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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NHSN UPDATE

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 oxytoca*; 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. oxytoca* (2%), *E. coli* (2%), and *Enterobacter* spp. (2%); and carbapenem-resistant *P. aeruginosa* (2%), *K. pneumoniae*/*oxytoca* (<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.

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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-

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vices (CMS) Prospective Payment System. This report builds on the methodology of the first report,[1] 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.[2] 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[2] and is summarized in the first NHSN antimicrobial resistance report.[1]

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.[3] 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 ceftazidime or cefepime (*Pseudomonas aeruginosa*) or to ceftazidime, cefepime, ceftriaxone, 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/sulbactam, was included for *Acinetobacter baumannii*. These criteria approximated, as best as possible, interim standard definitions for defining multidrug resistance.[4] 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 χ^2 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 by 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

	No. (%) of hospitals reporting		No. (%) of HAIs reported	
Characteristic	2007–2008 (n = 1,172)	2009–2010 (n = 2,039)	2007–2008 (n = 47,582)	2009–2010 (n = 69,475)
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[a]	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[b]				
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[c]	84 (7.2)	123 (6.0)	888 (1.9)	2,704 (3.9)
Region 2[d]	209 (17.8)	248 (12.2)	8,833 (18.6)	10,190 (14.7)
Region 3[e]	307 (26.2)	371 (18.2)	14,043 (29.5)	18,603 (26.8)
Region 4[f]	184 (15.7)	339 (16.6)	10,010 (21.0)	12,915 (18.6)
Region 5[g]	123 (10.5)	265 (13.0)	4,758 (10.0)	7,686 (11.1)
Region 6[h]	47 (4.0)	135 (6.6)	1,602 (3.4)	3,091 (4.4)
Region 7[i]	21 (1.8)	55 (2.7)	1,274 (2.7)	1,648 (2.4)
Region 8[j]	55 (4.7)	71 (3.5)	925 (1.9)	1,576 (2.3)
Region 9[k]	93 (7.9)	333 (16.3)	3,676 (7.7)	8,427 (12.1)
Region 10[l]	49 (4.2)	99 (4.9)	1,573 (3.3)	2,635 (3.8)

[a] 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.
[b] Critical care does not include surgical site infections because they do not require location to be reported.
[c] Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.
[d] New Jersey, New York, Puerto Rico, and the Virgin Islands.
[e] Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia.
[f] Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.
[g] Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin.
[h] Arkansas, Louisiana, New Mexico, Oklahoma, and Texas.
[i] Iowa, Kansas, Missouri, and Nebraska.
[j] Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming.
[k] Arizona, California, Hawaii, Nevada, American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Marshall Islands, and Republic of Palau.
[l] 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 CLABSIs 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 CLABSIs, 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 CLABSIs 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)
Cardiothoracic 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[a]	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 transplant[b]	55	939 (1.8)	909 (3.3)	29 (0.2)	1 (0.0)
Hematology/oncology[c]	144	1,584 (3.0)	1,364 (4.9)	218 (1.1)	2 (0.0)
Inpatient acute dialysis[d]	3	5 (0.0)	5 (0.0)	...	...
Long-term acute care[e]	167	3,554 (6.6)	1,778 (6.4)	1,630 (8.6)	146 (2.2)
Solid-organ transplant[f]	15	178 (0.3)	135 (0.5)	42 (0.2)	1 (0.0)
Long-term care[g]	22	135 (0.3)	44 (0.2)	91 (0.5)	...
Inpatient adult wards[h]	1,271	5,398 (10.1)	2,297 (8.3)	3,074 (16.1)	27 (0.4)
Inpatient pediatric wards[i]	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 acuity[j]	13	16 (0.0)	9 (0.0)	6 (0.0)	1 (0.0)
Step-down units[k]	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

TABLE 4. Distribution of Procedure-Associated Infections Reported to the National Healthcare Safety Network, by Type of Surgery, 2009–2010

Type of surgery	No. (%) of SSIs
Orthopedic[a]	6,486 (40.5)
Abdominal[b]	3,598 (22.5)
Cardiac[c]	3,508 (21.9)
Ob/gyn[d]	1,543 (9.6)
Neurological[e]	386 (2.4)
Vascular[f]	245 (1.5)
Transplant[g]	160 (1.0)
Breast[h]	64 (0.4)
Neck[i]	14 (0.1)
Other[j]	15 (0.1)
Total	16,019 (100)

NOTE. Ob/gyn, obstetrical and gynecological; SSI, surgical site infection. Postprocedure pneumonia ($n = 37$) was not included in this table.

