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Antibiotic Stewardship Programs in U.S. Acute Care Hospitals: Findings From the 2014 National Healthcare Safety Network Annual Hospital Survey

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Abstract

Background.—The National Action Plan to Combat Antibiotic Resistant Bacteria calls for all US hospitals to improve antibiotic prescribing as a key prevention strategy for resistance and *Clostridium difficile*. Antibiotic stewardship programs (ASPs) will be important in this effort but implementation is not well understood.

Methods.—We analyzed the 2014 National Healthcare Safety Network Annual Hospital Survey to describe ASPs in US acute care hospitals as defined by the Center for Disease Control and Prevention's (CDC) Core Elements for Hospital ASPs. Univariate analyses were used to assess stewardship infrastructure and practices by facility characteristics and a multivariate model determined factors associated with meeting all ASP core elements.

Results.—Among 4184 US hospitals, 39% reported having an ASP that met all 7 core elements. Although hospitals with greater than 200 beds (59%) were more likely to have ASPs, 1 in 4 (25%) of hospitals with less than 50 beds reported achieving all 7 CDC- defined core elements of a comprehensive ASP. The percent of hospitals in each state that reported all seven elements ranged from 7% to 58%. In the multivariate model, written support (adjusted relative risk [RR] 7.2 [95% confidence interval [CI], 6.2–8.4]; $P < .0001$) or salary support (adjusted RR 1.5 [95% CI, 1.4–1.6]; $P < .0001$) were significantly associated with having a comprehensive ASP.

Conclusions.—Our findings show that ASP implementation varies across the United States and provide a baseline to monitor progress toward national goals. Comprehensive ASPs can be established in facilities of any size and hospital leadership support for antibiotic stewardship appears to drive the establishment of ASPs.

Keywords

anti-bacterial agents (therapeutic use); Health Care Surveys; Hospitals; Centers for Disease Control and Prevention (US); United States

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Overuse of antibiotics contributes to the development of antibiotic resistance and increases patient risk for *Clostridium difficile* infection and other adverse events [1–8]. Antibiotic stewardship refers to a coordinated approach to ensure optimal prescribing and is a key component of a national strategy for combating antibiotic-resistant bacteria in the United States [3]. Antibiotic stewardship programs (ASPs) are recommended by numerous professional, clinical, and public health organizations [9–13] and supported by a Presidential Executive Order—Combating Antibiotic-Resistant Bacteria [14]. In March 2014, the Centers for Disease Control and Prevention (CDC) released guidance on hospital ASPs developed from previously published recommendations, systematic reviews, and collaborative work with the Institute for Healthcare Improvement [1, 8, 9, 15–17]. Seven core elements associated with successful ASPs were identified: leadership commitment; a single program leader responsible for outcomes; a pharmacy leader; specific interventions to improve prescribing; tracking antibiotic use and resistance; reporting data back to providers; and education. The goal of Core Elements of Hospital Antibiotic Stewardship Programs was to provide a framework for ASP implementation in hospitals, regardless of facility size or resources [16].

To assess the national status of implementation of the core elements, CDC included questions on stewardship practices in the 2014 National Healthcare Safety Network (NHSN) Annual Hospital Survey. NHSN is a facility-based surveillance system administered by CDC to provide standard national measures for healthcare-associated infections (HAIs) and measure progress of HAI prevention efforts. Participation in NHSN is required by the Center for Medicare and Medicaid Services in order to receive full reimbursement from the Inpatient Prospective Payment System; thus ensuring high participation from nearly all US acute care hospitals. Prior to this effort, the understanding of the current state of ASP implementation in inpatient settings the United States was limited to smaller, voluntary assessments with response rates of 39% to 53% [18–21]. A previous nationwide ASP assessment was sent surveys to over 5000 hospital pharmacy directors, but resulted in only a 7% response rate [20].

In this study, we used NHSN data to describe the self-reported implementation of ASPs in the United States using the CDC Core Elements of Hospital ASP framework. Our objective was to understand the variation in ASPs by hospital characteristics and state, and to explore the association between infrastructure (support, staffing) and ASP implementation (actions, tracking, reporting, and education). To our knowledge this is the first comprehensive national assessment of antibiotic stewardship practices in the United States and will serve as a baseline for implementation of ASPs in the future.

METHODS

Data Source

Healthcare facilities that participate in the NHSN are required by CDC to complete a facility survey each calendar year. The Patient Safety Component Annual Hospital Survey (ie, the survey) is administered online within the NHSN application and includes questions on facility demographics, laboratory practices, and infection control practices, all of which are

based on characteristics of the facility [22]. Questions specific to the infrastructure and activities of ASPs were also included in NHSN's 2014 survey. The survey is typically completed by the hospital's infection preventionist(s), however when completing the antibiotic stewardship questions, hospitals were encouraged to request assistance from "pharmacists and/or physicians who focus on infectious diseases, where available, and/or members of the facility's pharmacy and therapeutics committee" [22]. All responses were self-reported. Responses to the 2014 NHSN survey as of 1 May 2015 were included in this analysis and represented practices in place during 2014. The survey was approved by the Office of Management and Budget prior to administration (OMB No. 0920-0666).

