Antimicrobial-Resistant Pathogens Associated with Healthcare-Associated Infections: Summary of Data Reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009–2010

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OBJECTIVE. To describe antimicrobial resistance patterns for healthcare-associated infections (HAIs) reported to the National Healthcare Safety Network (NHSN) during 2009–2010.

METHODS. Central line-associated bloodstream infections, catheter-associated urinary tract infections, ventilator-associated pneumonia, and surgical site infections were included. Pooled mean proportions of isolates interpreted as resistant (or, in some cases, nonsusceptible) to selected antimicrobial agents were calculated by type of HAI and compared to historical data.

RESULTS. Overall, 2,039 hospitals reported 1 or more HAIs; 1,749 (86%) were general acute care hospitals, and 1,143 (56%) had fewer than 200 beds. There were 69,475 HAIs and 81,139 pathogens reported. Eight pathogen groups accounted for about 80% of reported pathogens: Staphylococcus aureus (16%), Enterococcus spp. (14%), Escherichia coli (12%), coagulase-negative staphylococci (11%), Candida spp. (9%), Klebsiella pneumoniae (and Klebsiella oxytox; 8%), Pseudomonas aeruginosa (8%), and Enterobacter spp. (5%). The percentage of resistance was similar to that reported in the previous 2-year period, with a slight decrease in the percentage of S. aureus resistant to oxacillins (MRSA). Nearly 20% of pathogens reported from all HAIs were the following multidrug-resistant phenotypes: MRSA (8.5%); vancomycin-resistant Enterococcus (3%); extended-spectrum cephalosporin-resistant K. pneumoniae and K. oxytox (2%), E. coli (2%), and Enterobacter spp. (2%); and carbapenem-resistant P. aeruginosa (2%), K. pneumoniae/oxytox (<1%), E. coli (<1%), and Enterobacter spp. (<1%). Among facilities reporting HAIs with 1 of the above gram-negative bacteria, 20%–40% reported at least 1 with the resistant phenotype.

CONCLUSION. While the proportion of resistant isolates did not substantially change from that in the previous 2 years, multidrug-resistant gram-negative phenotypes were reported from a moderate proportion of facilities.

The National Healthcare Safety Network (NHSN) began collecting data in 2005 as a national voluntary reporting system for patient and healthcare personnel safety surveillance data, managed by the Centers for Disease Control and Prevention (CDC). It is designed to allow for surveillance of selected healthcare-associated infection (HAI) data in intensive care units, as well as other location types, in hospitals and other types of healthcare facilities. Reporting of pathogens and the antimicrobial susceptibility test results of pathogens associated with HAIs is critically important for understanding the scope and magnitude of emerging and established antimicrobial-resistant infections in the United States. Analysis of these data produces summary measures of the prevalence of antimicrobial resistance among select pathogens in different patient care settings. Such measures should help inform decisions involving infection prevention practice, antimicrobial development, and public policy regarding efforts to detect and prevent transmission of resistant strains and/or their resistance determinants, especially those with phenotypes having the fewest viable treatment options.

This report is the second summary report of NHSN data, and it summarizes the antimicrobial susceptibility data reported to NHSN for the 2-year period 2009–2010. This time period coincides with an increased use of NHSN by acute care state mandates and early adoption of the reporting rules for participation in Centers for Medicare and Medicaid Ser-
vices (CMS) Prospective Payment System. This report builds on the methodology of the first report, with additional evaluation of some temporal changes and degree of spread among reporting facilities.

METHODS

We analyzed data that hospitals reported for 2009–2010 to the Patient Safety Component of NHSN. Data included those reported for central line–associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), ventilator-associated pneumonia (VAP), and surgical site infections (SSIs). These data were compared to data reported from HAIs occurring during 2007–2008. Postprocedure pneumonia (which accounts for <1% of all HAIs reported) was excluded. NHSN methodology has been reported elsewhere and is summarized in the first NHSN antimicrobial resistance report.

Pathogen and antimicrobial susceptibility data reported to NHSN are provided by the facility’s designated clinical microbiology laboratory. Up to 3 organisms can be reported per HAI. There is a select group of pathogens and antimicrobials for which susceptibility test results must be reported if testing was performed and reported to the clinician. Laboratories are expected to use Clinical and Laboratory Standards Institute standards for antimicrobial susceptibility testing. Results for each pathogen were reported to NHSN using the category interpretations “susceptible” (S), “intermediate” (I), “resistant” (R), and “not tested.” Because laboratories may test different antimicrobial agents within a class, for some phenotypes, resistance was defined using data from at least 1 of several agents within the same antimicrobial class. To be defined as resistant to extended-spectrum cephalosporins, organisms were reported as I or R either to cefazidime or cefepime (Pseudomonas aeruginosa) or to ceftazidime, cefepime, ceftiraxone, or cefotaxime (Enterobacteriaceae). Carbapenem resistance was defined for all organisms as a result of I or R to imipenem or meropenem. Fluoroquinolone resistance was defined as a result of I or R either to ciprofloxacin or levofloxacin (P. aeruginosa) or to ciprofloxacin, levofloxacin, or moxifloxacin (Escherichia coli). Aminoglycoside resistance in P. aeruginosa was defined as a result of I or R to gentamicin, amikacin, or tobramycin. Finally, for some of the pathogens, definitions of multidrug resistance were used that required a report of I or R for at least 1 of the agents within a class—thus establishing nonsusceptibility to the class—and nonsusceptibility to at least 3 of the specified classes. For Klebsiella pneumoniae, Klebsiella oxytoca, E. coli, Enterobacter spp., and P. aeruginosa, 5 classes were included: extended-spectrum cephalosporins, fluoroquinolones, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam. A sixth class, ampicillin/subactam, was included for Acinetobacter baumannii. These criteria approximated, as best as possible, interim standard definitions for defining multidrug resistance. For the purpose of this report, “Klebsiella spp.” refers to results for K. pneumoniae and K. oxytoca combined, with the exclusion of other species of Klebsiella, which were extremely rare.

Statistical analysis. Data were analyzed with SAS software, version 9.3 (SAS Institute). For reporting hospitals and all reported HAIs, absolute frequencies and distributions are described by hospital type, size, and region. Absolute frequencies and distributions of pathogens by location or procedure were calculated. For each HAI type, pooled mean percent resistance (ie, the pooled proportion of bacteria resistant to antimicrobial agents) was calculated for the pathogen–antimicrobial agent combinations by pooling data from all NHSN hospitals for the specified time period (sum of pathogens testing resistant, divided by the sum of pathogens tested for susceptibility, multiplied by 100). Pooled mean percent resistance is reported by HAI type. Differences in pooled percent resistance were compared across HAI types by means of the χ² test for independence (lowest vs highest percent resistance for device-associated HAIs and device-associated HAI pooled percent resistance vs SSI percent resistance). Percent resistance was found to differ in most cases across the device-associated infections for a specific pathogen–antimicrobial combination; thus, device-associated pooled percent resistance values are not reported. Because of the historical association between higher prevalence of antimicrobial resistance and specimen collection from patients in critical care locations, the pathogen percent resistance was stratified by location. Differences in pooled percent resistance were compared by location (critical care locations vs non–critical care locations) with log-binomial regression analysis for CLABSI and CAUTI. Statistical significance was determined at a P value of .05.