[a] Open reduction of fracture, hip prosthesis, knee prosthesis, limb amputation, spinal fusion, refusion of spine, and laminectomy.

[b] Appendectomy, bile duct surgery, liver surgery, pancreatic surgery, gallbladder surgery, colon surgery, gastric surgery, herniorrhaphy, small-bowel surgery, spleen surgery, abdominal surgery, and rectal surgery.

[c] Cardiac surgery, coronary artery bypass graft with chest incision with or without donor incision, pacemaker surgery, and thoracic surgery.

[d] Cesarean section, abdominal hysterectomy, ovarian surgery, and vaginal hysterectomy.

[e] Craniotomy and ventricular shunt.

[f] Abdominal aortic aneurysm repair, shunt for dialysis, carotid endarterectomy, and peripheral vascular bypass surgery.

[g] Heart transplant, kidney transplant, and liver transplant.

[h] Breast surgery.

[i] Neck surgery and thyroid and/or parathyroid surgery.

[j] Prostate surgery and kidney surgery.

results for other HAI types. However, the proportion of facilities reporting SSIs with resistant phenotypes was overall quite low among those pathogens most commonly associated with SSIs.

DISCUSSION

These data present a high-level overview of the antimicrobial resistance problem challenging clinicians and affecting patients who develop HAIs in US hospitals. From these data, 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.[5,6] 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.[7-10] 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.[8] 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.[11]

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.

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

	Overall		CLABSI		CAUTI		VAP		SSI	
Pathogen	No. (%) of pathogens	Rank	No. (%) of pathogens	Rank[a]	No. (%) of pathogens	Rank[a]	No. (%) of pathogens	Rank[a]	No. (%) of pathogens	Rank[a]
Staphylococcus aureus	12,635 (15.6)	1	3,735 (12.3)	2	442 (2.1)	...	2,043 (24.1)	1	6,415 (30.4)	1
Escherichia coli	9,351 (11.5)	2	1,206 (4.0)	9	5,660 (26.8)	1	504 (5.9)	6	1,981 (9.4)	3
Coagulase-negative staphylococci	9,261 (11.4)	3	6,245 (20.5)	1	467 (2.2)	...	72 (0.9)	...	2,477 (11.7)	2
Klebsiella (*pneumoniae/oxytoca*)	6,470 (8.0)	4	2,407 (7.9)	5	2,365 (11.2)	3	854 (10.1)	3	844 (4.0)	7
Pseudomonas aeruginosa	6,111 (7.5)	5	1,166 (3.8)	10	2,381 (11.3)	2	1,408 (16.6)	2	1,156 (5.5)	5
Enterococcus faecalis	5,484 (6.8)	6	2,680 (8.8)	3	1,519 (7.2)	5	45 (0.5)	...	1,240 (5.9)	4
Candida albicans	4,275 (5.3)	7	1,974 (6.5)	7	1,887 (8.9)	4	147 (1.7)	...	267 (1.3)	...
Enterobacter spp.	3,821 (4.7)	8	1,365 (4.5)	8	880 (4.2)	8	727 (8.6)	4	849 (4.0)	6
Other *Candida* spp. or NOS	3,408 (4.2)	9	2,465 (8.1)	4	811 (3.8)	9	36 (0.4)	...	96 (0.5)	...
Enterococcus faecium	3,314 (4.1)	10	2,118 (7.0)	6	654 (3.1)	10	25 (0.3)	...	517 (2.5)	...
Enterococcus spp.	2,409 (3.0)	11	703 (2.3)	12	1,010 (4.8)	7	11 (0.1)	...	685 (3.2)	8
Proteus spp.	2,031 (2.5)	12	232 (0.8)	...	1,013 (4.8)	6	119 (1.4)	...	667 (3.2)	9
Serratia spp.	1,737 (2.1)	13	762 (2.5)	11	204 (1.0)	...	386 (4.6)	7	385 (1.8)	...
Acinetobacter baumannii	1,490 (1.8)	14	629 (2.1)	13	185 (0.9)	...	557 (6.6)	5	119 (0.6)	...
Other[a]	9,304 (11.5)	...	2,762 (9.1)	...	1,633 (7.7)	...	1,510 (17.8)	...	3,399 (16.1)	...
Total	81,139 (100)		30,454 (100)		21,111 (100)		8,474 (100)		21,100 (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] 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).

