ORIGINAL ARTICLE

Multistate Point-Prevalence Survey of Health Care–Associated Infections

Shelley S. Magill, M.D., Ph.D., Jonathan R. Edwards, M.Stat., Wendy Bamberg, M.D., Zintars G. Beldavs, M.S., Ghinwa Dumyati, M.D., Marion A. Kainer, M.B., B.S., M.P.H., Ruth Lynfield, M.D., Meghan Maloney, M.P.H., Laura McAllister-Hollod, M.P.H., Joelle Nadle, M.P.H., Susan M. Ray, M.D., Deborah L. Thompson, M.D., M.S.P.H., Lucy E. Wilson, M.D., and Scott K. Fridkin, M.D., for the Emerging Infections Program Healthcare-Associated Infections and Antimicrobial Use Prevalence Survey Team*

ABSTRACT

BACKGROUND

Currently, no single U.S. surveillance system can provide estimates of the burden of all types of health care–associated infections across acute care patient populations. We conducted a prevalence survey in 10 geographically diverse states to determine the prevalence of health care–associated infections in acute care hospitals and generate updated estimates of the national burden of such infections.

METHODS

We defined health care–associated infections with the use of National Healthcare Safety Network criteria. One-day surveys of randomly selected inpatients were performed in participating hospitals. Hospital personnel collected demographic and limited clinical data. Trained data collectors reviewed medical records retrospectively to identify health care–associated infections active at the time of the survey. Survey data and 2010 Nationwide Inpatient Sample data, stratified according to patient age and length of hospital stay, were used to estimate the total numbers of health care–associated infections and of inpatients with such infections in U.S. acute care hospitals in 2011.

RESULTS

Surveys were conducted in 183 hospitals. Of 11,282 patients, 452 had 1 or more health care–associated infections (4.0%; 95% confidence interval, 3.7 to 4.4). Of 504 such infections, the most common types were pneumonia (21.8%), surgical-site infections (21.8%), and gastrointestinal infections (17.1%). *Clostridium difficile* was the most commonly reported pathogen (causing 12.1% of health care–associated infections). Device-associated infections (i.e., central-catheter–associated bloodstream infection, catheter-associated urinary tract infection, and ventilator-associated pneumonia), which have traditionally been the focus of programs to prevent health care–associated infections, accounted for 25.6% of such infections. We estimated that there were 648,000 patients with 721,800 health care–associated infections in U.S. acute care hospitals in 2011.

CONCLUSIONS

Results of this multistate prevalence survey of health care–associated infections indicate that public health surveillance and prevention activities should continue to address *C. difficile* infections. As device- and procedure-associated infections decrease, consideration should be given to expanding surveillance and prevention activities to include other health care–associated infections.

From the Centers for Disease Control and Prevention (S.S.M., J.R.E., L.M.-H., S.K.F.) and Emory University School of Medicine (S.M.R.) — both in Atlanta; Colorado Department of Public Health and Environment, Denver (W.B.); Oregon Public Health Authority, Portland (Z.G.B.); New York–Rochester Emerging Infections Program and University of Rochester, Rochester (G.D.); Tennessee Department of Health, Nashville (M.A.K.); Minnesota Department of Health, St. Paul (R.L.); Connecticut Department of Public Health, Hartford (M.M.); California Emerging Infections Program, Oakland (J.N.); Georgia Emerging Infections Program and the Atlanta Veterans Affairs Medical Center, Decatur (S.M.R.); New Mexico Department of Health, Santa Fe (D.L.T.); and Maryland Department of Health and Mental Hygiene, Baltimore (L.E.W.). Address reprint requests to Dr. Magill at the Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, 1600 Clifton Rd., MS A-24, Atlanta, GA 30333, or at smagill@cdc.gov.

*A complete list of members of the Emerging Infections Program Healthcare-Associated Infections and Antimicrobial Use Prevalence Survey Team is in the Supplementary Appendix, available at NEJM.org.

N Engl J Med 2014;370:1198-208.
DOI: 10.1056/NEJMoa1306801

Elimination of health care–associated infections is a priority of the Department of Health and Human Services.[1] Considerable success in prevention has been reported for some infections, particularly central-catheter–associated bloodstream infections.[2-5] Continued improvements in patient safety depend on maintaining a comprehensive understanding of the epidemiology of health care–associated infections. Currently, no single U.S. surveillance system can provide estimates of the burden of all types of such infections across acute care patient populations. The most recent estimate produced by the Centers for Disease Control and Prevention (CDC) and published in 2007 — 1.7 million health care–associated infections per year — relied on historical data combined with contemporary hospitalization data.[6] The CDC surveillance system for health care–associated infections, the National Healthcare Safety Network (NHSN), provides information on incidence rates of common infections. Most hospitals limit reporting to device-associated infections, selected surgical-site infections, and infections due to *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus* (MRSA). Therefore, the NHSN cannot provide national-scale data on the overall burden and distribution of health care–associated infections across acute care patient populations.

To address this knowledge gap, the CDC began a three-phase effort in 2009 to develop and conduct a multistate prevalence survey of health care–associated infections and use of antimicrobial agents. Prevalence surveys have been used in other countries to describe the scope and magnitude of the problem of such infections.[7-30] The CDC effort culminated in 2011 in a large-scale survey that estimated the prevalence of health care–associated infections in acute care hospitals, determined the distribution of these infections according to infection site and pathogen, and generated updated estimates of the national burden of these infections.

Methods

Survey Design and Hospital Selection

Survey methods were developed in two phases: a single-city pilot in 2009[31] and a limited-rollout survey in 2010 that was performed in collaboration with the Emerging Infections Programs (EIP), a network of 10 state health departments (in California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon, and Tennessee) and academic partners. The current survey was also conducted with the EIP.