To highlight significant changes in percent resistance reported for the 4 HAI types between the 2009–2010 and 2007–2008 reports, the pooled mean percent resistance was compared between the two time periods for each of the evaluated pathogen–antimicrobial combinations described above, separately for each of the HAI types. To evaluate changes in percent resistance over time for each of the selected pathogen–antimicrobial combinations by HAI type, log-binomial regression analysis was conducted to compare the pooled mean percent resistances from 2009–2010 and 2007–2008. Confidence intervals, overall change, and P values are presented to indicate any significant increase or decrease in a specific percent resistance between the 2 time periods. To provide a measure that reflects the degree of spread of these antimicrobial-resistant pathogens among the reported HAIs, we calculated the number and proportion of facilities, among those reporting at least 1 occurrence of a pathogen-HAI combination, that reported a phenotype resistant to a particular antimicrobial for that HAI.
### TABLE 1. Characteristics of Hospitals Reporting Healthcare-Associated Infections (HAIs) to the National Healthcare Safety Network, by Time Period, 2007–2010

| Characteristic                              | 2007–2008 (n = 1,172) No. (%) | 2009–2010 (n = 2,039) No. (%) | 2007–2008 (n = 47,582) No. (%) | 2009–2010 (n = 69,475) No. (%) |
|---------------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| **Type of hospital**                        |                               |                               |                               |                               |
| Children's                                 | 33 (2.8)                      | 46 (2.3)                      | 1,559 (3.3)                   | 2,238 (3.2)                   |
| General                                    | 1,029 (87.8)                  | 1,749 (85.8)                  | 43,734 (91.9)                 | 61,364 (88.3)                 |
| Military                                    | 6 (0.5)                       | 16 (0.8)                      | 103 (0.2)                     | 425 (0.6)                     |
| Veterans Affairs                           | 27 (2.3)                      | 22 (1.1)                      | 648 (1.4)                     | 431 (0.6)                     |
| Long-term acute care                       | 33 (2.8)                      | 122 (6.0)                     | 755 (1.6)                     | 3,382 (4.9)                   |
| Other                                       | 44 (3.8)                      | 84 (4.1)                      | 783 (1.6)                     | 1,635 (2.4)                   |
| Size of hospital, beds                     |                               |                               |                               |                               |
| <200                                        | 592 (50.5)                    | 1,143 (56.1)                  | 8,837 (18.6)                  | 16,375 (23.6)                 |
| 200–499                                     | 450 (38.4)                    | 717 (35.2)                    | 19,310 (40.6)                 | 28,851 (41.5)                 |
| 500–999                                     | 127 (10.8)                    | 174 (8.5)                     | 18,836 (39.6)                 | 23,442 (33.7)                 |
| ≥1,000                                      | 3 (0.3)                       | 5 (0.2)                       | 599 (1.3)                     | 807 (1.2)                     |
| Location type                               |                               |                               |                               |                               |
| Non-critical care                           | 386 (29.0)                    | 956 (38.3)                    | 8,935 (24.3)                  | 18,667 (34.9)                 |
| Critical care                               | 946 (71.0)                    | 1,538 (61.7)                  | 27,869 (75.7)                 | 34,789 (65.1)                 |
| Region                                      |                               |                               |                               |                               |
| Region 1<sup>a</sup>                        | 84 (7.2)                      | 123 (6.0)                     | 888 (1.9)                     | 2,704 (3.9)                   |
| Region 2<sup>d</sup>                        | 209 (17.8)                    | 248 (12.2)                    | 8,833 (18.6)                  | 10,190 (14.7)                 |
| Region 3<sup>d</sup>                        | 307 (26.2)                    | 371 (18.2)                    | 14,043 (29.5)                 | 18,603 (26.8)                 |
| Region 4<sup>d</sup>                        | 184 (15.7)                    | 339 (16.6)                    | 10,010 (21.0)                 | 12,915 (18.6)                 |
| Region 5<sup>e</sup>                        | 123 (10.5)                    | 265 (13.0)                    | 4,758 (10.0)                  | 7,686 (11.1)                  |
| Region 6<sup>e</sup>                        | 47 (4.0)                      | 135 (6.6)                     | 1,602 (3.4)                   | 3,091 (4.4)                   |
| Region 7<sup>g</sup>                        | 21 (1.8)                      | 55 (2.7)                      | 1,274 (2.7)                   | 1,648 (2.4)                   |
| Region 8<sup>g</sup>                        | 55 (4.7)                      | 71 (3.5)                      | 925 (1.9)                     | 1,576 (2.3)                   |
| Region 9<sup>g</sup>                        | 93 (7.9)                      | 333 (16.3)                    | 3,676 (7.7)                   | 8,427 (12.1)                  |
| Region 10<sup>h</sup>                       | 49 (4.2)                      | 99 (4.9)                      | 1,573 (3.3)                   | 2,635 (3.8)                   |

<sup>a</sup> Ambulatory surgical centers, oncology hospitals, orthopedic hospitals, psychiatric hospitals, inpatient rehabilitation hospitals, surgical hospitals, women's hospitals, women's and children's hospitals, and long-term care skilled-nursing facilities.

<sup>b</sup> Critical care does not include surgical site infections because they do not require location to be reported.

<sup>c</sup> Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.

<sup>d</sup> New Jersey, New York, Puerto Rico, and the Virgin Islands.

<sup>e</sup> Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia.

<sup>f</sup> Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

<sup>g</sup> Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin.

<sup>h</sup> Arkansas, Louisiana, New Mexico, Oklahoma, and Texas.

<sup>i</sup> Iowa, Kansas, Missouri, and Nebraska.

<sup>j</sup> Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming.

<sup>k</sup> Arizona, California, Hawaii, Nevada, American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Marshall Islands, and Republic of Palau.

<sup>l</sup> Alaska, Idaho, Oregon, and Washington.

### RESULTS

#### Distribution of Infections by Hospital or Location Types

From January 2009 through December 2010, 69,475 HAIs were reported to NHSN from 2,039 hospitals. The relative proportions of HAIs reported varied by hospital type, bed size category, and region of the United States (Table 1), where more infections were reported from regions or groupings with more facilities participating in surveillance. Of these infections, 40% were CLABSIs, 27% were CAUTIs, 10% were VAP, and 23% were SSIs. The distribution by category was similar for the 2 reporting periods (Tables 1, 2).

Overall, 6,505 locations were represented in the surveillance data, including 12 different general categories of critical care location types and 11 different general categories of non–critical care location types (Table 3). Roughly 65% of the device-associated HAIs reported were from critical care locations (Table 1), including mostly medical-surgical combined units and medical, surgical, and neonatal units (Table 3). The other 35% of HAIs were reported from non–critical
TABLE 2. Types of Healthcare-Associated Infections (HAIs) Reported to the National Healthcare Safety Network by HAI Type, by Time Period, 2007-2010

| Event   | No. (%) of events reported 2007-2008 (n = 47,582) | No. (%) of events reported 2009-2010 (n = 69,475) |
|---------|---------------------------------------------------|---------------------------------------------------|
| CLABSI  | 18,651 (39.2)                                     | 27,766 (40.0)                                     |
| CAUTI   | 11,863 (24.9)                                     | 19,058 (27.4)                                     |
| VAP     | 6,290 (13.2)                                      | 6,632 (9.5)                                       |
| SSI     | 10,778 (22.7)                                     | 16,019 (23.1)                                     |

*NOTE.* CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; SSI, surgical site infection; VAP, ventilator-associated pneumonia. Postprocedure pneumonia (2007-2008, \(n = 24\); 2009-2010, \(n = 23\)) is not included in this table.

...care locations (Table 1), including mostly inpatient adult medical wards, medical-surgical wards, and long-term acute care locations (Table 3). The majority of procedure-associated HAIs were identified on inpatient surgical wards (data not shown), and most were associated with 1 of the 3 most commonly tracked major procedure types: cardiac surgeries (22%), abdominal surgeries (23%), and orthopedic surgeries (41%), which in this report includes spinal fusion/refusion and laminectomy (Table 4).

Pathogen Distribution

Overall, 81,139 pathogens were reported from the 69,475 HAIs; overall, 90% were bacteria and 10% were fungi (Table 5). Roughly 82% of pathogens were from 1 of 8 main pathogen groups: *Staphylococcus aureus* (15.6%), *Enterococcus* spp. (13.9%), *E. coli* (11.5%), Coagulase-negative staphylococci (11.4%), *Candida* spp. (9.5%), *Klebsiella* spp. (8%), *P. aeruginosa* (7.5%), or *Enterobacter* spp. (4.7%); other common pathogens included *Proteus* spp. (2.5%), *Serratia* spp. (2.1%), and *A. baumannii* (1.8%). The remaining (roughly 12%) of reported pathogens included a very wide variety of organisms (an additional table can be found at the CDC website, http://www.cdc.gov/nhsn/dataStat.html). For the 21,100 pathogens reported among SSIs, the pathogen distribution varied by type of surgery (Table 6). Coagulase-negative staphylococci and *S. aureus* were the most prevalent SSI pathogens for most types of surgery, but gram-negative rods were more prevalent in abdominal surgeries. Enterococci were associated with approximately one-third of SSIs following transplant surgery.