Antibiotic Stewardship Practices

The 15 ASP questions on the 2014 survey were based on CDC's Core Elements for Hospital ASPs and informed by a panel of stewardship experts that participated in a modified Delphi process to develop structure and process indicators for hospital ASPs in response to a recommendation from the Transatlantic Taskforce for Antimicrobial Resistance [15, 23, 24]. In addition, many of the questions were piloted by the Georgia Department of Public Health as a pre-assessment survey given to hospital pharmacists attending a stewardship training workshop. The core elements for hospital ASPs were categorized as infrastructure or implementation. Infrastructure elements included leadership commitment (leadership), a leader responsible for program outcomes (accountability), and a pharmacist who supports improved prescribing (drug expertise). Implementation elements included monitoring of prescribing practices (track), prescribing improvement actions, such as: facility-specific treatment recommendations; audit with feedback; prior-approval; requirement to document antibiotic indication; or an antibiotic time out (act); regularly reporting prescribing and resistance patterns to staff and recommending steps to improve (report) and education (educate) (Table 1).

Analysis

Responses to the survey from acute care hospitals were aggregated and analyzed at the state and national levels. Responses for inpatient rehabilitation facilities, long-term acute care hospitals, and psychiatric hospitals were excluded from this analysis. Hospitals were further stratified by bed size (fewer than 50 beds, 51 to 200 beds, and >200 beds) and facility type as general acute care (general acute care, military, oncology, Veterans Affairs, women's and women's/children's hospitals); children's; critical access (generally facilities with 25 inpatient beds in rural settings); and surgical (orthopedic and surgical) hospitals. For this analysis, major teaching status includes hospitals that offered graduate medical education programs and nonteaching/undergraduate status includes those that had no physicians-in-training or teaching was limited to medical students only.

Each of the 7 core elements were reviewed individually, and then the proportion of facilities meeting all 7 core elements was calculated and stratified by facility type, bed size, medical school affiliation, and state. Univariate analyses were performed on facility characteristics and the stewardship practice factors identified in the survey to determine their relationship to the presence of an ASP. To assess independent predictors of implementation of all 7 elements, we built a multivariate model using forward stagewise log binomial regression

retaining only factors that were statistically significant in the previous step. Likelihood ratio tests and Akaike information criterion statistics we used to assess model fit. The best model was reflected including adjusted risk ratios (RR) and 95% confidence intervals (CI). All statistical analyses were conducted using SAS version 9.3 (Cary, North Carolina).

RESULTS

Hospital Characteristics

Overall, 4184 acute care hospitals responded to the NHSN Annual Hospital Survey: 3385 (81%) general acute care hospitals, 577 (14%) critical access hospitals, 146 (3%) surgical hospitals, and 76 (2%) children's hospitals (Table 2). The average bed size reported was 114 (interquartile range: 40–243). There were 1121 (27%) facilities classified as major teaching hospitals and the 3063 hospitals (73%) classified as nonteaching or undergraduate only programs (Table 2).

Antibiotic Stewardship Practices

Overall, 60% of respondents reported hospital leadership commitment to ASPs through either a written statement of support (53%) or salary support for stewardship staff (32%); 926 hospitals (22%) reported both (Table 1). A leader responsible for the ASP outcomes was identified in 72% of hospitals. The primary ASP leader was more likely to be a pharmacist (37%) than a physician (30%). Regardless of program leadership, most of hospitals reported having at least one pharmacist responsible for improving antibiotic use (87%). Combining the above core elements of leadership, accountability, and drug expertise, we found that 2298 (55%) of US acute care hospitals had the infrastructure needed for a successful ASP in the year 2014. Nearly all hospitals (94%) reported having specific practices to improve prescribing (Figure 1), most commonly facility specific treatment recommendations (77%); oversight of prescribing of specified drugs by prior authorization (74%); or audit with feedback (63%). Tracking compliance with facility specific recommendations (53%) or antibiotic indication documentation (18%) was less frequent than monitoring antibiotic use (69%), by either days of therapy (37%), defined daily dose (26%), or purchasing (37%). Sixty-eight percent (68%) of hospitals reported prescribing patterns to prescribers through either feedback (59%) or reports (45%). Antibiotic stewardship education in the past year was reported by 62% of hospitals. Overall, 2112 (51%) of hospitals reported all four core implementation elements (action, tracking reporting, and education), and thus were implementing a comprehensive set of ASP activities.

