Supplementary Appendix

This appendix has been provided by the authors to give readers additional information about their work.

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Supplementary Appendix, “Changes in Prevalence of Health Care-Associated Infections in U.S. Hospitals”

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Methods: hospital and patient selection

To engage additional hospitals beyond those that participated in the 2011 survey, Emerging Infections Program sites used the same approach employed in the 2011 survey.[1] Each site recruited additional hospitals using randomly sorted hospital lists stratified by bed size, with the following goals in each bed size stratum: 13 small (<150 beds), 9 medium (150–399 beds), and 3 large (≥400 beds) hospitals. Participation was voluntary.

The numbers of randomly selected acute care inpatients to be included in the survey were determined by hospital bed size category, as in 2011. For small and medium hospitals, the sample goal was 75 patients; if the hospital had < 75 patients on the survey date then all patients were to be included. For large hospitals, the sample goal was 100 patients.

Methods: training and data collection

Hospital staff participating in 2015 survey activities were asked to view recorded survey operations training or join a live training session prior to their hospitals’ survey dates. Emerging Infections Program staff participated in live training or viewed recorded training on survey operations, health care-associated infection (HAI) definitions, and data collection. Training provided for the 2015 survey was similar to training provided for the 2011 survey, except for the option of viewing recorded training sessions. Emerging Infections Program data collectors also received training for expanded data collection activities in the 2015 survey, including HAI data collection using two different sets of National Healthcare Safety Network HAI surveillance definitions (the 2011 definitions and the 2015 definitions).

Hospitals in the 2015 survey were asked to complete a questionnaire that included information on hospital characteristics and infection control and antimicrobial stewardship policies and practices. Emerging Infections Program staff also gathered limited information on selected hospital characteristics. Hospital data were entered into a Research Electronic Data Capture (REDCap)[2] database hosted at CDC, and were included with patient data in the analysis. Emerging Infections Program sites had the option of utilizing their data collectors for all aspects of patient data collection, or engaging hospital staff to collect a limited amount of demographic and clinical information for each surveyed patient in their facility. In addition, in the 2015 survey Emerging Infections Program sites and hospitals were given the option of collecting the initial, limited demographic and clinical data on the survey date or retrospectively. If these data were collected retrospectively, data collectors were instructed only to report information present in the medical record up until 17:00 hours on the survey date. Emerging Infections Program staff reviewed medical records to collect detailed information on antimicrobial use and HAIs; hospital staff did not participate in these reviews. CDC staff provided support to Emerging Infections Program data collectors for questions regarding National Healthcare Safety Network HAI definitions, HAI determinations, or other aspects of data collection.

Methods: National Healthcare Safety Network surveillance definitions

The Emerging Infections Program hospital prevalence surveys of HAIs and antimicrobial use are conducted using the National Healthcare Safety Network’s acute care hospital HAI surveillance definitions. Each year CDC updates these surveillance definitions to improve the objectivity, usability or clinical credibility of the definitions. In 2015, major revisions to the National Healthcare Safety Network definitions were implemented. Therefore, in the 2015 survey, we opted to collect HAI data using two different sets of National Healthcare Safety Network HAI definitions. Data were collected using the same HAI definitions used in the 2011 survey[3] for the purposes of comparing HAI prevalence and distribution in the 2011 and 2015 surveys, which is the focus of this manuscript. Data were also collected using the 2015 definitions for the five most common HAI types (pneumonia, surgical-site infections, gastrointestinal infections, bloodstream infections, and urinary tract infections) and for ventilator-associated events.[4] A detailed description of the National Healthcare Safety Network HAI definition changes implemented in 2015 is beyond the scope of this appendix; in general, changes were designed to reduce the subjectivity of the surveillance definitions by providing specific time periods within which HAI definition criteria must be met, and update HAI definition criteria to reflect current practices in diagnostic testing (see https://www.cdc.gov/nhsn/pdfs/newsletters/vol9-3-eNL-Sept-2014.pdf). A “repeat infection timeframe” was also implemented in the National Healthcare Safety Network in 2015, specifying a duration of 14 days for most HAIs, but this timeframe was not strictly implemented in the 2015 survey due to its cross-sectional design. We did not have the data to be able to apply the 2015 definitions retroactively to patients in the 2011 survey.