Percent Resistance

Antimicrobial susceptibility testing data were received on most pathogens reported, although the percentage of pathogens with testing data varied by specific agent, pathogen, and HAI type. As in the previous NHSN report, the highest reported testing frequencies (ie, >90% of isolates reported had testing results reported) were for *S. aureus* susceptibility to oxacillin, *Enterococcus faecium* and *Enterococcus faecalis* susceptibility to vancomycin, *P. aeruginosa* and *E. coli* susceptibility to fluoroquinolones, and *P. aeruginosa* and *Enterobacter* spp. susceptibility to extended-spectrum cephalosporins (Table 7). Although the value varied by HAI type, hospitals reported lower frequencies of testing *Klebsiella* spp. and *E. coli* susceptibility to carbapenems (range 64.3%–77.2% and 63.2%–77.2%, respectively). Pooled mean percent resistance for the pathogen-antimicrobial combinations is shown in Table 7. Pathogen percent resistance overall was generally lower for each resistance phenotype among SSIs, compared to that among device-associated HAIs. For most other pathogens, percent resistance differed only slightly between device-associated infection types. Notably, carbapenem resistance in CAUTIs and CLABSI was very similar for *Klebsiella* spp. (12.5% and 12.8%, respectively) and *E. coli* (2.3% and 1.9%, respectively).

For the majority of resistant phenotypes evaluated, the percent resistance did not significantly differ by critical care location status (Table 8). Some differences did border on statistical significance, including higher values in the critical care areas for carbapenem resistance among *A. baumannii* or *Klebsiella* spp. and lower values in critical care units for *S. aureus* resistance to oxacillins (ie, MRSA) and *E. coli* resistance to fluoroquinolones. Because of the lack of consistent evidence that critical care locations are associated with higher percent resistance, data from all location types were combined, and changes in percent resistance for select resistant phenotypes are presented in Tables 9–12. Among CLABSI, there was no significant change in percent resistance between the 2 time periods for most phenotypes. Exceptions include increases in extended-spectrum cephalosporin resistance among *E. coli* (and a corresponding increase in multidrug-resistant *E. coli*) and carbapenem resistance among *A. baumannii* (although this organism caused <2% of all HAIs reported). Similar patterns were observed among pathogens associated with CAUTIs. Among pathogens associated with VAP (Table 11) and SSI (Table 12), the percent resistance for MRSA declined slightly in the current period, compared to the earlier period.

There was great variation in the degree of spread of antimicrobial-resistant infections (additional figures can be found on the CDC website, http://www.cdc.gov/nhsn/dataStat.html). Of the 2,039 facilities that reported at least 1 HAI to NHSN during 2009–2010, 1,637 reported at least 1 CLABSI. Among facilities reporting 1 or more CLABSI with a bacterial pathogen of interest (regardless of resistance), the proportion reporting a resistant phenotype was very high for MRSA (76%) and vancomycin-resistant *E. faecium* (89%); it was very low for *E. coli* or *Enterobacter* spp. resistant to carbapenems, 4% and 7%, respectively. It was modest for the other resistant pathogens. For example, 20% of facilities reporting a CLABSI with *Klebsiella* spp. reported at least 1 as carbapenem resistant.

Among the 871 facilities reporting 1 or more CAUTIs with a select bacterial pathogen (regardless of resistance), the proportion reporting a resistant phenotype was very high for...
### TABLE 3. Distribution of Device-Associated Infections Reported to the National Healthcare Safety Network, by Type of Location, 2009–2010

| Location                  | No. of units reporting (n = 6,505) | No. (%) of HAIs                  |
|---------------------------|-------------------------------------|----------------------------------|
|                           | Overall | CLABSI   | CAUTI    | VAP    |
| Critical care             |         |          |          |        |
| Burn                      | 42       | 792 (1.5)| 389 (1.4)| 216 (1.1)| 187 (2.8) |
| Cardiopulmonary surgical  | 251      | 2,242 (4.2)| 1,098 (4.0)| 703 (3.7)| 441 (6.7) |
| Medical                   | 358      | 4,660 (8.7)| 2,403 (8.7)| 1,572 (8.2)| 685 (10.3) |
| Medical cardiac           | 257      | 2,106 (3.9)| 1,086 (3.9)| 772 (4.1)| 248 (3.7) |
| Medical-surgical          | 1,329    | 11,023 (20.6)| 5,796 (20.9)| 3,523 (18.5)| 1,704 (25.7) |
| Neonatal                  | 377      | 3,294 (6.2)| 2,902 (10.5)| ...| 392 (5.9) |
| Neurologic                | 24       | 393 (0.7)| 98 (0.4)| 185 (1.0)| 110 (1.7) |
| Neurosurgical             | 92       | 1,529 (2.9)| 418 (1.5)| 837 (4.4)| 274 (4.1) |
| Pediatric*                | 203      | 2,025 (3.8)| 1,431 (5.2)| 342 (1.8)| 252 (3.8) |
| Respiratory               | 9        | 76 (0.1)| 34 (0.1)| 35 (0.2)| 7 (0.1) |
| Surgical                  | 251      | 3,776 (7.1)| 1,486 (5.4)| 1,271 (6.7)| 1,019 (15.4) |
| Trauma                    | 96       | 2,873 (5.4)| 836 (3.0)| 963 (5.1)| 1,074 (16.2) |
| Non-critical care         |         |          |          |        |
| Bone marrow transplantb   | 55       | 939 (1.8)| 909 (3.3)| 29 (0.2)| 1 (0.0) |
| Hematology/oncologyc      | 144      | 1,584 (3.0)| 1,364 (4.9)| 218 (1.1)| 2 (0.0) |
| Inpatient acute dialysisd | 3        | 5 (0.0)| 5 (0.0)| ...| ... |
| Long-term acute caree     | 167      | 3,554 (6.6)| 1,778 (6.4)| 1,630 (8.6)| 146 (2.2) |
| Solid-organ transplantf   | 15       | 178 (0.3)| 135 (0.5)| 42 (0.2)| 1 (0.0) |
| Long-term careg           | 22       | 135 (0.3)| 44 (0.2)| 91 (0.5)| ... |
| Inpatient adult wardsb    | 1,271    | 5,398 (10.1)| 2,297 (8.3)| 3,074 (16.1)| 27 (0.4) |
| Inpatient pediatric wardsi| 109      | 421 (0.8)| 360 (1.3)| 60 (0.3)| 1 (0.0) |
| Medical-surgical ward     | 1,099    | 4,647 (8.7)| 2,074 (7.5)| 2,561 (13.4)| 12 (0.2) |
| Mixed acuityf             | 13       | 16 (0.0)| 9 (0.0)| 6 (0.0)| 1 (0.0) |
| Step-down unitsg          | 318      | 1,790 (3.3)| 814 (2.9)| 928 (4.9)| 48 (0.7) |
| Total                     | 6,505    | 53,456 (100)| 27,766 (100)| 19,058 (100)| 6,632 (100) |

**NOTE.** CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; VAP, ventilator-associated pneumonia.

*a* Pediatric burn critical care, pediatric cardiothoracic critical care, pediatric medical critical care, pediatric medical/surgical critical care, pediatric neurosurgical critical care, pediatric respiratory critical care, pediatric surgical critical care, and pediatric trauma critical care.

*b* Includes pediatric bone marrow transplant (n = 7).

*c* Includes pediatric hematology/oncology (n = 26).

*d* Includes pediatric dialysis (n = 0).

*e* Includes pediatric long-term acute care (n = 0).

*f* Includes pediatric solid-organ transplant (n = 2).

*g* Inpatient hospice, Alzheimer’s unit, behavioral health/psychiatry unit, rehabilitation unit, long-term care unit, and ventilator-dependent unit.

*h* Other than adult specialty care areas and inpatient medical-surgical wards.

*i* Burn ward; behavioral-health ward; ear, nose, throat ward; genitourinary ward; medical ward; medical/surgical ward; neurology ward; neurosurgical ward; orthopedic ward; rehabilitation ward; and surgical ward.

*j* Adult, pediatric, and mixed-aged acuity units.