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

		No. (%) of pathogens, by type of surgery[a]									
Pathogen	Overall, *n*	Abdominal (*n* = 5,617)	Breast (*n* = 83)	Cardiac (*n* = 4,453)	Neck (*n* = 20)	Neurological (*n* = 433)	Ob/gyn (*n* = 2,124)	Orthopedic (*n* = 7,765)	Transplant (*n* = 250)	Vascular (*n* = 333)	Other (*n* = 22)
Staphylococcus aureus	6,415	648 (11.5)	31 (37.3)	1,368 (30.7)	3 (15.0)	160 (37.0)	418 (19.7)	3,656 (47.1)	17 (6.8)	109 (32.7)	5 (22.7)
Escherichia coli	1,981	1,043 (18.6)	3 (3.6)	283 (6.4)	...	12 (2.8)	274 (12.9)	314 (4.0)	24 (9.6)	25 (7.5)	3 (13.6)
Coagulase-negative staphylococci	2,477	288 (5.1)	16 (19.3)	743 (16.7)	1 (5.0)	99 (22.9)	189 (8.9)	1,073 (13.8)	39 (15.6)	27 (8.1)	2 (9.1)
Klebsiella (*pneumoniae/oxytoca*)	844	305 (5.4)	4 (4.8)	261 (5.9)	3 (15.0)	15 (3.5)	63 (3.0)	159 (2.0)	18 (7.2)	15 (4.5)	1 (4.5)
Pseudomonas aeruginosa	1,156	316 (5.6)	7 (8.4)	350 (7.9)	2 (10.0)	14 (3.2)	83 (3.9)	341 (4.4)	16 (6.4)	26 (7.8)	1 (4.5)
Enterococcus faecalis	1,240	524 (9.3)	1 (1.2)	136 (3.1)	2 (10.0)	15 (3.5)	176 (8.3)	354 (4.6)	16 (6.4)	15 (4.5)	1 (4.5)
Candida albicans	267	153 (2.7)	1 (1.2)	59 (1.3)	...	7 (1.6)	16 (0.8)	22 (0.3)	8 (3.2)	1 (0.3)	...
Enterobacter spp.	849	254 (4.5)	5 (6.0)	228 (5.1)	1 (5.0)	31 (7.2)	58 (2.7)	238 (3.1)	13 (5.2)	20 (6.0)	1 (4.5)
Other *Candida* spp. or NOS	96	48 (0.9)	...	20 (0.4)	...	2 (0.5)	4 (0.2)	14 (0.2)	6 (2.4)	1 (0.3)	1 (4.5)
Enterococcus faecium	517	313 (5.6)	...	51 (1.1)	...	5 (1.2)	26 (1.2)	76 (1.0)	38 (15.2)	8 (2.4)	...
Enterococcus spp.	685	334 (5.9)	4 (4.8)	76 (1.7)	1 (5.0)	2 (0.5)	87 (4.1)	154 (2.0)	13 (5.2)	11 (3.3)	3 (13.6)
Acinetobacter baumannii	119	16 (0.3)	...	36 (0.8)	...	6 (1.4)	8 (0.4)	51 (0.7)	...	1 (0.3)	1 (4.5)
Streptococcus spp.	1,028	305 (5.4)	1 (1.2)	93 (2.1)	1 (5.0)	12 (2.8)	162 (7.6)	433 (5.6)	9 (3.6)	11 (3.3)	1 (4.5)
Proteus spp.	667	135 (2.4)	5 (6.0)	190 (4.3)	...	4 (0.9)	86 (4.0)	231 (3.0)	4 (1.6)	12 (3.6)	...
Serratia spp.	385	26 (0.5)	1 (1.2)	216 (4.9)	1 (5.0)	9 (2.1)	21 (1.0)	98 (1.3)	3 (1.2)	10 (3.0)	...
Other[b]	2,374	909 (16.2)	4 (4.8)	343 (7.7)	5 (35.0)	40 (9.2)	453 (21.3)	551 (7.1)	26 (10.4)	41 (12.3)	2 (9.1)
Total	21,100	5,617 (100)	83 (100)	4,453 (100)	20 (100)	433 (100)	2,124 (100)	7,765 (100)	250 (100)	333 (100)	22 (100)

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

[a] 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 with or without donor incision, pacemaker surgery, and thoracic surgery. Neck: neck surgery and thyroid and/or parathyroid surgery. Neurological: craniotomy and ventricular shunt. Ob/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.