Methods: modeling and national burden estimates

We developed approaches to handling missing or unknown data to maximize the numbers of patients whose data could be included in the modeling process. For patients who had surgical-site infections (SSIs) with onset before hospitalization but for whom a specific onset date was unknown, we created a proxy onset date. First, we determined the median number of days from the operative procedure date to SSI onset date in patients with known SSI onset dates before admission. We added the median number of days from procedure to SSI onset to the operative procedure dates of patients with unknown SSI onset dates before admission to create proxy SSI onset dates. For one patient with pneumonia for whom onset date was unknown, but onset was before hospitalization (such infections could be deemed HAIs if related to a prior, recent hospitalization), we set the onset date equal to the admission date. There were also patients with missing hospital length of stay data. Of these 9 patients, 8 were still in the hospital 6 months after the survey date when follow up for discharge and outcome information ended. For these patients, a proxy for hospital length of stay was considered the time from admission to last follow up date. For the ninth patient, hospital discharge date was unknown.

We developed national burden estimates for 2015 using a process similar to the method used in 2011.[1] First, we used logistic and log-binomial regression models to identify patient and hospital factors associated with HAIs, and we assessed model fit using the likelihood ratio test and Akaike Information Criterion score. Log-binomial regression models were compared and verified for robustness using Poisson regression in a Generalized Estimating Equations framework. Second, we used factors independently associated with HAIs to partition survey data and 2014 National Inpatient Sample (NIS) data (Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality) into patient strata.[5] We predicted HAI prevalence within each stratum using the final log-binomial regression model. We calculated HAI incidence in each stratum with the formula of Rhame and Sudderth,[6] using the predicted prevalence and stratum-specific data from the prevalence survey on hospital length of stay

and time to HAI onset. Finally, we generated national burden estimates of hospital patients with HAIs by multiplying HAI incidence by the total number of discharges in each NIS stratum and summing across strata. The point estimate of the total number of patients with HAIs and the upper and lower bounds of the 95% confidence interval (CI) were rounded to the nearest hundred.

Results: comparison of HAI prevalence

Among patients in the 2015 survey, we compared the percentage of patients with HAIs detected by the 2011 definitions vs. the 2015 definitions. When the 2011 definitions were applied, 342 of 12,299 patients had pneumonia, SSIs, bloodstream infections, urinary tract infections, or gastrointestinal infections (2.8%; 95% confidence interval [CI], 2.5 to 3.1). When the 2015 definitions were applied, 345 patients had ≥1 of these 5 HAI types (2.8%; 95% CI, 2.5 to 3.1). A comparison of the distribution of HAI types using the 2011 definitions vs. the 2015 definitions is shown in Table S5.

Discussion: limitations

Additional limitations of our prevalence survey include its restriction to only those HAIs that were active at the time of the survey, defined as HAIs with signs or symptoms on the survey date, or HAIs still being treated with antimicrobial agents. Although we used the same definitions in 2011 and in 2015, practice changes could have affected detection of active HAIs. For example, substantial changes in medical record documentation of signs and symptoms or antimicrobial prescribing could have affected our ability to detect HAIs. Similar findings were observed in the subset of hospitals that participated in both surveys and in the subset of patients who received antimicrobial agents and met our HAI review criterion, suggesting that changes in documentation and prescribing likely do not account for the observed decrease in prevalence.

Point prevalence surveys have the potential to over-represent HAIs of longer duration, such as SSIs, since on any given day patients with such infections are more likely to have signs or symptoms or be receiving antibiotics than patients with shorter-duration infections, such as urinary tract infections.[7] Although this prevalence survey bias could influence the distribution of HAI types detected in the survey, it would not be expected to affect substantially the comparison of overall prevalence in 2011 compared with 2015.

We used the Rhame and Sudderth formula for converting HAI prevalence to incidence,[4] which is a method with well-described limitations.[8-12] The formula was published almost 40 years ago, and its components may not fully account for the complexities of present-day health care delivery. For example, the formula incorporates a term representing the time from hospital admission to HAI onset, which may present challenges for HAIs that begin prior to the prevalence survey hospitalization. As an example, most SSIs have their onset outside the hospital, following discharge from the hospitalization during which the operative procedure occurred, and some investigators have reported a poor correlation between observed SSI incidence and SSI incidence calculated using the Rhame and Sudderth

formula.[12] Similarly, patients may be readmitted for *Clostridioides difficile* infections that begin in the outpatient setting but are related to a prior hospitalization. Although the HAI surveillance definitions we used allow for detection of certain HAIs that are present on admission, whether the timing of these infections is adequately accounted for in the conversion of prevalence to incidence is unclear.