*k* Adult, pediatric, and neonatal step-down units.

vancomycin-resistant *E. faecium* (86%) and fluoroquinolone-resistant *E. coli* (67%); it was lower for *E. coli* resistant to carbapenems (8%). Similar to data for CLABSIs, 20% of facilities reporting a CAUTI with *Klebsiella* spp. reported at least 1 as carbapenem resistant. Among the 570 facilities reporting at least 1 VAP with a bacterial pathogen, the proportion reporting a resistant phenotype was very high for MRSA (77%) and carbapenem-resistant *A. baumannii* (56%); 16% of facilities reporting a VAP with *Klebsiella* spp. reported at least 1 as carbapenem resistant. The proportions of facilities reporting CAUTI or VAP pathogens resistant to select antimicrobials are summarized on the CDC website (http://www.cdc.gov/nhsn/dataStat.html).

Among the 1,029 facilities reporting 1 or more SSIs, the pattern was very different. Most (77%) facilities reporting an SSI with *S. aureus* reported at least 1 as MRSA, similar to...
we can make several observations that will help advance our understanding of the pathogenesis, preventability, and treatment options of these infections. First, pooled mean percent resistance for certain high-profile resistance phenotypes has decreased. Most notably, we observed a slightly lower percent resistance among device-associated HAIs for MRSA, with relative decreases of 1.7% among CLABSIs, 10.2% among CAUTIs, 6.7% among VAP, and 9% among SSIs (the latter 2 being statistically significant decreases). The changes in MRSA are consistent with recent findings from different surveillance programs focused on MRSA. Although this decrease in percent resistance is noteworthy, the reasons for it are not known with certainty and are likely multifactorial.

Second, among gram-negative bacteria, there were no consistent trends but some reason for concern. Although they are a less common cause of HAIs, both multidrug resistance and carbapenem resistance were reported in more than 60% of Acinetobacter spp. among most HAI types, and 70%-80% of facilities reporting an HAI with Acinetobacter spp. reported at least one multidrug-resistant strain. Carbapenem resistance among Klebsiella spp. was stable between time periods (about 13%), but almost 1 in 5 hospitals reporting CLABSIs or CAUTIs with Klebsiella spp. have reported a carbapenem-resistant phenotype as the cause of the infection. This suggests that the problem of highly resistant gram-negative bacteria causing HAIs is not limited to just a small subset of hospitals, and it reinforces the need for prevention efforts designed to prevent the further emergence and spread of these pathogens. The fact that carbapenem-resistant Enterobacteriaceae (CRE) are not routinely identified from HAIs from a large proportion of hospitals reporting to NHSN highlights that in many places the identification of CRE from a clinical culture should prompt an aggressive response to prevent further transmission. CDC’s updated CRE prevention recommendations are highlighted at http://www.cdc.gov/HAI/organisms/cre/index.html.

Third, there have been some changes in the distribution of pathogens reported in these device- and procedure-associated HAIs: coagulase-negative staphylococci are a less prominent cause of HAIs in the more recent years, and Candida spp. are slightly more common. This latter observation is subtle, because the current data exclude asymptomatic CAUTI, which is no longer reported to NHSN as of 2009, when the NHSN changed the case definition of CAUTI to exclude asymptomatic bacteriuria (http://www.cdc.gov/nhsn/library.html). Among CLABSIs, these changes suggest that recent prevention efforts may preferentially prevent certain pathogenesis of infection over others. Another possibility for the observed change is less frequent reporting of CLABSIs associated with certain pathogens because of suboptimal implementation of case-finding and reporting methodology.

Participation in NHSN during the time period covered in this report was a combination of voluntary and mandatory reporting; participation in NHSN related to the CMS Hospital Inpatient Quality Reporting Program was not in effect until 2011 for CLABSIs among critical care patients and 2012 for CAUTIs or SSIs among patients undergoing abdominal hysterectomies or colon surgery. As reporting becomes more comprehensive across the United States, tracking the degree of spread of these and other emerging resistant pathogens will improve and will allow more accurate assessments of how widespread any one resistant phenotype is and how successful facilities and states have been in curtailing or reversing the spread of specific phenotypes across hospitals in the United States.
Direct comparisons of these resistance data with those reported in other studies and even with prior NHSN data have limitations. The patient population may not be representative of the US patient population as a whole; although the data in this report are not from a comprehensive set of hospitals, they represent the largest group of hospitals reporting antimicrobial susceptibility data related to clinically relevant infections. Of note, the majority of hospitals (56.1%) contributing to this report had fewer than 200 beds; the changing demographics of hospital participation in NHSN toward inclusion of more small hospitals may explain some of the new observations noted in this report. Most US hospitals will expand reporting of HAIs to comply with federal pay-for-reporting programs in 2011–2013. Analysis of data

**TABLE 5. Distribution of Rank Order of Selected Pathogens Associated with Healthcare-Associated Infections (HAIs) Reported to the National Healthcare Safety Network, by Type of HAI, 2009–2010**

| Pathogen                        | Overall | CAUTI | VAP | SSI |
|---------------------------------|---------|-------|-----|-----|
|                                 | No. (%) of pathogens | Rank | No. (%) of pathogens | Rank | No. (%) of pathogens | Rank | No. (%) of pathogens | Rank |
| **Staphylococcus aureus**       | 12,635 (15.6)      | 1    | 3,735 (12.3)       | 2    | 442 (2.1)         |       | 2,043 (24.1)        | 1    |
| **Enterococcus faecalis**       | 5,484 (6.8)        | 6    | 2,680 (8.8)        | 3    | 1,519 (7.2)       | 5    | 45 (0.5)            |       |
| **Escherichia coli**            | 9,351 (11.5)       | 2    | 1,206 (4.0)        | 9    | 5,660 (26.8)      | 1    | 504 (5.9)           | 6    |
| **Pseudomonas aeruginosa**      | 1,028 (1.3)        | 3    | 93 (3.1)           | 1    | 19 (0.9)          |       | 17 (0.2)            | 1    |
| **Klebsiella pneumoniae/oxytoca** | 1,043 (1.3)    | 11   | 762 (2.5)          | 11   | 204 (1.0)         | 6    | 386 (2.1)           | 7    |
| **Proteus* spp.**               | 2,477 (3.1)        | 5    | 27 (0.1)           | 3    | 162 (7.6)         | 10   | 28 (1.0)            | 3    |
| **Serratia* spp.**              | 2,477 (3.1)        | 7    | 269 (2.2)          | 13   | 189 (8.9)         | 4    | 147 (7.7)           | 5    |
| **Acinetobacter baumannii**     | 1,990 (2.5)        | 14   | 629 (2.1)          | 1     | 99 (5.0)          |       | 96 (0.5)            |     |
| **Enterobacter spp.**           | 3,821 (4.7)        | 8    | 1,365 (4.5)        | 8     | 880 (4.2)         | 8    | 727 (8.6)           | 4    |
| **Other Candida spp. or NOS**   | 3,804 (4.9)        | 9    | 2,465 (8.1)        | 4     | 811 (3.8)         | 9    | 36 (0.4)            |     |
| **Enterococcus faecium**        | 3,314 (4.1)        | 10   | 2,118 (7.0)        | 6     | 654 (3.1)         | 10   | 25 (0.3)            |     |
| **Streptococcus* spp.**         | 2,409 (3.0)        | 11   | 703 (2.3)          | 12    | 1,010 (4.8)       | 7    | 11 (0.1)            |     |
| **Proteus* spp.**               | 2,031 (2.5)        | 12   | 232 (0.8)          |       | 1,013 (4.8)       | 6    | 119 (1.4)           |     |
| **Serratia* spp.**              | 1,737 (2.2)        | 15   | 762 (2.5)          | 11    | 204 (1.0)         | 6    | 386 (2.1)           | 7    |
| **Acinetobacter baumannii**     | 1,990 (2.5)        | 14   | 629 (2.1)          | 13    | 189 (8.9)         | 4    | 147 (7.7)           | 5    |
| **Enterobacter spp.**           | 3,821 (4.7)        | 8    | 1,365 (4.5)        | 8     | 880 (4.2)         | 8    | 727 (8.6)           | 4    |
| **Other* spp.**                 | 9,304 (11.5)       |      | 2,762 (9.1)        |      | 1,633 (7.7)       |      | 2,770 (15.7)        |     |
| **Total**                       | 81,139 (100)       |      | 30,454 (100)       |      | 21,111 (100)      |      | 8,474 (100)         |     |

**NOTE.** CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; NOS, not otherwise specified; SSI, surgical site infection; VAP, ventilator-associated pneumonia.