Each EIP site was asked to recruit a total of up to 25 general and children's acute care hospitals, with the following distribution according to size, if possible: 13 small hospitals (<150 beds), 9 medium-sized hospitals (150 to 399 beds), and 3 large hospitals (≥400 beds). Eligible hospitals were randomly selected within each size stratum to participate in a 1-day survey. When a selected hospital declined to participate, an alternative hospital was used.

The CDC determined the survey to be a public health surveillance activity. Institutional review boards at the state health departments, academic partners, and participating hospitals (where applicable) reviewed the protocol and either determined that the survey did not constitute human-subjects research or approved the survey with a waiver of the requirement for informed consent.

Patient Selection

Inpatients of any age in acute care hospitals were eligible for inclusion. Patients in outpatient areas, emergency departments, and psychiatry, skilled nursing, and rehabilitation units were excluded. Each hospital surveyed a random sample of eligible patients obtained from the morning census on the survey date: 100 patients in each large hospital and 75 patients (or all eligible patients if <75) in each small or medium-sized hospital (for details, see the Supplementary Appendix, available with the full text of this article at NEJM.org).

Training and Data Collection

Two teams collected data in each hospital: a primary team of infection preventionists and other personnel at the participating hospital and an EIP team of staff members from state health departments, academic partner institutions, or both. Both teams received training in survey operations and data-collection procedures; the EIP team also received training in NHSN terms and definitions for health care–associated infections.

Primary teams reviewed medical records on the survey date to collect demographic and limited clinical information, including whether patients were receiving or were scheduled to receive antimicrobial drugs at the time of the survey.

Primary teams did not collect detailed antimicrobial data or identify health care–associated infections. In some cases, EIP teams assisted with or performed the primary-team data collection.

EIP teams reviewed medical records retrospectively to collect data on antimicrobial therapy and identify active health care–associated infections with the use of NHSN surveillance definitions in place at that time.[32] EIP teams were instructed to use only information present in the medical record on or before the survey date, including results of cultures collected or other testing performed on or before the survey date. EIP teams used the NHSN definitions of gastrointestinal infections for reporting *C. difficile* infection when possible; in circumstances in which a patient with a positive test result for *C. difficile* infection did not meet the NHSN gastrointestinal definitions, EIP teams used a prevalence survey–specific definition of *C. difficile* infection (described in the Supplementary Appendix).

On the basis of pilot data[31] and unpublished data showing that antimicrobial therapy is a sensitive proxy indicator for health care–associated infections (sensitivity, 95 to 100%), EIP teams reviewed records for active health care–associated infections only for those patients who were receiving antimicrobial agents for the treatment of active infections or for no documented reason. Additional information on the use of data on antimicrobial therapy to identify patients with active infections is presented in the Supplementary Appendix (Methods section and Fig. S1).

Active health care–associated infections were defined as infections not present or incubating on admission to the survey hospital (with certain exceptions, noted below) that met NHSN surveillance definition criteria, with signs or symptoms of infection present on the survey date or with antimicrobial therapy still being given on the survey date. Infections present on admission to the survey hospital were considered health care–associated infections if they were surgical-site infections related to surgery performed at the survey hospital within the preceding 30 days (or within 1 year if an implant was in place), *C. difficile* infections related to a previous stay in the survey hospital within 28 days before specimen collection, or infections related to a prior hospitalization in the survey hospital within the preceding 48 hours.

STATISTICAL ANALYSIS

Data were analyzed with the use of SAS software, version 9.3 (SAS Institute), and OpenEpi software, versions 2.3.1 and 3.01 (www.openepi.com). The mid-P exact method was used to generate confidence intervals for infection prevalence. Comparisons of patients with and those without health care–associated infections were performed with the use of chi-square tests for categorical variables and Wilcoxon rank-sum tests for continuous variables.

To generate estimates of the national burden of health care–associated infections, we converted infection prevalence to incidence using the formula of Rhame and Sudderth[33]: $I = P \times [LA \div (LN - INT)]$, where I denotes incidence, P prevalence, LA the mean length of hospitalization for all patients, LN the mean length of hospitalization for patients who acquired one or more health care–associated infections, and INT the mean interval between admission and the onset of the first such infection. Numbers of patients with health care–associated infections were obtained by multiplying infection incidence by numbers of U.S. hospital discharges, obtained from the 2010 Nationwide Inpatient Sample (NIS).[34] This database of hospitalizations from a sample of U.S. community hospitals was developed as part of the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality; discharge weighting allows national estimates to be generated from the sample.

We sought to improve the precision of the burden-estimation process by performing log-binomial regression modeling to identify factors significantly associated with the prevalence of health care–associated infections. Through a process described in the Supplementary Appendix, the results of regression modeling were used to create multiple strata based on patient age and a proxy measure of the length of the hospital stay. Within each stratum, the predicted prevalence of health care–associated infections was converted to incidence with the use of the median length of the hospital stay for surveyed patients for whom such information was available (LA in the formula of Rhame and Sudderth), the median length of hospital stay for patients with health care–associated infections (LN), and the median interval from admission to the onset of the first health care–associated infection (INT). Median

rather than mean values were used owing to a skewed distribution. The incidence in each stratum of age and length of stay was multiplied by the total number of U.S. discharges in that stratum (with the use of weighted discharge data from the NIS), under the assumption that each discharge represented a unique patient, to get stratum-specific numbers of patients with health care–associated infections. These stratum-specific numbers were summed to obtain an estimate of the total number of inpatients with health care–associated infections in U.S. acute care hospitals in 2011. Because our estimates of the median length of the hospital stay for all patients were based on data from patients receiving antimicrobial therapy, who may have had a longer median length of stay than patients not receiving such therapy, we also performed the burden-estimation process using data from the NIS for the median length of the hospital stay for all patients in the formula of Rhame and Sudderth.