The formula is intended to capture active and cured infections and uses the time from admission to the first HAI in patients with multiple HAIs;[6] because of our survey methods, we detected only active HAIs, and we cannot assume that all infections active at the time of the survey were in fact patients’ first HAIs during the hospitalization. For patients with multiple HAIs active at the time of the survey, we used time from admission to onset of the first infection in our analysis.

Finally, Rhame and Sudderth recommended using the average daily census and average daily admissions from the survey month to approximate the average length of stay of all hospital patients in their formula. They cautioned that using the average length of stay of all patients on the survey date would result in an artificially inflated length of stay, since prevalence surveys are biased toward longer-stay patients.[6] Although we asked hospitals to provide data on average daily census from a recent year, we did not have data on average daily census or daily admissions at the time of the survey, and therefore we used the average length of stay of patients included in the survey. It is unlikely that this or the other limitations discussed above affected the results of our analysis comparing 2011 and 2015 HAI prevalence, since we used the same approach in both surveys.

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Figure S1. Numbers of patients surveyed by month, 2011 vs. 2015.

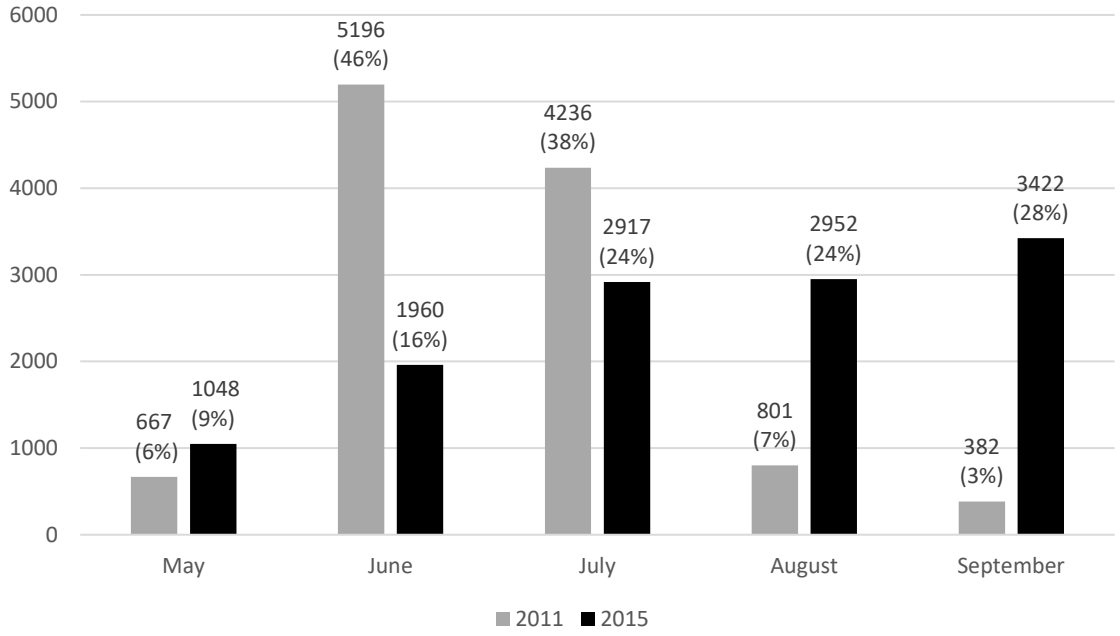

Table S1. Catchment areas, hospitals and patients included in the survey, by Emerging Infections Program site.

Site	Survey Catchment Area[a]	No. of Hospitals (%)	No. of Patients (%)
California	3-county San Francisco Bay area	14 (7.0)	919 (7.5)
Colorado	11-county Front Range area[b]	16 (8.0)	1078 (8.8)
Connecticut	Entire state	14 (7.0)	1049 (8.5)
Georgia	20-county metropolitan Atlanta area	22 (11.1)	1525 (12.4)
Maryland	Entire state	22 (11.1)	1437 (11.7)
Minnesota	Entire state	25 (12.6)	1377 (11.2)
New Mexico	Entire state	18 (9.0)	876 (7.1)
New York	10-county western New York area[c]	22 (11.1)	1312 (10.7)
Oregon	10-county metropolitan Portland and Eugene area	22 (11.1)	1370 (11.1)
Tennessee	Entire state	24 (12.1)	1356 (11.0)
Total		199 (100)	12,299 (100)

Percentages may not total 100 due to rounding.