* A rank is not given if pathogen is not in the top 14 reported for the specific HAI type listed in Table 3 of the supplemental report on the CDC website (http://www.cdc.gov/nhsn/dataStat.html).

**TABLE 6. Distribution of Selected Pathogens Associated with Surgical Site Infections Reported to the National Healthcare Safety Network, by Type of Surgery, 2009–2010**

| Pathogen                        | Overall | Abdominal | Breast | Cardiac | Neck | Neurological | Ortho/gyn | Orthopedic | Transplant | Vascular | Other |
|---------------------------------|---------|-----------|--------|---------|------|--------------|-----------|------------|------------|----------|--------|
|                                 | No. (%) of pathogens | Rank | No. (%) of pathogens | Rank | No. (%) of pathogens | Rank | No. (%) of pathogens | Rank | No. (%) of pathogens | Rank |
| **Staphylococcus aureus**       | 6,415 (64.8)       | 31   | 3,168 (30.7)       | 10   | 160 (15.0)      | 13   | 418 (19.7)        | 7    | 3,656 (47.1)       | 17   |
| **Escherichia coli**            | 1,981 (19.0)       | 3     | 283 (6.4)          | 12    | 1,287 (27.8)    | 34   | 314 (4.0)         | 24   | 29 (9.6)           | 25   |
| **Pseudomonas aeruginosa**      | 1,028 (1.0)        | 1     | 93 (0.9)           | 3    | 19 (1.0)        | 3    | 96 (0.9)          | 1    | 5 (0.5)            | 10   |
| **Klebsiella pneumoniae/oxytoca** | 1,043 (1.0)    | 11   | 762 (7.2)          | 11    | 204 (1.0)       | 6    | 386 (2.1)         | 7    | 385 (1.8)          |     |
| **Acinetobacter baumannii**     | 2,477 (3.1)        | 5     | 27 (0.1)           | 3    | 162 (7.6)       | 10   | 28 (1.0)          | 3    | 557 (6.6)          | 5    |
| **Enterobacter spp.**           | 2,477 (3.1)        | 9     | 269 (2.1)          | 13    | 189 (8.9)       | 4    | 147 (7.7)         | 5    | 119 (6.6)          | 6    |
| **Other* spp.**                 | 2,031 (2.5)        | 12    | 232 (0.8)          |       | 1,013 (4.8)     | 6    | 119 (1.4)         |     | 667 (3.2)          | 8    |
| **Total**                       | 81,139 (100)       |      | 30,454 (100)       |      | 21,111 (100)    |      | 8,474 (100)       |     | 21,100 (100)       |     |

**NOTE.** NOS, not otherwise specified; Ortho/gyn, obstetrical and gynecological.

* The types of surgery included in each category are as follows: Abdominal: appendectomy, bile duct, liver, or pancreatic surgery, gallbladder surgery, colon surgery, gastric surgery, herniorrhaphy, small-bowel surgery, spleen surgery, abdominal surgery, and rectal surgery. Breast: breast surgery. Cardiac: cardiac surgery, coronary artery bypass graft with chest incision or without donor incision, pacemaker surgery, and thoracic surgery. Neck: neck surgery and thyroid and/or parathyroid surgery. Neurological: craniorhaphy and ventricular shunt. Ortho/gyn: cesarean section, abdominal hysterectomy, ovarian surgery, and vaginal hysterectomy. Orthopedic: open reduction of fracture, hip prosthesis, knee prosthesis, limb amputation, spinal fusion, refusion of spine, and laminectomy. Transplant: heart transplant, kidney transplant, and liver transplant. Vascular: abdominal aortic aneurysm repair, shunt for dialysis, carotid endarterectomy, and peripheral vascular bypass surgery. Other: prostate surgery and kidney surgery.

* Genus and species not indicated elsewhere in the table.
| Pathogen, antimicrobial | CLABSI No. (%) of isolates reported | CAUTI No. (%) of isolates tested | VAP No. (%) of isolates reported | SSI No. (%) of isolates reported |
|-------------------------|------------------------------------|--------------------------------|---------------------------------|-------------------------------|
| **Staphylococcus aureus** | 3,735 | 442 | 2,043 | 6,415 |
| OX/METH                 | 3,611 (96.7) | 438 (99.1) | 1,974 (96.6) | 6,304 (98.3) |
| **Enterococcus spp.**   | 2,118 | 654 | 25 | 517 |
| VAN                     | 2,069 (97.7) | 639 (97.7) | 23 (92) | 509 (98.5) |
| **E. faecalis**         | 2,680 | 1,519 | 45 | 1,240 |
| VAN                     | 2,578 (96.2) | 1,446 (95.2) | 41 (91.1) | 1,187 (95.7) |
| **Klebsiella (pneumoniae/oxytoca)** | 2,407 | 2,365 | 854 | 844 |
| ESC4                    | 2,109 (87.6) | 1,998 (84.5) | 747 (87.5) | 710 (84.1) |
| Carbapenem              | 1,858 (77.2) | 1,520 (64.3) | 617 (72.2) | 582 (69.0) |
| MDR1                    | 1,932 (80.3) | 1,650 (69.8) | 658 (77.0) | 621 (73.6) |
| **Escherichia coli**    | 1,206 | 5,660 | 504 | 1,981 |
| ESC4                    | 1,067 (88.5) | 4,656 (82.3) | 429 (85.1) | 1,627 (82.1) |
| FQ3                     | 1,137 (94.3) | 5,513 (97.4) | 466 (92.5) | 1,876 (94.7) |
| Carbapenem              | 931 (77.2) | 3,579 (63.2) | 344 (68.3) | 1,330 (67.1) |
| MDR1                    | 992 (82.3) | 3,929 (69.4) | 365 (72.4) | 1,390 (70.2) |
| **Enterobacter spp.**   | 1,365 | 880 | 727 | 849 |
| ESC4                    | 1,309 (95.9) | 818 (93.0) | 690 (94.9) | 816 (96.1) |
| Carbapenem              | 1,041 (76.3) | 614 (69.8) | 530 (72.9) | 594 (70.0) |
| MDR1                    | 1,123 (82.3) | 667 (75.8) | 579 (79.6) | 648 (76.3) |
| **Pseudomonas aeruginosa** | 1,166 | 2,381 | 1,408 | 1,156 |
| AMINOS                  | 819 (70.2) | 1,495 (62.8) | 920 (65.3) | 664 (57.4) |
| ESC2                    | 1,120 (96.1) | 2,294 (96.3) | 1,355 (96.2) | 1,097 (94.9) |
| FQ2                     | 1,114 (95.5) | 2,337 (98.2) | 1,378 (97.9) | 1,111 (96.1) |
| Carbapenem              | 982 (84.2) | 1,883 (79.1) | 1,162 (82.5) | 872 (75.4) |
| PIP/PIPTAZ              | 809 (69.4) | 1,792 (75.3) | 1,059 (75.2) | 818 (70.8) |
| MDR2                    | 1,096 (94) | 2,250 (94.5) | 1,342 (95.3) | 1,053 (91.1) |
| **Acinetobacter baumannii** | 629 | 185 | 557 | 119 |
| Carbapenem              | 522 (83) | 128 (60.2) | 449 (80.6) | 102 (85.7) |
| MDR3                    | 617 (98.1) | 183 (98.9) | 552 (99.1) | 114 (95.8) |

Note: CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; SSI, surgical site infection; VAP, ventilator-associated pneumonia.

