and changes in the utilization density of various antimicrobials requires further study. Nonetheless, this study supports the recently reported emergence of *C difficile* as a health care–associated pathogen in hospital settings.[12]

Even though there was a significant increase in patient-days at UNC Health Care over the study period, we observed substantial reductions in both overall HAIs and device-associated HAIs for all pathogens except *C difficile*. Although we could not identify specifically what types of infection control interventions reduced the HAI incidence by pathogen between 2005 and 2011, the observed decrease in the incidence of HAI by most pathogens may be related to several factors. Over the study period, multiple interventions were introduced to control device-associated HAIs; for example, interventions were undertaken to decrease CLABSIs following Institute for Healthcare Improvement bundle recommendations, such as a checklist, to ensure compliance with aseptic central line insertion.[13] In addition, the establishment of an infection control liaison program in the fall of 2007, provided clinical staff to serve as a highly visible infection control resource, monitor practices, collect data, and provide appropriate feedback.[14]

In conclusion, despite the reduction in HAIs caused by most pathogen groups over the study period, *C difficile* was the sole HAI pathogen identified as problematic at our study hospital. Given that other recent HAI studies have reported significant increases in the incidence of *C difficile*,[12] the emergence of this pathogen may be inevitable in modern health care settings characterized by the frequent use of antimicrobial agents, prolonged hospital stays, and an increased number of immunocompromised patients. No single intervention has proven effective in controlling and preventing *C difficile* infections,[15] and thus reducing the incidence of *C difficile* in every hospital setting is a formidable challenge. Although some control measures have been studied, including barrier precautions (eg, patient isolation, hand hygiene, gloving), environmental cleaning/disinfection with sporicidal disinfectant, antimicrobial restriction, and the identification of asymptomatic carriers of *C difficile*,[15] more research is needed to establish the gold standard of infection control practice for *C difficile* infection in hospital settings.

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