Burden estimates for major types of health care–associated infection were generated by multiplying the proportion of surveyed patients with each infection type by the estimated total number of patients with health care–associated infections. The numbers of each major type of infection were summed to obtain an estimate of the total number of inpatient health care–associated infections in U.S. acute care hospitals in 2011.

RESULTS

HOSPITALS AND PATIENTS

A total of 183 hospitals (79% of the goal of 232 hospitals) participated (Table S1 in the Supplementary Appendix). Of the 183 hospitals, 93 (51%) were small, 68 (37%) were medium-sized, and 22 (12%) were large — proportions that were similar to those for all 406 hospitals in the 10 EIP sites (55% small, 35% medium-sized, and 10% large).

Overall, 11,290 patients were included in surveys performed between May and September 2011; data collection was completed for 11,282 patients (99.9%). The median patient age was 58 years (interquartile range, 32 to 74). Most patients (71.2%) were in non-nursery wards; 15.1% were in critical care units. Approximately 51.9% of patients were receiving or were scheduled to receive antimicrobial agents at the time of the survey (Table 1, and Fig. S1 in the Supplementary Appendix).

PREVALENCE AND DISTRIBUTION OF HEALTH CARE–ASSOCIATED INFECTIONS

The medical records of 4504 patients (39.9%) — those receiving antimicrobial agents for treatment of active infections or for no documented reason — were reviewed for health care–associated infections (Fig. S1 in the Supplementary Appendix). A total of 504 such infections were detected in 452 of 11,282 patients; therefore, 4.0% of patients had at least 1 health care–associated infection (95% confidence interval [CI], 3.7 to 4.4). Pneumonia and surgical-site infection were most common, followed by gastrointestinal infection, urinary tract infection, and primary bloodstream infection (Table 2). In addition to 50 primary bloodstream infections, there were 37 secondary bloodstream infections. Device-associated infections (i.e., ventilator-associated pneumonia, catheter-associated urinary tract infection, and central-catheter–associated bloodstream infection) accounted for 25.6% of all health care–associated infections; together, device-associated infections and surgical-site infections (21.8%) accounted for 47.4% of all health care–associated infections (239 of 504 infections). The remaining 52.6% of infections were not associated with devices or operative procedures.

Overall, 169 of 394 non–surgical-site infections (42.9%) developed during or within 48 hours after a stay in a critical care unit; 167 (42.4%) developed during or within 48 hours after a stay in a non-nursery ward. The NHSN operative-procedure types associated with the most surgical-site infections were colon surgeries (accounting for 16 of 110 surgical-site infections [14.5%]), hip arthroplasties (11 [10.0%]), and small-bowel surgeries (7 [6.4%]). Ten surgical-site infections (9.1%) were attributed to other, unspecified procedures.

The median interval from hospital admission to the onset of symptoms of a health care–associated infection was 6 days (interquartile range, 2 to 13) among 494 patients for whom symptom-onset dates were reported. Overall, 98 health care–associated infections (19.4%) were present on admission and were therefore related to a previous admission to the same hospital. Most infections present on admission were surgical-site infections (66 [67.3%]) and gastrointestinal in-

fections (9 [9.2%]). The outcome was known for 436 of the 452 patients with health care–associated infections (96.5%). Fifty of these 436 patients (11.5%) died during their survey hospitalization.

PATHOGENS CAUSING HEALTH CARE–ASSOCIATED INFECTIONS

A total of 481 pathogens were reported for 372 of 504 health care–associated infections (73.8%).

Table 1. Demographic and Clinical Characteristics of Surveyed Patients.*

Characteristic	All Patients (N=11,282)	Patients without Health Care–Associated Infections (N=10,830)	Patients with Health Care–Associated Infections (N=452)	P Value†
Sex — no. (%)				0.13
Male	5,034 (44.6)	4,813 (44.4)	221 (48.9)	
Female	6,236 (55.3)	6,006 (55.5)	230 (50.9)	
Missing data	12 (0.1)	11 (0.1)	1 (0.2)	
Age — no. (%)				0.09
<1 yr	1,151 (10.2)	1,115 (10.3)	36 (8.0)	
1–17 yr	479 (4.2)	460 (4.2)	19 (4.2)	
18–24 yr	462 (4.1)	448 (4.1)	14 (3.1)	
25–44 yr	1,686 (14.9)	1,634 (15.1)	52 (11.5)	
45–64 yr	3,060 (27.1)	2,927 (27.0)	133 (29.4)	
65–84 yr	3,429 (30.4)	3,269 (30.2)	160 (35.4)	
≥85 yr	1,014 (9.0)	976 (9.0)	38 (8.4)	
Missing data	1 (<0.1)	1 (<0.1)	0	
Race or ethnic group — no. (%)‡				0.09
American Indian or Alaska Native	119 (1.1)	117 (1.1)	2 (0.4)	
Asian	254 (2.3)	244 (2.3)	10 (2.2)	
Black	1,905 (16.9)	1,809 (16.7)	96 (21.2)	
Multiple races or other unspecified race	254 (2.3)	244 (2.3)	10 (2.2)	
Native Hawaiian or other Pacific Islander	20 (0.2)	18 (0.2)	2 (0.4)	
White	7,537 (66.8)	7,244 (66.9)	293 (64.8)	
Missing data	1,193 (10.6)	1,154 (10.7)	39 (8.6)	
Hispanic or Latino ethnic group — no. (%)‡				0.04
Hispanic or Latino	846 (7.5)	826 (7.6)	20 (4.4)	
Not Hispanic or Latino	3,715 (32.9)	3,564 (32.9)	151 (33.4)	
Missing data	6,721 (59.6)	6,440 (59.5)	281 (62.2)	
Hospital size — no. (%)§				<0.001
Small	4,073 (36.1)	3,964 (36.6)	109 (24.1)	
Medium	4,995 (44.3)	4,794 (44.3)	201 (44.5)	
Large	2,214 (19.6)	2,072 (19.1)	142 (31.4)	
Location of patient in hospital on survey date — no. (%)¶				<0.001
Critical care unit	1,707 (15.1)	1,551 (14.3)	156 (34.5)	
Mixed acuity unit	119 (1.1)	114 (1.1)	5 (1.1)	
Newborn or special care nursery	485 (4.3)	482 (4.5)	3 (0.7)	
Specialty care area	469 (4.2)	439 (4.1)	30 (6.6)	
Step-down unit	466 (4.1)	443 (4.1)	23 (5.1)	
Ward, not nursery	8,036 (71.2)	7,801 (72.0)	235 (52.0)	

Table 1. (Continued.)