* AMINOS, aminoglycosides (amikacin, gentamicin, tobramycin). Carbapenem are imipenem and meropenem. ESC2, extended-spectrum (ES) cephalosporins (cefpime, cefazidine, cetazidime, ceftriaxone). FQ2, fluoroquinolones (ciprofloxacin, levofloxacin); FQ3, fluoroquinolones (ciprofloxacin, levofloxacin, moxifloxacin). MDR1, pathogens tests as "I" (intermediate) or "R" (resistant) to at least 1 drug in 3 of the 5 following classes: ESC4, FQ3, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; MDR2, pathogens test as R to at least 1 drug in 3 of the 5 following classes: ESC4, FQ3, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; MDR3, pathogens must test as I or R to at least 1 drug in 3 of the 5 following classes: ESC2, FQ2, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; and ampicillin/sulbactam. OX/METH, oxacillin/methicillin; PIP, piperacillin; PIPTAZ, piperacillin/tazobactam; VAN, vancomycin.
### TABLE 8. Percentage of Pathogenic Isolates Resistant to Selected Antimicrobial Agents, by Location of Patient Reported to the National Healthcare Safety Network, 2009–2010

| Pathogen, antimicrobial agents | CLABSI | CAUTI |
|-------------------------------|--------|-------|
|                              | ICU    | Non-ICU | ICU    | Non-ICU |
| **Staphylococcus aureus, oxacillins** |        |        |
| Enterococcus species          |        |        |
| *E. faecium*, vancomycin       |        |        |
| *E. faecalis*, vancomycin      |        |        |
| **Klebsiella (pneumoniae/oxytoca)** |        |        |
| ES cephalosporins 4           |        |        |
| Carbapenems                   |        |        |
| Multidrug resistant 1         |        |        |
| **Escherichia coli**          |        |        |
| ES cephalosporins 2           |        |        |
| Fluoroquinolones 3            |        |        |
| Carbapenems                   |        |        |
| Multidrug resistant 1         |        |        |
| **Enterobacter species**      |        |        |
| ES cephalosporins 2           |        |        |
| Fluoroquinolones 2            |        |        |
| Carbapenems                   |        |        |
| Multidrug resistant 1         |        |        |
| **Pseudomonas aeruginosa**    |        |        |
| Aminoglycosides               |        |        |
| ES cephalosporins 2           |        |        |
| Fluoroquinolones 2            |        |        |
| Carbapenems                   |        |        |
| Multidrug resistant 2         |        |        |
| **Acinetobacter baumannii**   |        |        |
| Carbapenems                   |        |        |
| Multidrug resistant 3         |        |        |

**NOTE.** CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; ICU, intensive care unit.

* Aminoglycosides are amikacin, gentamicin, and tobramycin. Carbapenems are imipenem and meropenem. ES (extended-spectrum) cephalosporins 2 are ceftazidime; ES cephalosporins 4 are ceftazidime, cefotaxime, ceftriaxone. Fluoroquinolones 2 are ciprofloxacin and levofloxacin; fluoroquinolones 3 are ciprofloxacin, levofloxacin, and moxifloxacin. Multidrug resistant 1, pathogen must test as “I” (intermediate) or “R” (resistant) to at least 1 drug in 3 of the 6 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; multidrug resistant 2, pathogen must test as 1 or R to at least 1 drug in 3 of the 5 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carpapenems, and piperacillin or piperacillin/tazobactam; multidrug resistant 3, pathogen must test as 1 or R to at least 1 drug in 3 of the 6 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbapenems, piperacillin or piperacillin/tazobactam, and ampicillin/sulbactam. Oxacillins are oxacillin and methicillin.

reported from 2011 and beyond will be more representative of all US hospitals and will lead to more informed guidance regarding treatment or prophylaxis strategies. An additional limitation of this report is the use of antimicrobial susceptibility testing data from laboratories servicing the hospitals and not from a single referral laboratory. Related to this fact is that facilities may perform selective testing (cascade testing) of broad-spectrum agents or have systems that have suppression rules in place preventing testing results from being readily available to NHSN users entering data, resulting in some selection bias; inasmuch as more than 80% of isolates had testing results for most phenotypes, any inflation of proportions is likely to be small. In addition, as NHSN captures only the interpretation (S, I, or R) and not the measured...
| Pathogen, antimicrobial agents | Resistance percentage, 2007-2008, % (95% CI) | Resistance percentage, 2009-2010, % (95% CI) | Overall change, % | P value |
|-------------------------------|---------------------------------------------|---------------------------------------------|------------------|---------|
| **Staphylococcus aureus**     |                                             |                                             |                  |         |
| Oxacillins                    | 55.5 (53.5, 57.6)                           | 54.6 (53.0, 56.2)                           | -1.7             | .49     |
| **Enterococcus species**      |                                             |                                             |                  |         |
| E. faecium, vancomycin        | 80.6 (78.4, 82.8)                           | 82.6 (81.0, 84.2)                           | 2.5              | .15     |
| E. faecalis, vancomycin       | 8.8 (7.4, 10.1)                             | 9.5 (8.3, 10.6)                            | 8.1              | .43     |
| **Klebsiella (pneumoniae/oxytoca)** |                                         |                                             |                  |         |
| ES cephalosporins 4           | 31.7 (29.3, 34.2)                           | 28.8 (26.9, 30.8)                           | -9.2             | .07     |
| Carbenapems                   | 13.2 (11.3, 15.1)                           | 12.8 (11.2, 14.3)                           | -3.3             | .73     |
| Multidrug resistant 1         | 18.1 (16.0, 20.2)                           | 16.8 (15.1, 18.4)                           | -7.4             | .32     |
| **Escherichia coli**          |                                             |                                             |                  |         |
| ES cephalosporins 4           | 12.3 (9.7, 15.0)                            | 19.0 (16.7, 21.4)                           | 54.3             | <.001   |
| Fluoroquinolones 3            | 37.7 (33.8, 41.5)                           | 41.8 (38.9, 44.6)                           | 10.9             | .10     |
| Carbenapems                   | 1.9 (0.7, 3.1)                              | 1.9 (1.0, 2.8)                              | 0.9              | .98     |
| Multidrug resistant 1         | 1.5 (0.5, 2.5)                              | 3.7 (2.6, 4.9)                              | 150.8            | .02     |
| **Enterobacter species**      |                                             |                                             |                  |         |
| ES cephalosporins 4           | 40.2 (37.0, 43.5)                           | 37.4 (34.8, 40.1)                           | -7.0             | .19     |
| Carbenapems                   | 3.1 (1.8, 4.3)                              | 4.0 (2.8, 5.2)                              | 31.2             | .29     |
| Multidrug resistant 1         | 3.2 (2.0, 4.5)                              | 3.7 (2.6, 4.8)                              | 15.3             | .57     |
| **Pseudomonas aeruginosa**    |                                             |                                             |                  |         |
| Aminoglycosides               | 7.4 (5.1, 9.6)                              | 10.0 (8.0, 12.1)                            | 36.2             | .10     |
| ES cephalosporins 2           | 27.6 (24.2, 31.0)                           | 26.1 (23.5, 28.6)                           | -5.6             | .48     |
| Fluoroquinolones 2            | 31.4 (27.9, 35.0)                           | 30.5 (27.8, 33.2)                           | -2.9             | .69     |
| Carbenapems                   | 26.8 (23.2, 30.4)                           | 26.1 (23.3, 28.8)                           | -2.8             | .74     |
| Piperacillin/tazobactam       | 21.1 (17.4, 24.7)                           | 17.4 (14.8, 20.0)                           | -17.2            | .11     |
| Multidrug resistant 2         | 17.5 (14.5, 20.4)                           | 15.4 (13.3, 17.6)                           | -11.7            | .26     |
| **Acinetobacter baumannii**   |                                             |                                             |                  |         |
| Carbenapems                   | 50.0 (45.6, 54.4)                           | 62.6 (58.5, 66.8)                           | 25.3             | <.001   |
| Multidrug resistant 3         | 61.7 (57.6, 65.7)                           | 67.6 (63.9, 71.3)                           | 9.6              | .04     |

Note. The 2007-2008 numbers may differ from those in the previous report, which was limited to a slightly shorter time period. CI, confidence interval; CLABSI, central line-associated bloodstream infection.