[a]Catchment areas for the 2015 survey were the same as for the 2011 survey unless otherwise specified.

[b]Catchment area for the 2011 survey consisted of 5 Front Range counties.

[c]Catchment area for the 2011 survey consisted of 9 western New York counties.

Table S2. Characteristics of hospitals participating in the 2015 survey.

Characteristic	Hospitals (N=199)
Region — no. (%)	
Midwest	25 (12.6)
Northeast	36 (18.1)
South	68 (34.2)
West	70 (35.2)
Location[a] — no. (%)	
Rural	22 (11.1)
Urban	177 (88.9)
Teaching hospital[b] — no. (%)	
Yes	88 (44.2)
No	111 (55.8)
Infection preventionist staffing[c] — no. (%)	
At least 1 full-time equivalent	171 (85.9)
Less than 1 full-time equivalent	28 (14.1)
Hospital epidemiologist staffing[d] — no. (%)	
At least 1 full-time equivalent	42 (21.1)
Less than 1 full-time equivalent	157 (78.9)

Percentages may not total 100 due to rounding.

[a]Urban vs. rural location was determined based on 2010 U.S. Census data. Hospitals located in counties that are part of metropolitan statistical areas were considered urban. Hospitals located in counties in micropolitan statistical areas or rural areas were considered rural.

[b]Teaching hospitals were defined on the basis of membership in the Council of Teaching Hospitals, or having an American Medical Association-approved residency program, or a self-reported or calculated intern/resident to bed ratio of ≥0.25. This is similar to how teaching status was defined in the 2014 National Inpatient Sample.[13] Teaching status was initially missing for one hospital; this hospital was subsequently categorized as a teaching hospital based on information submitted by Emerging Infections Program staff.

[c]Hospitals were asked to submit staffing data from the most recent year for which data were available: 2015 (51 hospitals, 26%); 2014 (146, 73%); or 2013 (2, 1%). In one instance where data were reported in aggregate for >1 hospital in the same system, Emerging Infections Program site staff were consulted, and aggregated data were apportioned to each hospital.

[d]Hospitals were asked to submit staffing data from the most recent year for which data were available: 2015 (52 hospitals, 26%); 2014 (145, 73%); 2013 (2, 1%). In one instance where data were reported in aggregate for >1 hospital in the same system, Emerging Infections Program site staff were consulted, and aggregated data were apportioned to each hospital.

Table S3. Additional demographic and clinical characteristics of surveyed patients, 2015.

Characteristic	All Patients (N=12,299)	Patients without HAIs (N=11,905)	Patients with HAIs (N=394)	P Value[a,b]
Sex — no. (%)				0.01
Female	6822 (55.5)	6628 (55.7)	194 (49.2)	
Male	5476 (44.5)	5276 (44.3)	200 (50.8)	
Missing data	1 (<0.1)	1 (<0.1)	0	
Age category — no. (%)				<0.001
<1 year	1339 (10.9)	1319 (11.1)	20 (5.1)	
1-17 years	527 (4.3)	514 (4.3)	13 (3.3)	
18-24 years	457 (3.7)	444 (3.7)	13 (3.3)	
25-44 years	1951 (15.9)	1910 (16.0)	41 (10.4)	
45-64 years	3211 (26.1)	3056 (25.7)	155 (39.3)	
65-84 years	3756 (30.5)	3634 (30.5)	122 (31.0)	
≥85 years	1058 (8.6)	1028 (8.6)	30 (7.6)	
Race — no. (%)				0.33
American Indian or Alaska Native	142 (1.2)	140 (1.2)	2 (0.5)	
Asian	312 (2.5)	307 (2.6)	5 (1.3)	
Black or African-American	2007 (16.3)	1939 (16.3)	68 (17.3)	
Multiple races or other unspecified race	615 (5.0)	598 (5.0)	17 (4.3)	