Characteristic	All Patients (N=11,282)	Patients without Health Care–Associated Infections (N=10,830)	Patients with Health Care–Associated Infections (N=452)	P Value†
Central catheter in place on survey date — no. (%)‖				
Any	2,121 (18.8)	1,862 (17.2)	259 (57.3)	<0.001
Femoral	54 (0.5)	44 (0.4)	10 (2.2)	
Peripherally inserted	1,037 (9.2)	878 (8.1)	159 (35.2)	
Other known type	1,057 (9.4)	958 (8.8)	99 (21.9)	
Unknown type	32 (0.3)	29 (0.3)	3 (0.7)	
None	9,140 (81.0)	8,948 (82.6)	192 (42.5)	
Missing data	21 (0.2)	20 (0.2)	1 (0.2)	
Urinary catheter in place on survey date — no. (%)				<0.001
Yes	2,659 (23.6)	2,482 (22.9)	177 (39.2)	
No	8,594 (76.2)	8,321 (76.8)	273 (60.4)	
Missing data	29 (0.3)	27 (0.2)	2 (0.4)	
Patient receiving mechanical ventilatory support on survey date — no. (%)				<0.001
Yes	527 (4.7)	432 (4.0)	95 (21.0)	
No	10,748 (95.3)	10,391 (95.9)	357 (79.0)	
Missing data	7 (0.1)	7 (0.1)	0	
Patient receiving or scheduled to receive antimicrobial therapy at time of survey — no. (%)**	5,860 (51.9)	5,408 (49.9)	452 (100)	—
Patient receiving dialysis at time of survey — no. (%)	446 (4.0)	410 (3.8)	36 (8.0)	<0.001
Interval from admission to survey — days				
Median	3	2	12	<0.001††
Interquartile range	1–6	1–5	7–23	

* Percentages may not add up to 100 because of rounding.
† P values were calculated with the use of the chi-square test, except where indicated.
‡ Race and ethnic group were determined on the basis of medical-record documentation.
§ Small hospitals had fewer than 150 beds, medium-sized hospitals had 150 to 399 beds, and large hospitals had 400 or more beds.
¶ Hospital units were defined according to the National Healthcare Safety Network classification. Critical care units included level II–III and level III neonatal intensive care units.
‖ Patients could have more than one type of central catheter.
** For four patients without health care–associated infections, information on antimicrobial therapy was not available on the survey date; medical records of these patients were reviewed retrospectively to collect data on antimicrobial therapy and health care–associated infections. By definition, all patients with health care–associated infections were receiving antimicrobial agents at the time of the survey.
†† The P value was calculated with the use of the Wilcoxon rank-sum test.

C. difficile was the most common pathogen, causing 61 health care–associated infections (12.1%) (Table 3). *S. aureus* was the second most common pathogen (54 infections [10.7%]), followed by *Klebsiella pneumoniae* and *K. oxytoca* (50 infections [9.9%]) and *Escherichia coli* (47 infections [9.3%]) (Table 3).

RISK FACTORS FOR HEALTH CARE–ASSOCIATED INFECTIONS AND OVERALL U.S. BURDEN

Multivariable regression analysis showed that patients who were older, had been in the hospital longer at the time of the survey, were in a large hospital, had a central catheter in place, were receiving mechanical ventilatory support, or were in a critical care unit had an increased risk of health care–associated infection (Table S2 in the Supplementary Appendix). The total estimated number of patients with at least 1 health care–associated infection in 2011 was 648,000 (95% CI, 246,400 to 987,300). The use of data on the median length of the hospital stay from the NIS in the burden-estimation process, in place of data on the length of stay from surveyed patients receiving anti-

microbial therapy, did not substantially change the overall burden estimate (582,000 infections; 95% CI, 216,600 to 875,400). Estimated numbers of selected major types of health care–associated infection are shown in Table 4; summing the estimates for each of the 13 major types shown in Table 2 yielded an overall total estimate of 721,800 infections (95% CI, 214,700 to 1,411,000).

DISCUSSION

In this survey, 4.0% of inpatients in U.S. acute care hospitals had at least 1 health care–associated infection, yielding an estimate of 648,000 inpatients with a total of approximately 721,800 such infections in 2011. These estimates of the national burden of health care–associated infections in acute care hospitals were generated through the use of a modeling process that accounted for selected predictors of infection prevalence, including age and length of stay, and application of the results of this modeling to the NIS, a nationally representative sample of U.S. community-hospital stays. The current estimates of the overall burden are lower than older estimates, such as those from the Study on the Efficacy of Nosocomial Infection Control in the 1970s (2.1 million infections)[36] and those from analyses of National Nosocomial Infections Surveillance system data collected from 1990 through 2002 (1.7 million infections),[6] although it is difficult to draw conclusions from these comparisons because of the differences in patient populations, surveillance definitions of health care–associated infections, and data-collection and analytical methods among these CDC efforts.[31]

Device-associated infections, which have been a major focus of infection prevention in recent decades, accounted for only 25.6% of all health care–associated infections detected in the current survey. Infections not associated with devices or operative procedures — including *C. difficile* infections and other gastrointestinal infections and non–ventilator-associated pneumonia — accounted for approximately half of all health care–associated infections in the survey. This finding should expand the public health focus to include these other types of infections, identifying patients at risk and developing effective prevention measures. An example is the recent focus of the CDC on surveillance and prevention of *C. difficile* infections.[37]