[b] Genus and species not indicated elsewhere in the table.

TABLE 7. Percentage of Pathogenic Isolates Resistant to Selected Antimicrobial Agents, National Healthcare Safety Network, 2009–2010

	CLABSI			CAUTI			VAP			SSI		
Pathogen, antimicrobial[a]	No. of isolates reported	No. (%) of isolates tested	Resistance, %	No. of isolates reported	No. (%) of isolates tested	Resistance, %	No. of isolates reported	No. (%) of isolates tested	Resistance, %	No. of isolates reported	No. (%) of isolates tested	Resistance, %
Staphylococcus aureus	3,735			442			2,043			6,415		
OX/METH		3,611 (96.7)	54.6		438 (99.1)	58.7		1,974 (96.6)	48.4		6,304 (98.3)	43.7
Enterococcus spp.												
E. faecium	2,118			654			25			517		
VAN		2,069 (97.7)	82.6		639 (97.7)	82.5		23 (92)	82.6		509 (98.5)	62.3
E. faecalis	2,680			1,519			45			1,240		
VAN		2,578 (96.2)	9.5		1,446 (95.2)	8.4		41 (91.1)	9.8		1,187 (95.7)	6.2
Klebsiella (*pneumoniae*/*oxytoca*)	2,407			2,365			854			844		
ESC4		2,109 (87.6)	28.8		1,998 (84.5)	26.9		747 (87.5)	23.8		710 (84.1)	13.2
Carbapenems		1,858 (77.2)	12.8		1,520 (64.3)	12.5		617 (72.2)	11.2		582 (69.0)	7.9
MDR1		1,932 (80.3)	16.8		1,650 (69.8)	16.1		658 (77.0)	13.4		621 (73.6)	6.8
Escherichia coli	1,206			5,660			504			1,981		
ESC4		1,067 (88.5)	19.0		4,656 (82.3)	12.3		429 (85.1)	16.3		1,627 (82.1)	10.9
FQ3		1,137 (94.3)	41.8		5,513 (97.4)	31.2		466 (92.5)	35.2		1,876 (94.7)	25.3
Carbapenems		931 (77.2)	1.9		3,579 (63.2)	2.3		344 (68.3)	3.5		1,330 (67.1)	2.0
MDR1		992 (82.3)	3.7		3,929 (69.4)	2.0		365 (72.4)	3.3		1,390 (70.2)	1.6
Enterobacter spp.	1,365			880			727			849		
ESC4		1,309 (95.9)	37.4		818 (93.0)	38.5		690 (94.9)	30.1		816 (96.1)	27.7
Carbapenems		1,041 (76.3)	4.0		614 (69.8)	4.6		530 (72.9)	3.6		594 (70.0)	2.4
MDR1		1,123 (82.3)	3.7		667 (75.8)	4.8		579 (79.6)	1.4		648 (76.3)	1.7
Pseudomonas aeruginosa	1,166			2,381			1,408			1,156		
AMINOS		819 (70.2)	10.0		1,495 (62.8)	10.9		920 (65.3)	11.3		664 (57.4)	6.0
ESC2		1,120 (96.1)	26.1		2,294 (96.3)	25.2		1,355 (96.2)	28.4		1,097 (94.9)	10.2
FQ2		1,114 (95.5)	30.5		2,337 (98.2)	33.5		1,378 (97.9)	32.7		1,111 (96.1)	16.9
Carbapenems		982 (84.2)	26.1		1,883 (79.1)	21.3		1,162 (82.5)	30.2		872 (75.4)	11.0
PIP/PIPTAZ		809 (69.4)	17.4		1,792 (75.3)	16.6		1,059 (75.2)	19.1		818 (70.8)	6.8
MDR2		1,096 (94)	15.4		2,250 (94.5)	14.0		1,342 (95.3)	17.7		1,053 (91.1)	5.3
Acinetobacter baumannii	629			185			557			119		
Carbapenems		522 (83)	62.6		128 (69.2)	74.2		449 (80.6)	61.2		102 (85.7)	37.3
MDR3		617 (98.1)	67.6		183 (98.9)	77.6		552 (99.1)	63.4		114 (95.8)	43.9