Characteristic	All Patients (N=12,299)	Patients without HAIs (N=11,905)	Patients with HAIs (N=394)	P Value[a,b]
Native Hawaiian or other Pacific Islander	41 (0.3)	40 (0.3)	1 (0.3)	
White	8161 (66.4)	7895 (66.3)	266 (67.5)	
Missing data	1021 (8.3)	986 (8.3)	35 (8.9)	
Ethnicity — no. (%)				0.79
Hispanic or Latino	977 (7.9)	944 (7.9)	33 (8.4)	
Not Hispanic or Latino	7991 (65.0)	7734 (65.0)	257 (65.2)	
Missing data	3331 (27.1)	3227 (27.1)	104 (26.4)	
Primary payer — no. (%)				0.39
Medicaid	2446 (19.9)	2377 (20.0)	69 (17.5)	
Medicare	4952 (40.3)	4781 (40.2)	171 (43.4)	
No charge	11 (<0.1)	10 (<0.1)	1 (0.3)	
Other	309 (2.5)	300 (2.5)	9 (2.3)	
Private	3850 (31.3)	3724 (31.3)	126 (32.0)	
Self-pay	430 (3.5)	421 (3.5)	9 (2.3)	
Missing data	301 (2.5)	292 (2.5)	9 (2.3)	
Body mass index category[c] — no. (%)				
Normal	3601 (29.3)	3464 (29.1)	137 (34.8)	0.12
Overweight	2887 (23.5)	2789 (23.4)	98 (24.9)	0.91
Obese	3846 (31.3)	3727 (31.3)	119 (30.2)	0.15

Characteristic	All Patients (N=12,299)	Patients without HAIs (N=11,905)	Patients with HAIs (N=394)	P Value[a,b]
Missing data	1965 (16.0)	1925 (16.2)	40 (10.2)	0.001
Outcome of hospitalization — no. (%)				<0.001[d]
Died	358 (2.9)	313 (2.6)	45 (11.4)	
Survived	11,927 (97.0)	11,579 (97.3)	348 (88.3)	
Still in hospital 6 months after survey	8 (<0.1)	7 (<0.1)	1 (0.3)	
Missing data	6 (<0.1)	6 (<0.1)	0	

Percentages may not total 100 due to rounding.

[a]Chi-square test, unless otherwise indicated.

[b]Comparison excludes patients with missing data, unless otherwise indicated.

[c]Body mass index (BMI) categories were generated using reported or calculated body mass index for patients ≥2 years of age. BMI was considered missing for children <2 years of age, even if BMI was reported in the medical record. For adults (≥20 years), normal weight was BMI <25; overweight 25≤BMI<30; and obese BMI ≥30. For children (2–19 years), normal weight was BMI <85th percentile for age and sex; overweight BMI between the 85th and 95th percentile for age and sex; and obese BMI ≥95th percentile for age and sex.

[d]Comparison includes patients who were known to have survived or died during the hospitalization; patients still in the hospital and those with unknown outcome were excluded.

Table S4. Comparison of additional, selected patient characteristics, 2011 vs. 2015 survey.

Characteristic	2011 Survey Patients (N=11,282)	2015 Survey Patients (N=12,299)	P Value[a,b]
Sex — no. (%)			0.83
Female	6236 (55.3)	6822 (55.5)	
Male	5034 (44.6)	5476 (44.5)	
Missing data	12 (0.1)	1 (<0.1)	
Age category — no. (%)			0.08
<1 year	1151 (10.2)	1339 (10.9)	
1–17 years	479 (4.3)	527 (4.3)	
18–24 years	462 (4.1)	457 (3.7)	
25–44 years	1686 (15.0)	1951 (15.9)	
45–64 years	3060 (27.1)	3211 (26.1)	
65–84 years	3429 (30.4)	3756 (30.5)	
≥85 years	1014 (9.0)	1058 (8.6)	
Missing data	1 (<0.1)	0	
Race — no. (%)			<0.001[c]
American Indian or Alaska Native	119 (1.1)	142 (1.2)	
Asian	254 (2.3)	312 (2.5)	
Black or African-American	1905 (16.9)	2007 (16.3)	
Multiple races or other unspecified race	254 (2.3)	615 (5.0)	

Characteristic	2011 Survey Patients (N=11,282)	2015 Survey Patients (N=12,299)	P Value[a,b]
Native Hawaiian or other Pacific Islander	20 (0.2)	41 (0.3)	
White	7537 (66.8)	8161 (66.4)	
Missing data	1193 (10.6)	1021 (8.3)	
Ethnicity — no. (%)			<0.001[c]
Hispanic or Latino	846 (7.5)	977 (7.9)	
Not Hispanic or Latino	3715 (32.9)	7991 (65.0)	
Missing data	6721 (59.6)	3331 (27.1)	
Ventilator in place on survey date — no. (%)			0.71
Yes	527 (4.7)	586 (4.8)	
No	10,748 (95.3)	11,683 (95.0)	
Missing data	7 (<0.1)	30 (0.2)	
Median hospital length of stay among patients who received antimicrobial therapy at the time of the survey (or information not available) (IQR)	6 (3–13)[d]	6 (3–13)[d]	0.15[e]

Percentages may not total 100 due to rounding. IQR denotes interquartile range.