Gastrointestinal infections, 70.9% of which were *C. difficile* infections, were the third most common type of health care–associated infection in this survey, in contrast to the results of previous analyses.[6,36] Although there is ample evidence to support our finding that *C. difficile* infections are a major contributor to the overall U.S. burden of health care–associated infections in acute care hospitals,[38-41] the high prevalence of *C. difficile* infections in this survey may be partially explained by the use of a sensitive definition. This definition, as opposed to the more restrictive NHSN surveillance definitions of gastrointestinal infections, was used for reporting 31 of the 61 cases of *C. difficile* infection (51%) detected in the survey. It is also likely that nucleic acid amplification testing for diagnosis of *C. difficile* infection was used in some participating facilities, resulting in increased case detection.[42]

This survey has important limitations that must be considered. First, although we are confident that the survey hospitals are representative of hospitals within the EIP catchment areas, they may not be representative of all U.S. acute care hospitals. Only 183 hospitals and 11,282 pa-

Table 2. Distribution of 504 Health Care–Associated Infections.*

Type of Infection	Rank	No. of Infections	Percentage of All Health Care–Associated Infections (95% CI)
Pneumonia†	1 (tie)	110	21.8 (18.4–25.6)
Surgical-site infection	1 (tie)	110	21.8 (18.4–25.6)
Gastrointestinal infection	3	86	17.1 (14.0–20.5)
Urinary tract infection‡	4	65	12.9 (10.2–16.0)
Primary bloodstream infection§	5	50	9.9 (7.5–12.8)
Eye, ear, nose, throat, or mouth infection	6	28	5.6 (3.8–7.8)
Lower respiratory tract infection	7	20	4.0 (2.5–6.0)
Skin and soft-tissue infection	8	16	3.2 (1.9–5.0)
Cardiovascular system infection	9	6	1.2 (0.5–2.5)
Bone and joint infection	10	5	1.0 (0.4–2.2)
Central nervous system infection	11	4	0.8 (0.3–1.9)
Reproductive tract infection	12	3	0.6 (0.2–1.6)
Systemic infection	13	1	0.2 (0.01–1.0)

* Infections were defined with the use of National Healthcare Safety Network criteria. CI denotes confidence interval.
† A total of 43 pneumonia events (39.1%) were associated with a mechanical ventilator.
‡ A total of 44 urinary tract infections (67.7%) were associated with a catheter.
§ A total of 42 primary bloodstream infections (84.0%) were associated with a central catheter.

Table 3. Reported Causative Pathogens, According to Type of Infection.*

Pathogen	All Health Care–Associated Infections (N=504)†		Pneumonia (N=110)	Surgical-Site Infections (N=110)	GI Infections (N=86)	UTIs (N=65)	Bloodstream Infections (N=50)
	no. (%)	*rank*			*number (percent)*		
Clostridium difficile	61 (12.1)	1	0	0	61 (70.9)	0	0
Staphylococcus aureus	54 (10.7)	2	18 (16.4)	17 (15.5)	1 (1.2)	2 (3.1)	7 (14.0)
Klebsiella pneumoniae or *K. oxytoca*	50 (9.9)	3	13 (11.8)	15 (13.6)	1 (1.2)	15 (23.1)	4 (8.0)
Escherichia coli	47 (9.3)	4	3 (2.7)	14 (12.7)	1 (1.2)	18 (27.7)	5 (10.0)
Enterococcus species‡	44 (8.7)	5	2 (1.8)	16 (14.5)	5 (5.8)	11 (16.9)	6 (12.0)
Pseudomonas aeruginosa	36 (7.1)	6	14 (12.7)	7 (6.4)	1 (1.2)	7 (10.8)	2 (4.0)
Candida species§	32 (6.3)	7	4 (3.6)	3 (2.7)	3 (3.5)	3 (4.6)	11 (22.0)
Streptococcus species¶	25 (5.0)	8	7 (6.4)	8 (7.3)	2 (2.3)	2 (3.1)	2 (4.0)
Coagulase-negative staphylococcus species	24 (4.8)	9	0	7 (6.4)	0	1 (1.5)	9 (18.0)
Enterobacter species	16 (3.2)	10	3 (2.7)	5 (4.5)	0	2 (3.1)	2 (4.0)
Acinetobacter baumannii	8 (1.6)	11, tie	4 (3.6)	2 (1.8)	0	0	0
Proteus mirabilis	8 (1.6)	11, tie	1 (0.9)	5 (4.5)	0	1 (1.5)	0
Yeast, unspecified	8 (1.6)	11, tie	3 (2.7)	0	1 (1.2)	4 (6.2)	0
Stenotrophomonas maltophilia	8 (1.6)	11, tie	6 (5.5)	0	0	2 (3.1)	0
Citrobacter species	6 (1.2)	15, tie	2 (1.8)	1 (0.9)	0	1 (1.5)	0
Serratia species	6 (1.2)	15, tie	2 (1.8)	0	0	2 (3.1)	0
Bacteroides species	6 (1.2)	15, tie	0	5 (4.5)	1 (1.2)	0	0
Haemophilus species	6 (1.2)	15, tie	2 (1.8)	2 (1.8)	0	0	0
Viruses‖	3 (0.6)	19, tie	1 (0.9)	0	0	0	0
Peptostreptococcus species	3 (0.6)	19, tie	0	2 (1.8)	0	0	1 (2.0)
Klebsiella species other than *K. pneumoniae* and *K. oxytoca*	2 (0.4)	21, tie	1 (0.9)	0	0	0	1 (2.0)
Clostridium species other than *C. difficile*	2 (0.4)	21, tie	0	2 (1.8)	0	0	0
Prevotella species	2 (0.4)	21, tie	0	1 (0.9)	0	0	0
Morganella morganii	2 (0.4)	21, tie	0	1 (0.9)	0	1 (1.5)	0
Lactobacillus species	2 (0.4)	21, tie	0	0	1 (1.2)	0	1 (2.0)
Other organisms**	13 (2.6)	—	1 (0.9)	6 (5.5)	0	1 (1.5)	3 (6.0)