NOTE. CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; SSI, surgical site infection; VAP, ventilator-associated pneumonia.
[a] AMINOS, aminoglycosides (amikacin, gentamicin, tobramycin). Carbapenems are imipenem and meropenem. ESC2, extended-spectrum (ES) cephalosporins (cefepime, ceftazidime); ESC4, ES cephalosporins (cefepime, cefotaxime, ceftazidime, 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, pathogen 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; MDR3, pathogen must test as I or R to at least 1 drug in 3 of the 6 following classes: ESC2, FQ2, aminoglycosides, carbapenems, 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

	CLABSI		CAUTI	
Pathogen, antimicrobial agents[a]	ICU	Non-ICU	ICU	Non-ICU
Staphylococcus aureus, oxacillins	51.5	59.3	52.0	63.3
Enterococcus species				
E. faecium, vancomycin	83.6	80.7	81.8	83.1
E. faecalis, vancomycin	9.4	9.5	5.5	11.8
Klebsiella (*pneumoniae*/*oxytoca*)				
ES cephalosporins 4	29.7	27.7	24.6	29.0
Carbapenems	14.2	10.9	12.4	12.6
Multidrug resistant 1	19.1	13.7	15.2	17.0
Escherichia coli				
ES cephalosporins 4	18.6	19.5	11.5	13.2
Fluoroquinolones 3	36.5	47.1	29.1	33.5
Carbapenems	1.9	2.0	1.7	2.9
Multidrug resistant 1	3.4	4.0	1.6	2.3
Enterobacter species				
ES cephalosporins 4	38.0	36.2	38.8	38.2
Carbapenems	4.9	2.2	5.5	3.5
Multidrug resistant 1	4.0	3.1	4.6	5.0
Pseudomonas aeruginosa				
Aminoglycosides	11.6	7.5	11.8	9.9
ES cephalosporins 2	28.3	22.6	22.5	28.3
Fluoroquinolones 2	30.3	30.8	31.8	35.5
Carbapenems	26.8	24.9	20.6	22.3
Piperacillin/tazobactam	19.6	13.8	16.1	17.1
Multidrug resistant 2	16.8	13.3	12.6	15.6
Acinetobacter baumannii				
Carbapenems	64.5	56.1	73.8	75.0
Multidrug resistant 3	69.7	60.4	78.6	76.1

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

[a] 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.

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

TABLE 9. Changes in Resistance Percentage among Pathogens Associated with CLABSIs Reported to the National Healthcare Safety Network, 2007–2010, from both Critical Care and Non–Critical Care Locations

Pathogen, antimicrobial agents[a]	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
Carbapenems	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
Carbapenems	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
Carbapenems	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
Carbapenems	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				
Carbapenems	50.0 (45.6, 54.4)	62.6 (58.5, 66.8)	25.3	<.0001
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,[1] which was limited to a slightly shorter time period. CI, confidence interval; CLABSI, central line–associated bloodstream infection.

[a] 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.

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[a]	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)	49.9	.02
Klebsiella (*pneumoniae*/*oxytoca*)				
ES cephalosporins 4	27.1 (24.6, 29.6)	26.9 (24.9, 28.8)	−0.7	.91
Carbapenems	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
Carbapenems	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
Carbapenems	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
Carbapenems	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				
Carbapenems	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,[1] which was limited to a slightly shorter time period. CAUTI, catheter-associated urinary tract infection; CI, confidence interval.

[a] 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.

TABLE 11. Changes in Percent Resistance among Pathogens Associated with VAPs Reported to the National Healthcare Safety Network, 2007–2010

Resistant pathogen, antimicrobial agents[a]	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 species				
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
Carbapenems	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
Carbapenems	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
Carbapenems 2	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
Carbapenems 2	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				
Carbapenems	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.

[a] 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.

TABLE 12. Changes in Percent Resistance among Pathogens Associated with SSIs Reported to the National Healthcare Safety Network, 2007–2010

Resistant pathogen, antimicrobial agents[a]	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,[1] which was limited to a slightly shorter time period. CI, confidence interval; SSI, surgical site infection.

[a] 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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