[a]Chi-square test, unless otherwise indicated.

[b]Comparison excludes patients with missing data, unless otherwise indicated.

[c]Comparison includes patients with missing data.

[d]Hospital length of stay data were missing for 53 patients in the 2011 survey and 2 patients in the 2015 survey. Excludes patients in the 2011 survey who were screen-positive for antimicrobial therapy at the time of the survey based on a special criterion for dialysis patients. This criterion was not implemented in the 2015 survey.

[e]Median 2-sample test

Table S5. Distribution of common HAI types in the 2015 survey, 2011 definitions vs. 2015 definitions.

	No. of HAIs (%), 2011 HAI Definitions (N=361)	**No. of HAIs (%), 2015 HAI Definitions (N=370)**
Pneumonia	110 (30.5)	97 (26.2)
Gastrointestinal infection	91 (25.2)	95 (25.7)
Surgical site infection	69 (19.1)	88 (23.8)
Bloodstream infection	52 (14.4)	55 (14.9)
Urinary tract infection	39 (10.8)	35 (9.5)

Percentages may not total 100 due to rounding.

Table S6. Multivariable log binomial regression model to identify variables associated with health care-associated infections (HAIs) in the subset of patients meeting the HAI review criterion, combined 2011 and 2015 survey populations (N=9118).

Variable*	Total No. of Patients	No. of Patients with HAIs	Adjusted Risk Ratio	95% Confidence Interval	P Value
Survey year 2015	4614	394	0.84	0.75–0.94	0.003
Ventilator on the survey date[a]	700	176	1.28	1.09–1.52	0.003
Survey date in May or June[b]	3662	310	0.88	0.78–1.00	0.04
Large hospital	1744	280	1.25	1.11–1.41	<0.001
Critical care unit on the survey date	1597	271	1.28	1.10–1.49	0.002
Time from admission to survey					
≤1 day	1881	27	Ref	--	--
2–4 days	3501	81	1.62	1.07–2.54	0.03
5–6 days	1144	76	4.59	3.02–7.19	<0.001
7–9 days	942	127	8.95	6.06–13.74	<0.001
10–12 days	480	122	16.17	10.98–24.76	<0.001
13–20 days	606	174	18.38	12.62–27.93	<0.001
≥21 days	564	239	24.15	16.66–36.57	<0.001

*Other variables that were tested but found not to be statistically significant predictors of HAI risk were age and presence of a central line or urinary catheter on the survey date.

[a]Ventilator presence was unknown for 17 patients without HAIs and 1 patient with HAI (patients with unknown ventilator status were grouped with patients without ventilators for analysis).

[b]Survey dates were categorized as being in May–June versus July–September.

Table S7. Multivariable log binomial regression model to identify variables associated with health care-associated infections (HAIs) in the subset of patients in 148 hospitals that participated in both the 2011 and 2015 surveys, combined 2011 and 2015 survey populations (N=18,451).

Variable*	Total No. of Patients	No. of Patients with HAIs	Adjusted Risk Ratio	95% Confidence Interval	P Value
Survey year 2015	9169	297	0.78	0.68–0.90	<0.001
Ventilator on the survey date[a]	877	139	1.69	1.40–2.02	<0.001
Central line on the survey date[b]	3371	382	1.87	1.59–2.20	<0.001
Urinary catheter on the survey date[c]	3875	241	1.18	1.01–1.39	0.04
Large hospital	4310	255	1.24	1.07–1.43	0.004
Time from admission to survey					
≤1 day	5408	20	Ref	Ref	—
2–4 days	7043	69	2.43	1.51–4.10	<0.001
5–6 days	1688	56	6.93	4.24–11.81	<0.001
7–9 days	1480	105	13.68	8.68–22.71	<0.001
≥10 days	2832	430	26.52	17.30–43.14	<0.001
Age[d]					
<45 years	6389	166	Ref	Ref	—
45–84 years	10,448	456	1.49	1.26–1.78	<0.001
≥85 years	1614	58	1.76	1.31–2.31	<0.001

*Other variables that were tested but found not to be statistically significant predictors of HAI risk were survey month (May–June versus July–September) and location in a critical care unit on the survey date.