* One or more pathogens were reported for 372 of 504 infections (73.8%). No pathogens were reported for the remaining 132 infections (26.2%).
† Values for all health care–associated infections include those for the 13 major types of infection listed in Table 2.
‡ Enterococcus species include *E. faecalis* (23 infections), *E. faecium* (8), other or unspecified enterococci (11), *E. faecalis* and *E. faecium* (1), and *E. faecalis* and *E. avium* (1).
§ Candida species include *C. albicans* (18 infections), *C. parapsilosis* (6), *C. glabrata* (4), other or unspecified candida species (2), and *C. albicans* and *C. dubliniensis* (2).
¶ Streptococcus species include *S. pneumoniae* (7 infections), viridans streptococci (7), group B streptococci (3), other or unspecified streptococci (7), and group G streptococci and *S. parasanguis* (1).
‖ Viruses include adenovirus (1 infection), herpes simplex virus (1), and parainfluenza virus (1).
** Other organisms include *Achromobacter xylosoxidans* (1 infection), *Aeromonas hydrophila* (1), aspergillus species (1), bacillus species (1), *Finegoldia magna* (1), fusobacterium species (1), *Moraxella catarrhalis* (1), propionibacterium species (1), *Pseudomonas alcaligenes* (1), *Rothia mucilaginosa* (1), unspecified gram-negative rods (2), and *Acinetobacter lwoffii* and micrococcus species (1).

tients were included, of a total of approximately 5000 U.S. community hospitals and 34 million annual admissions (2012 data) in the United States.[43] Second, because our survey was limited to acute care hospitals, we cannot estimate the numbers of health care–associated infections

occurring in other settings, such as skilled nursing facilities. Third, we were not able to validate data across the 10 EIP sites. Data evaluations were performed in the previous two phases of survey development; the results showed that the primary data-collection team and the evaluation team identified similar proportions of patients with health care–associated infections overall, although there were many discrepancies in patient-level determinations of such an infection.[31] Additional limitations are discussed in the Supplementary Appendix.

Table 4. Estimated Numbers of Major Types of Health Care–Associated Infection in the United States in 2011.

Type of Infection	Infections Identified in Survey	Surveyed Patients with Type of Infection	Estimated Infections in the United States*
	no.	*% (95% CI)*	*no. (95% CI)*
All health care–associated infections			
Pneumonia	110	24.3 (20.6–28.5)	157,500 (50,800–281,400)
Surgical-site infection	110†	24.3 (20.6–28.5)	157,500 (50,800–281,400)
Gastrointestinal infection	86	19.0 (15.6–22.8)	123,100 (38,400–225,100)
Urinary tract infection	65	14.4 (11.4–17.9)	93,300 (28,100–176,700)
Primary bloodstream infection	50	11.1 (8.4–14.2)	71,900 (20,700–140,200)
Eye, ear, nose, throat, or mouth infection	28‡	6.2 (4.2–8.7)	40,200 (10,400–85,900)
Lower respiratory tract infection	20	4.4 (2.8–6.6)	28,500 (6900–65,200)
Skin and soft-tissue infection	16	3.5 (2.1–5.6)	22,700 (5200–55,300)
Cardiovascular system infection	6	1.3 (0.5–2.7)	8,400 (1200–26,700)
Bone and joint infection	5	1.1 (0.4–2.4)	7,100 (1000–23,700)
Central nervous system infection	4	0.9 (0.3–2.1)	5,800 (700–20,700)
Reproductive tract infection	3	0.7 (0.2–1.8)	4,500 (500–17,800)
Systemic infection	1	0.2 (0.01–1.1)	1,300 (0–10,900)
Total			721,800 (214,700–1,411,000)
Infections in non-neonatal intensive care units			
Catheter-associated urinary tract infection	25	5.5 (3.7–7.9)	35,600 (9100–78,000)
Central-catheter–associated primary bloodstream infection	11	2.4 (1.3–4.2)	15,600 (3200–41,500)
Ventilator-associated pneumonia	35	7.7 (5.5–10.5)	49,900 (13,600–103,700)
Surgical-site infections attributed to Surgical Care Improvement Project procedures§	46	10.2 (7.6–13.2)	66,100 (18,700–130,300)
Hospital-onset infections caused by specific pathogens			
Clostridium difficile infection¶	56	12.4 (9.6–15.7)	80,400 (23,700–155,000)
MRSA bacteremia‖	7	1.5 (0.7–3.0)	9,700 (1700–29,600)

* Estimates are based on an overall estimate of 648,000 patients (95% CI, 246,400 to 987,300) with at least one health care–associated infection in 2011. To calculate the numbers of estimated infections, the point estimate of the percentage of patients with a particular type of infection (e.g., 24.3% for pneumonia) was multiplied by the point estimate of the overall number of patients with health care–associated infections. To calculate the 95% CIs, the lower bound of the 95% CI for the percentage of patients with a particular type of infection (e.g., 20.6% for pneumonia) was multiplied by the lower bound of the 95% CI for the overall number of patients with health care–associated infections, and the upper bound of the 95% CI for the percentage of patients with a particular type of infection (e.g., 28.5% for pneumonia) was multiplied by the upper bound of the 95% CI for the overall number of patients with health care–associated infections.

† There were 110 surgical-site infections in 109 patients. For the purposes of estimating the total number of such infections in the United States in 2011, we assumed that each of the 110 infections occurred in a unique patient.

‡ There were 28 eye, ear, nose, throat, or mouth infections in 27 patients. For the purposes of estimating the total number of such infections in the United States in 2011, we assumed that each of the 28 infections occurred in a unique patient.