* Aminoglycosides are amikacin, gentamicin, and tobramycin. Carbenapems are imipenem and meropenem. ES (extended-spectrum) cephalosporins 2 are cefepime and ceftazidime; ES cephalosporins 4 are cefepime, cefotaxime, ceftazidime, and ceftriaxone. Fluoroquinolones 2 are ciprofloxacin and levofloxacin; fluoroquinolones 3 are ciprofloxacin, levofloxacin, and moxifloxacin. Multidrug resistant 1, pathogen must test as “I” (intermediate) or “R” (resistant) to at least 1 drug in 3 of the 5 following classes: ES cephalosporins 4, fluoroquinolones 3, aminoglycosides, carbenapems, and piperacillin or piperacillin/tazobactam; multidrug resistant 2, pathogen must test as I or R to at least 1 drug in 3 of the 5 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbenapems, and piperacillin or piperacillin/tazobactam; multidrug resistant 3, pathogen must test as I or R to at least 1 drug in 3 of the 6 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbenapems, piperacillin or piperacillin/tazobactam, and ampicillin/sulbactam. Oxacillins are oxacillin and methicillin.
Table 10. Changes in Percent Resistance among Pathogens Associated with CAUTIs Reported to the National Healthcare Safety Network, 2007–2010, from Critical Care and Non–Critical Care Locations

| Resistant pathogen, antimicrobial agents | Resistance percentage, 2007–2008, % (95% CI) | Resistance percentage, 2009–2010, % (95% CI) | Overall change, % | P value |
|-----------------------------------------|-----------------------------------------------|-----------------------------------------------|-------------------|---------|
| **Staphylococcus aureus**                |                                               |                                               |                   |         |
| Oxacillins                               | 65.3 (59.6, 71.0)                             | 58.7 (54.1, 63.3)                             | -10.2             | .07     |
| **Enterococcus species**                 |                                               |                                               |                   |         |
| *E. faecium*, vancomycin                 | 79.9 (76.0, 83.8)                             | 82.5 (79.5, 85.4)                             | 3.2               | .30     |
| *E. faecalis*, vancomycin                | 5.6 (4.1, 7.2)                                | 8.4 (7.0, 9.9)                                | 11.7              | .02     |
| **Klebsiella (pneumoniae/oxytoca)**      |                                               |                                               |                   |         |
| ES cephalosporins 4                      | 27.1 (24.6, 29.6)                             | 26.9 (24.9, 28.8)                             | -0.7              | .91     |
| Carbenapems                              | 11.7 (9.6, 13.8)                              | 12.5 (10.8, 14.2)                             | 6.9               | .56     |
| Multidrug resistant 1                    | 16.0 (13.8, 18.3)                             | 16.1 (14.3, 17.9)                             | 0.5               | .96     |
| **Escherichia coli**                     |                                               |                                               |                   |         |
| ES cephalosporins 4                      | 10.6 (9.5, 11.7)                              | 12.3 (11.4, 13.3)                             | 16.3              | .02     |
| Fluoroquinolones 3                       | 27.0 (25.5, 28.5)                             | 31.2 (30.0, 32.5)                             | 15.6              | <.0001  |
| Carbenapems                              | 2.9 (2.2, 3.7)                                | 2.3 (1.8, 2.8)                                | -23.0             | .13     |
| Multidrug resistant 1                    | 1.8 (1.2, 2.3)                                | 2.0 (1.5, 2.4)                                | 11.0              | .59     |
| **Enterobacter species**                 |                                               |                                               |                   |         |
| ES cephalosporins 4                      | 40.6 (36.4, 44.9)                             | 38.5 (35.2, 41.8)                             | -5.2              | .44     |
| Carbenapems                              | 3.7 (1.7, 5.7)                                | 4.6 (2.9, 6.2)                                | 22.4              | .54     |
| Multidrug resistant 1                    | 3.0 (1.3, 4.7)                                | 4.8 (3.2, 6.4)                                | 58.3              | .17     |
| **Pseudomonas aeruginosa**               |                                               |                                               |                   |         |
| Aminoglycosides                          | 10.7 (8.7, 12.7)                              | 10.9 (9.3, 12.5)                              | 1.9               | .88     |
| ES cephalosporins 2                      | 24.3 (22.0, 26.5)                             | 25.2 (23.4, 27.0)                             | 3.9               | .53     |
| Fluoroquinolones 2                       | 35.2 (32.7, 37.6)                             | 33.5 (31.6, 35.4)                             | -4.7              | .29     |
| Carbenapems                              | 21.8 (19.3, 24.3)                             | 21.3 (19.5, 23.2)                             | -1.9              | .80     |
| Piperacillin/tazobactam                  | 14.5 (12.3, 16.7)                             | 16.6 (14.9, 18.3)                             | 14.4              | .16     |
| Multidrug resistant 2                    | 13.4 (11.6, 15.2)                             | 14.0 (12.6, 15.4)                             | 4.4               | .62     |
| **Acinetobacter baumannii**              |                                               |                                               |                   |         |
| Carbenapems                              | 63.5 (54.7, 72.3)                             | 74.2 (66.6, 81.8)                             | 16.9              | .08     |
| Multidrug resistant 3                    | 82.1 (75.8, 88.5)                             | 77.6 (71.6, 83.6)                             | -5.5              | .31     |

Note. The 2007–2008 numbers may differ from those in the previous report, which was limited to a slightly shorter time period. CAUTI, catheter-associated urinary tract infection; CI, confidence interval.

* Aminoglycosides are amikacin, gentamicin, and tobramycin. Carbenapems are imipenem and meropenem. ES (extended-spectrum) cephalosporins 2 are cefepime and ceftazidime; ES cephalosporins 4 are cefepime, cefotaxime, ceftazidime, and ceftriaxone. Fluoroquinolones 2 are ciprofloxacin and levofloxacin; fluoroquinolones 3 are ciprofloxacin, levofloxacin, and moxifloxacin. Multidrug resistant 1, pathogen must test as “I” (intermediate) or “R” (resistant) to at least 1 drug in 3 of the 5 following classes: ES cephalosporins 4, fluoroquinolones 3, aminoglycosides, carbenapems, and piperacillin or piperacillin/tazobactam; multidrug resistant 2, pathogen must test as I or R to at least 1 drug in 3 of the 5 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbenapems, and piperacillin or piperacillin/tazobactam; multidrug resistant 3, pathogen must test as I or R to at least 1 drug in 3 of the 6 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbenapems, piperacillin or piperacillin/tazobactam, and ampicillin/sulbactam. Oxacillins are oxacillin and methicillin.
| Resistant pathogen, antimicrobial agents | Resistance percentage, 2007–2008, % (95% CI) | Resistance percentage, 2009–2010, % (95% CI) | Overall change, % | P value |
|----------------------------------------|-----------------------------------------------|-----------------------------------------------|------------------|---------|
| *Staphylococcus aureus*                |                                               |                                               |                  |         |
| Oxacillins                             | 51.9 (49.6, 54.1)                             | 48.4 (46.2, 50.6)                             | −6.7             | .03     |
| *Enterococcus*                         |                                               |                                               |                  |         |
| *E. faecium*, vancomycin               | 82.4 (64.2, 100.5)                            | 82.6 (67.1, 98.1)                             | 0.3              | .98     |
| *E. faecalis*, vancomycin              | 6.4 (−0.6, 13.4)                              | 9.8 (0.7, 18.8)                               | 52.8             | .56     |
| *Klebsiella (pneumoniae/oxytoca)*     |                                               |                                               |                  |         |
| ES cephalosporins 4                    | 21.5 (18.5, 24.5)                             | 23.8 (20.8, 26.9)                             | 10.9             | .29     |
| Carbenemns                             | 9.9 (7.5, 12.4)                               | 11.2 (8.7, 13.7)                              | 12.6             | .48     |
| Multidrug resistant 1                  | 11.8 (9.3, 14.4)                              | 13.4 (10.8, 16.0)                             | 13.0             | .41     |
| *Escherichia coli*                     |                                               |                                               |                  |         |
| ES cephalosporins 4                    | 14.2 (10.6, 17.9)                             | 16.3 (12.8, 19.8)                             | 14.5             | .43     |
| Fluoroquinolones 3                     | 33.3 (28.6, 38.1)                             | 35.2 (30.9, 39.5)                             | 5.6              | .57     |
| Carbenemns                             | 3.0 (1.0, 5.1)                                | 3.5 (1.5, 5.4)                                | 15.1             | .75     |
| Multidrug resistant 1                  | 1.7 (0.2, 3.1)                                | 3.3 (1.5, 5.1)                                | 95.9             | .20     |
| *Enterobacter species*                 |                                               |                                               |                  |         |
| ES cephalosporins 4                    | 34.6 (30.9, 38.3)                             | 30.1 (26.7, 33.6)                             | −13.0            | .08     |
| Carbenemns                             | 4.6 (2.7, 6.6)                                | 3.6 (2.0, 5.2)                                | −22.7            | .41     |
| Multidrug resistant 1                  | 2.5 (1.1, 3.8)                                | 1.4 (0.4, 2.3)                                | −43.8            | .20     |
| *Pseudomonas aeruginosa*               |                                               |                                               |                  |         |
| Aminoglycosides                        | 10.8 (8.9, 12.7)                              | 11.3 (9.3, 13.4)                              | 4.6              | .73     |
| ES cephalosporins 2                    | 28.5 (26.1, 30.8)                             | 28.4 (26.0, 30.8)                             | −0.2             | .98     |
| Fluoroquinolones 2                     | 32.7 (30.3, 35.2)                             | 32.7 (30.3, 35.2)                             | 0.0              | .99     |
| Carbenemns                             | 31.1 (28.4, 33.8)                             | 30.2 (27.6, 32.8)                             | −2.8             | .65     |
| Piperacillin/tazobactam                | 19.2 (16.8, 21.6)                             | 19.1 (16.7, 21.4)                             | −0.8             | .93     |
| Multidrug resistant 2                  | 16.6 (14.7, 18.6)                             | 17.7 (15.6, 19.7)                             | 6.2              | .48     |
| *Acinetobacter baumannii*              |                                               |                                               |                  |         |
| Carbenemns                             | 56.7 (52.8, 60.6)                             | 61.2 (56.7, 65.8)                             | 8.1              | .13     |
| Multidrug resistant 3                  | 67.4 (63.9, 71.0)                             | 63.4 (59.4, 67.4)                             | −6.0             | .14     |