[a]Ventilator presence was unknown for 26 patients without HAIs and 0 patients with HAI (patients with unknown ventilator status were grouped with patients without ventilators for analysis).

[b]Central line presence was unknown for 51 patients without HAIs and 0 patients with HAI (patients with unknown central line status were grouped with patients without central lines for analysis).

[c]Urinary catheter presence was unknown for 45 patients without HAIs and 3 patients with HAI (patients with unknown catheter status were grouped with patients without urinary catheters for analysis).

[d]Model excluded 1 patient without HAIs in the 2011 survey for whom age was unknown.

Table S8. Multivariable log binomial regression model to identify variables associated with health care-associated infections (HAIs), excluding the presence of devices, in the subset of patients in 148 hospitals that participated in both the 2011 and 2015 surveys, combined 2011 and 2015 survey populations (N=18,451).

Variable*	Total No. of Patients	No. of Patients with HAIs	Adjusted Risk Ratio	95% Confidence Interval	P Value
Survey year 2015	9169	297	0.76	0.66–0.87	<0.001
Critical care unit on the survey date	2790	212	1.58	1.35–1.85	<0.001
Large hospital	4310	255	1.28	1.11–1.49	<0.001
Time from admission to survey					
≤1 day	5408	20	Ref	Ref	--
2–4 days	7043	69	2.51	1.56–4.24	<0.001
5–6 days	1688	56	7.74	4.74–13.17	<0.001
7–9 days	1480	105	16.39	10.43–27.14	<0.001
≥10 days	2832	430	35.90	23.59–58.08	<0.001
Age[a]					
<40 years	5739	143	Ref	Ref	--
40–50 years	1708	63	1.76	1.32–2.33	<0.001
51–65 years	4179	208	2.13	1.73–2.62	<0.001
66–69 years	1203	43	1.66	1.19–2.28	0.002
≥70 years	5622	223	2.15	1.75–2.65	<0.001

[*]Survey month (May–June versus July–September) was also tested but was not found to be a statistically significant predictor of HAI risk.

[a]Model excluded 1 patient without HAIs in the 2011 survey for whom age was unknown.

Table S9. Log-binomial regression model to identify factors associated with HAIs among patients surveyed in 2015 (N=12,299).

			Full, Final Model			Final Model* For Burden Estimation		
Factor	**Total No. of Patients**	**No. of Patients with HAIs**	**Adjusted Risk Ratio**	**95% Confidence Interval**	**P Value**	**Adjusted Risk Ratio**	**95% Confidence Interval**	**P Value**
Age[a]								
≤1 year	1388	22	Ref	Ref	—	Ref	Ref	—
2–26 years	1119	26	2.33	1.34–4.05	0.003			
27–51 years	2574	72	2.94	1.84–4.70	<0.001	2.26	1.58–3.22	<0.001
52–64 years	2404	122	4.10	2.62–6.42	<0.001	3.21	2.32–4.44	<0.001
65–77 years	2607	82	2.89	1.82–4.61	<0.001	2.19	1.54–3.11	<0.001
≥78 years	2207	70	3.77	2.35–6.04	<0.001	2.71	1.88–3.90	<0.001
Hospital length of stay[b]								
≤4 days	5861	20	Ref	Ref	—	Ref	Ref	—
5–6 days	1427	15	2.66	1.36–5.19	0.004			

			Full, Final Model			Final Model* For Burden Estimation		
Factor	Total No. of Patients	No. of Patients with HAIs	Adjusted Risk Ratio	95% Confidence Interval	P Value	Adjusted Risk Ratio	95% Confidence Interval	P Value
7–8 days	1064	26	5.84	3.26–10.44	<0.001	4.69	2.83–7.75	<0.001
9–14 days	1543	75	11.22	6.83–18.42	<0.001	9.43	6.34–14.04	<0.001
15–23 days	992	85	17.70	10.79–29.04	<0.001	16.98	11.51–25.03	<0.001
≥24 days	1412	173	26.90	16.58–43.67	<0.001	28.83	20.12–41.32	<0.001
Ventilator[c]	586	81	1.53	1.21–1.93	<0.001	Not included in final model		
Central line[d]	2081	213	1.88	1.52–2.32	<0.001	Not included in final model		
Rural hospital[e]	11,719	381	1.88	1.11–3.19	0.02	Not included in final model		
Hospital with >400 licensed beds[f]	3557	176	1.37	1.11–1.70	0.004	Not included in final model		
Hospital with 500–800 licensed beds[f]	1474	56	0.60	0.45–0.81	<0.001	Not included in final model		

*The final model for burden estimation included factors significant in multivariable models and available in the prevalence survey dataset and in the 2014 National Inpatient Sample.