§ Surgical Care Improvement Project procedures included those with the following National Healthcare Safety Network procedure codes: CARD, CBGB, CBGC, AAA, CEA, PVBY, COLO, REC, HYST, VHYS, HPRO, and KPRO.[35]

¶ *C. difficile* infection was defined by an onset of symptoms on or after the third day of hospitalization (with the day of admission counted as the first day).

‖ Methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia was defined as primary or secondary MRSA bloodstream infection with an onset of symptoms on or after the third day of hospitalization (with the first day of admission counted as the first day).

Despite these limitations, the national estimates that we generated for selected types of health care–associated infection are remarkably similar to estimates from other data sources. For example, we estimated that 15,600 central-catheter–associated bloodstream infections occurred in 2011 (not including such infections in neonatal intensive care units), and NHSN data yielded an estimate of 12,400.[35] Our estimate of 9700 hospital-onset cases of MRSA bacteremia is similar to that obtained from EIP population-based surveillance, in which 71.3% of the estimated 14,156 invasive, hospital-onset MRSA infections, or 10,093 infections, involved bacteremia.[44] Finally, we estimated that there were 66,100 Surgical Care Improvement Project procedure-associated surgical-site infections, as compared with the NHSN estimate of 52,567.[35] The similarity of these estimates from different data sources bolsters our confidence in the overall estimates of health care–associated infections that we have generated, as well as our estimates of infections for which other data sources do not currently exist.

In summary, our survey results indicate that on any given day approximately 1 of every 25 inpatients in U.S. acute care hospitals has at least one health care–associated infection. Pneumonia and surgical-site infection were the most common infection types, and *C. difficile* was the most common pathogen. Infections other than those associated with central catheters, urinary catheters, and ventilators account for the majority of the U.S. burden of health care–associated infections and may warrant increased attention. A better understanding of trends in the epidemiology of health care–associated infections and prevention success may be achieved through repeated prevalence surveys in which similar methods are used each time.

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC) or the Agency for Toxic Substances and Disease Registry.

Dr. Kainer reports receiving consulting, lecture, and board membership fees from and owning stock in the Infectious Disease Consulting Corporation. Dr. Lynfield reports receiving travel support from Parexel. No other potential conflict of interest relevant to this article was reported.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

We thank the staff of each hospital that participated in phases 2 and 3 of the Emerging Infections Program (EIP) Healthcare-Associated Infections and Antimicrobial Use Prevalence Survey, our colleagues in the EIP sites and at the CDC who contributed to this effort (listed in the Supplementary Appendix), and the Healthcare Cost and Utilization Project Data Partners (www.hcup-us.ahrq.gov/db/hcupdatapartners.jsp).

REFERENCES

1. National action plan to prevent healthcare-associated infections: roadmap to elimination. Washington, DC: Department of Health and Human Services (http://www.hhs.gov/ash/initiatives/hai/exec_summary.html).
2. Vital signs: central line–associated blood stream infections — United States, 2001, 2008, and 2009. MMWR Morb Mortal Wkly Rep 2011;60:243-8.
3. Anderson DJ, Miller BA, Chen LF, et al. The network approach for prevention of healthcare-associated infections: long-term effect of participation in the Duke Infection Control Outreach Network. Infect Control Hosp Epidemiol 2011;32:315-22.
4. Marsteller JA, Sexton JB, Hsu YJ, et al. A multicenter, phased, cluster-randomized controlled trial to reduce central line-associated bloodstream infections in intensive care units. Crit Care Med 2012;40:2933-9.
5. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. N Engl J Med 2006;355:2725-32. [Erratum, N Engl J Med 2007;356:2660.]
6. Klevens RM, Edwards JR, Richards CL Jr, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Rep 2007;122:160-6.
7. Zarb P, Coignard B, Griskeviciene J, et al. The European Centre for Disease Prevention and Control (ECDC) pilot point prevalence survey of healthcare-associated infections and antimicrobial use. Euro Surveill 2012;17(46):20316.
8. Smyth ET, McIlvenny G, Enstone JE, et al. Four country healthcare associated infection prevalence survey 2006: overview of the results. J Hosp Infect 2008;69:230-48.
9. Lyytikäinen O, Kanerva M, Agthe N, Möttönen T, Ruutu P. Healthcare-associated infections in Finnish acute care hospitals: a national prevalence survey, 2005. J Hosp Infect 2008;69:288-94.
10. Gastmeier P, Kampf G, Wischnewski N, et al. Prevalence of nosocomial infections in representative German hospitals. J Hosp Infect 1998;38:37-49.
11. Struwe J, Dumpis U, Gulbinovic J, Lagergren A, Bergman U. Healthcare associated infections in university hospitals in Latvia, Lithuania and Sweden: a simple protocol for quality assessment. Euro Surveill 2006;11:167-71.
12. Scheel O, Stormark M. National prevalence survey on hospital infections in Norway. J Hosp Infect 1999;41:331-5.
13. Vaqué J, Rosselló J, Arribas JL. Prevalence of nosocomial infections in Spain: EPINE study 1990-1997. J Hosp Infect 1999;43:Suppl:S105-S111.
14. The French Prevalence Survey Study Group. Prevalence of nosocomial infections in France: results of the nationwide survey in 1996. J Hosp Infect 2000;46:186-93.
15. Azzam R, Dramaix M. A one-day prevalence survey of hospital-acquired infections in Lebanon. J Hosp Infect 2001;49:74-8.
16. Zotti CM, Messori Ioli G, Charrier L, et al. Hospital-acquired infections in Italy: a region wide prevalence study. J Hosp Infect 2004;56:142-9.
17. Gikas A, Pediaditis J, Papadakis JA, et al. Prevalence study of hospital-acquired infections in 14 Greek hospitals: planning from the local to the national surveillance level. J Hosp Infect 2002;50:269-75.
18. Plowman R, Graves N, Griffin MA, et al. The rate and cost of hospital-acquired infections occurring in patients admitted to selected specialties of a district general hospital in England and the national burden imposed. J Hosp Infect 2001;47:198-209.
19. Emmerson AM, Enstone JE, Griffin MA, Kelsey MC, Smyth ET. The Second National Prevalence Survey of infection in hospitals — overview of the results. J Hosp Infect 1996;32:175-90.
20. Pittet D, Harbarth S, Ruef C, et al. Prevalence and risk factors for nosocomial infections in four university hospitals in