**NOTE.** The 2007–2008 numbers may differ from those in the previous report,¹ which was limited to a slightly shorter time period. CI, confidence interval; VAP, ventilator-associated pneumonia.

¹ Aminoglycosides are amikacin, gentamicin, and tobramycin. Carbenemns are imipenem and meropenem. ES (extended-spectrum) cephalosporins 2 are cefepime and ceftazidime; ES cephalosporins 4 are cefepime, cefotaxime, ceftazidime, and ceftriaxone. Fluoroquinolones 2 are ciprofloxacin and levofloxacin; fluoroquinolones 3 are ciprofloxacin, levofloxacin, and moxifloxacin. Multidrug resistant 1, pathogen must test as "I" (intermediate) or "R" (resistant) to at least 1 drug in 3 of the 5 following classes: ES cephalosporins 4, fluoroquinolones 3, aminoglycosides, carbenemns, and piperacillin or piperacillin/tazobactam; multidrug resistant 2, pathogen must test as I or R to at least 1 drug in 3 of the 5 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbenemns, and piperacillin or piperacillin/tazobactam; multidrug resistant 3, pathogen must test as I or R to at least 1 drug in 3 of the 6 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbenemns, piperacillin or piperacillin/tazobactam, and ampicillin/sulbactam. Oxacillins are oxacillin and methicillin.
Table 12. Changes in Percent Resistance among Pathogens Associated with SSIs Reported to the National Healthcare Safety Network, 2007–2010

| Resistant pathogen, antimicrobial agents | Resistance percentage, 2007–2008, % (95% CI) | Resistance percentage, 2009–2010, % (95% CI) | Overall change, % | P value |
|----------------------------------------|-----------------------------------------------|-----------------------------------------------|-------------------|---------|
| Staphylococcus aureus                  |                                               |                                               |                   |         |
| Oxacillins                             | 48.0 (46.5, 49.5)                             | 43.7 (42.5, 44.9)                             | -9.0              | <.0001  |
| Enterococcus species                   |                                               |                                               |                   |         |
| E. faecium, vancomycin                 | 65.2 (60.6, 69.7)                             | 62.3 (58.1, 66.5)                             | -4.4              | .36     |
| E. faecalis, vancomycin                | 4.6 (3.1, 6.2)                                | 6.2 (4.9, 7.6)                                | 34.7              | .14     |
| Klebsiella (pneumoniae/oxytoca)        |                                               |                                               |                   |         |
| ES cephalosporins 4                    | 19.4 (15.9, 22.9)                             | 13.2 (10.7, 15.7)                             | -31.7             | <.01    |
| Carbapenems                            | 9.6 (6.7, 12.5)                               | 7.9 (5.7, 10.1)                               | -17.7             | .35     |
| Multidrug resistant 1                  | 10.9 (7.9, 13.8)                              | 6.8 (4.8, 8.7)                                | -37.8             | .02     |
| Escherichia coli                       |                                               |                                               |                   |         |
| ES cephalosporins 4                    | 9.1 (7.5, 10.7)                               | 10.9 (9.4, 12.5)                              | 20.2              | .11     |
| Fluoroquinolones 3                     | 27.2 (24.8, 29.5)                             | 25.3 (23.3, 27.2)                             | -7.0              | .23     |
| Carbapenems                            | 1.5 (0.7, 2.2)                                | 2.0 (1.3, 2.8)                                | 38.2              | .31     |
| Multidrug resistant 1                  | 1.1 (0.5, 1.7)                                | 1.6 (0.9, 2.2)                                | 41.8              | .33     |
| Enterobacter species                   |                                               |                                               |                   |         |
| ES cephalosporins 4                    | 30.6 (26.8, 34.5)                             | 27.7 (24.6, 30.8)                             | -9.5              | .24     |
| Carbapenems                            | 2.8 (1.2, 4.3)                                | 2.4 (1.1, 3.6)                                | -14.4             | .69     |
| Multidrug resistant 1                  | 1.5 (0.4, 2.7)                                | 1.7 (0.7, 2.7)                                | 10.6              | .83     |
| Pseudomonas aeruginosa                 |                                               |                                               |                   |         |
| Aminoglycosides                        | 4.4 (2.5, 6.3)                                | 6.0 (4.2, 7.8)                                | 37.7              | .23     |
| ES cephalosporins 2                    | 13.6 (11.1, 16.0)                             | 10.2 (8.4, 12.0)                              | -24.8             | .03     |
| Fluoroquinolones 2                     | 15.8 (13.2, 18.4)                             | 16.9 (14.7, 19.1)                             | 7.2               | .51     |
| Carbapenems                            | 11.2 (8.7, 13.8)                              | 11.0 (8.9, 13.1)                              | -2.1              | .89     |
| Piperacillin/tazobactam                | 6.8 (4.7, 8.8)                                | 6.8 (5.1, 8.6)                                | 1.3               | .95     |
| Multidrug resistant 2                  | 4.9 (3.3, 6.5)                                | 5.3 (4.0, 6.7)                                | 8.4               | .70     |
| Acinetobacter baumannii                |                                               |                                               |                   |         |
| Carbapenems                            | 38.6 (28.5, 48.8)                             | 37.3 (27.9, 46.6)                             | -3.6              | .85     |
| Multidrug resistant 3                  | 49.5 (39.6, 59.3)                             | 43.9 (34.8, 53.0)                             | -11.4             | .41     |

Note. The 2007–2008 numbers may differ from those in the previous report, which was limited to a slightly shorter time period. CI, confidence interval; SSI, surgical site infection.

* Aminoglycosides are amikacin, gentamicin, and tobramycin. Carbapenems are imipenem and meropenem. ES (extended-spectrum) cephalosporins 2 are cefepime and ceftazidime; ES cephalosporins 4 are cefepime, cefotaxime, ceftazidime, and ceftriaxone. Fluoroquinolones 2 are ciprofloxacin and levofloxacin; fluoroquinolones 3 are ciprofloxacin, levofloxacin, and moxifloxacin. Multidrug resistant 1, pathogen must test as "I" (intermediate) or "R" (resistant) to at least 1 drug in 3 of the 5 following classes: ES cephalosporins 4, fluoroquinolones 3, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; multidrug resistant 2, pathogen must test as I or R to at least 1 drug in 3 of the 5 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbapenems, and piperacillin or piperacillin/tazobactam; multidrug resistant 3, pathogen must test as I or R to at least 1 drug in 3 of the 6 following classes: ES cephalosporins 2, fluoroquinolones 2, aminoglycosides, carbapenems, piperacillin or piperacillin/tazobactam, and ampicillin/sulbactam. Oxacillins are oxacillin and methicillin.
minimum inhibitory concentration, the interpretations of susceptibility by individual hospital might vary slightly.

However, despite these limitations, these data represent a current assessment of the prevalence of antimicrobial-resistant phenotypes associated with HAIs in patients across approximately 2,000 hospitals in the United States. Several of the resistant phenotypes assessed are not limited to a small subset of hospitals, which should alert the infection control community to the need for vigilance in identification and implementation of appropriate infection control as they address these challenges in coming years.

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