[a]Age categories ≤1 year and 2–26 years were collapsed in the final model for burden estimation due to no health care-associated infection events in certain categories of age and length of stay.

[b]Hospital length of stay was available for 12,290 patients; length of stay was unknown for 1 patient, and 8 patients were still in the hospital at least 6 months after the survey date. Time from admission to the date of follow-up (≥6 months following the survey date) was used as a proxy for hospital length of stay in patients who remained in the hospital for more than 6 months after the survey date. Hospital length of stay categories ≤4 days and 5–6 days were collapsed in the final model for burden estimation due to there being no health care-associated infection events in certain categories of age and length of stay.

[c]Ventilator presence was unknown for 29 patients without HAIs and 1 patient with HAI (patients with unknown ventilator status were grouped with patients without ventilators for analysis).

[d]Central line presence was unknown for 42 patients without HAIs and 1 patient with HAI (patients with unknown central line status were grouped with patients without central lines for analysis).

[e]Hospitals were categorized as urban versus rural based on U.S. Census data; hospitals located in a metropolitan county were considered urban, and hospitals located in a micropolitan or rural county were considered rural.

[f]Hospitals were asked to submit licensed bed data from the most recent year for which data were available: 2015 (39 hospitals, 20%); 2014 (157, 79%); 2013 (3, 2%). In one instance where data were reported in aggregate for >1 hospital in the same system, Emerging Infections Program site staff were consulted, and aggregated data were apportioned to each hospital.

Table S10. Estimated numbers of health care-associated infections in the United States in 2015.

Infection Type	No. of Infections	Percentage of Patients with Infection Type[a] (95% Confidence Interval)	Estimated Infections[b] in the United States (95% Confidence Interval)
Pneumonia	110	27.9 (23.7–32.5)	176,700 (51,200–621,600)
Gastrointestinal infection	91	23.1 (19.1–27.5)	146,300 (41,300–526,000)
Surgical-site infection	69	17.5 (14.0–21.5)	110,800 (30,200–411,200)
Bloodstream infection	52[c]	13.2 (10.1–16.8)	83,600 (21,800–321,300)
Urinary tract infection	39	9.9 (7.2–13.2)	62,700 (15,600–252,500)
Skin and soft tissue infection	22	5.6 (3.6–8.2)	35,500 (7,800–156,800)
Eye, ear, nose throat and mouth infection	21[d]	5.3 (3.4–7.9)	33,600 (7,300–151,100)
Lower respiratory infection	18	4.6 (2.8–7.0)	29,100 (6,000–133,900)
Bone and joint infection	2	0.5 (0.08–1.7)	3,200 (200–32,500)
Central nervous system infection	1	0.3 (0.01–1.2)	1,900 (0–23,000)
Cardiovascular infection	1	0.3 (0.01–1.2)	1,900 (0–23,000)
Reproductive tract infection	1	0.3 (0.01–1.2)	1,900 (0–23,000)
Systemic infection	0	0 (0–0.8)	0 (0–15,300)

Infection Type	No. of Infections	Percentage of Patients with Infection Type[a] (95% Confidence Interval)	Estimated Infections[b] in the United States (95% Confidence Interval)
Total			687,200 (181,400–2,691,200)

[a]Among the 394 surveyed patients with health care-associated infections, the percentage with each infection type.

[b]Estimates are based on the total number of patients with health care-associated infections (and upper and lower bounds of the 95% CI), prior to rounding to the nearest hundred, multiplied by the rounded proportions (and upper and lower bounds of the 95% CIs) of patients with each type of infection. These products were then rounded to the nearest hundred to estimate the total numbers of each HAI. The rounded products were added together to determine the total number of all HAIs. For the purposes of burden estimation, we assumed each infection occurred in a unique patient.

[c]One patient had 2 separate bloodstream infections. For the purposes of burden estimation, we assumed that each of these 52 infections occurred in a unique patient.

[d]One patient had 2 separate eye, ear, nose, throat and mouth infections. For the purposes of burden estimation, we assumed that each of these 21 infections occurred in a unique patient.

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