Switzerland. Infect Control Hosp Epidemiol 1999;20:37-42.
21. Faria S, Sodano L, Gjata A, et al. The first prevalence survey of nosocomial infections in the University Hospital Centre 'Mother Teresa' of Tirana, Albania. J Hosp Infect 2007;65:244-50.
22. Hajdu A, Samodova OV, Carlsson TR, et al. A point prevalence survey of hospital-acquired infections and antimicrobial use in a paediatric hospital in north-western Russia. J Hosp Infect 2007;66:378-84.
23. Lee MK, Chiu CS, Chow VC, Lam RK, Lai RW. Prevalence of hospital infection and antibiotic use at a university medical center in Hong Kong. J Hosp Infect 2007; 65:341-7.
24. Duerink DO, Roeshadi D, Wahjono H, et al. Surveillance of healthcare-associated infections in Indonesian hospitals. J Hosp Infect 2006;62:219-29.
25. Klavs I, Bufon Luznik T, Skerl M, et al. Prevalence of and risk factors for hospital-acquired infections in Slovenia — results of the first national survey, 2001. J Hosp Infect 2003;54:149-57.
26. Kallel H, Bahoul M, Ksibi H, et al. Prevalence of hospital-acquired infection in a Tunisian hospital. J Hosp Infect 2005;59:343-7.
27. Metintas S, Akgun Y, Durmaz G, Kalyoncu C. Prevalence and characteristics of nosocomial infections in a Turkish university hospital. Am J Infect Control 2004;32:409-13.
28. Danchaivijitr S, Judaeng T, Sripalakij S, Naksawas K, Plipat T. Prevalence of nosocomial infection in Thailand 2006. J Med Assoc Thai 2007;90:1524-9.
29. Gravel D, Matlow A, Ofner-Agostini M, et al. A point prevalence survey of health care-associated infections in pediatric populations in major Canadian acute care hospitals. Am J Infect Control 2007;35:157-62.
30. Gravel D, Taylor G, Ofner M, et al. Point prevalence survey for healthcare-associated infections within Canadian adult acute-care hospitals. J Hosp Infect 2007;66:243-8.
31. Magill SS, Hellinger W, Cohen J, et al. Prevalence of healthcare-associated infections in acute care hospitals in Jacksonville, Florida. Infect Control Hosp Epidemiol 2012;33:283-91.
32. Horan TC, Andrus M, Dudeck MA. March 2010 update to: CDC/NHSN surveillance definition of healthcare-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008;36:309-32 (http://www.cdc.gov/nhsn/pdfs/archive/17pscNosInfDef_NOTcurrent.pdf).
33. Rhame FS, Sudderth WD. Incidence and prevalence as used in the analysis of the occurrence of nosocomial infections. Am J Epidemiol 1981;113:1-11.
34. Healthcare Cost and Utilization Project (HCUP). Nationwide Inpatient Sample (NIS), 2010. Rockville, MD: Agency for Healthcare Research and Quality (http://www.hcup-us.ahrq.gov/nisoverview.jsp).
35. 2011 National and state healthcare-associated infections standardized infection ratio report: using data reported to the National Healthcare Safety Network as of September 4, 2012. Atlanta: Centers for Disease Control and Prevention (http://www.cdc.gov/hai/pdfs/SIR/SIR-Report_02_07_2013.pdf).
36. Haley RW, Culver DH, White JW, Morgan WM, Emori TG. The nationwide nosocomial infection rate: a new need for vital statistics. Am J Epidemiol 1985;121:159-67.
37. Vital signs: preventing *Clostridium difficile* infections. MMWR Morb Mortal Wkly Rep 2012;61:157-62.
38. Dubberke ER, Olsen MA. Burden of *Clostridium difficile* on the healthcare system. Clin Infect Dis 2012;55:Suppl 2:S88-S92.
39. Zerey M, Paton BL, Lincourt AE, Gersin KS, Kercher KW, Heniford BT. The burden of *Clostridium difficile* in surgical patients in the United States. Surg Infect (Larchmt) 2007;8:557-66.
40. Dubberke ER, Butler AM, Nyazee HA, et al. The impact of ICD-9-CM code rank order on the estimated prevalence of *Clostridium difficile* infections. Clin Infect Dis 2011;53:20-5.
41. Dubberke ER, Butler AM, Yokoe DS, et al. Multicenter study of *Clostridium difficile* infection rates from 2000 to 2006. Infect Control Hosp Epidemiol 2010;31:1030-7.
42. Cohen J, MacCannell D, Clark LA, et al. Changes in *Clostridium difficile* testing practices and their impact on stool rejection policies across multiple U.S. laboratories. Presented at IDWeek 2012, San Diego, CA, October 16–21, 2012. abstract (https://idsa.confex.com/idsa/2012/webprogram/Paper34539.html).
43. Fast facts on US hospitals. Washington, DC: American Hospital Association (http://www.aha.org/research/rc/stat-studies/fast-facts.shtml).
44. Active Bacterial Core Surveillance (ABCs) report: Emerging Infections Program Network methicillin-resistant *Staphylococcus aureus*, 2011. Atlanta: Centers for Disease Control and Prevention (http://www.cdc.gov/abcs/reports-findings/survreports/mrsa11.pdf).