Hospitals Meeting All ASP Core Elements

Overall, 1642 (39%) of US acute care hospitals reporting to NHSN reported implementing all 7 core elements for hospital ASPs (Table 1). In univariate analyses, the proportion of facilities meeting all 7 core elements varied by facility type: 50% for children's hospitals, 43% in general acute care hospitals, 33% in surgical hospitals, and 18% in critical access hospitals. Hospitals with larger bed sizes were more likely to report all 7 core elements: 775 (56%) hospitals with more than 200 beds compared to 672 (39%) hospitals with 51 to 200 beds, and 328 (22%) of hospitals with 50 or fewer beds. Hospitals with 50 beds were less likely to report leadership support (40%) or antibiotic stewardship education (46%) than

facilities larger than 50 beds (69% leadership; 69% education) (data not shown). Major teaching hospitals were more likely to report all 7 core elements (54%) compared to hospitals that had only undergraduate education or no teaching affiliation (34%) (Table 2). The proportion of facilities reporting all seven elements by state ranged from 7% to 58% (Figure 2). In eleven states, 50% or more of hospitals reported meeting all 7 core elements in 2014 (Arizona, California, Delaware, Idaho, Maine, Maryland, Massachusetts, Nebraska, Nevada, New York, Utah). In the final multivariate model, teaching status, written support, and salary support were each independently predictive of reported achievement of all 7 elements. The strongest predictor for meeting all core elements was written support from the facility administration (adjusted RR 7.2 [95% CI, 6.2–8.4]; $P < .0001$) (Table 3).

DISCUSSION

This report summarizes the results of the largest national assessment of ASPs in the United States. Using CDC's NHSN Annual Hospital Survey, we found that nearly 40% of more than 4000 US hospitals reported having ASPs that implemented all the core elements defined by CDC in 2014 [15]. A higher percentage of larger and teaching hospitals reported implementing all seven elements, compared to smaller and nonteaching facilities. California, the only state at the time of the survey with state legislative policy mandating antimicrobial stewardship programs had the highest percentage (58%) of facilities reporting all 7 core elements [19]. Written support from the facility administration was the single strongest, independent predictor of a hospital reporting implementation of all 7 elements.

When we classified the recommended elements into two categories, infrastructure and implementation; we found that at least half of respondent hospitals reported meeting all three infrastructure elements (55%) or all 4 implementation elements (51%). The vast majority (94%) reported implementation of at least one specific intervention to improve antibiotic use such as having facility-specific treatment recommendations, or physician or pharmacist approval to dispense specified antibiotics. Although this finding is encouraging, previous studies suggest that such interventions are most effective when they are carried out within an ASP infrastructure to promote, support and sustain action [25–28]. The need for this comprehensive approach was the rationale for the development of the CDC's Core Elements for Hospital Antibiotic Stewardship Programs. Our findings suggest that many hospitals need to add infrastructure and measurement support to their current actions to improve antibiotic use.

More than 50% of hospitals with more than 200 beds, major teaching hospitals and children's hospitals reported implementing all 7 elements, compared to 33% of nonteaching hospitals of any size and 22% of hospitals with fewer than 50 beds. There is certainly some degree of overlap in these numbers as teaching hospitals are often larger than 200 beds, and children's hospitals are more likely to also be teaching hospitals. Although our study showed that small hospitals may need assistance or resources to implement stewardship programs, an encouraging finding was that almost 300 hospitals with fewer than 50 beds reported successful implementation of all elements. Direct outreach to and discussions with some of these small hospitals to provide examples and offer key lessons is a high priority for CDC. Our findings also suggest that general implementation guidance would be useful to all

hospitals, as more than 40% of larger and teaching hospitals have not yet implemented all of the core elements. To address this need, CDC is partnering with a number of national organizations including the American Hospital Association, The Pew Charitable Trusts, and the National Quality Partnership.

Difficulty in measuring antibiotic use, especially for purposes of risk-adjusted benchmarking, has long been identified as a key barrier to advancing antibiotic stewardship. Our findings highlight this ongoing challenge. Although 69% of hospitals reported tracking antibiotic use, 50% reported using either defined daily doses or purchase data, neither of which are optimal for benchmarking [29, 30]. Over one-third (37%) of hospitals did report measuring antibiotic use in days of therapy, which is the measure used for benchmarking through the NHSN Antibiotic Use Option and is the foundation of the Standardized Antibiotic Administration Ratio, a risk adjusted antibiotic use measure recently recommended by National Quality Forum [31]. As more health information technology companies facilitate reporting into the antibiotic use option, we expect to see many more facilities monitoring antibiotic use in days of therapy and using benchmarking to drive improvements [32].

Our finding that both written and salary support were independently predictive of full ASP implementation is supported by the extensive experience in the quality improvement arena that has demonstrated successful initiatives have leadership backing. We were somewhat surprised to find that written support was most strongly predictive. This finding is important in light of the need to expand stewardship programs in smaller hospitals, which are often more resource limited than larger ones. Even hospitals that might not have financial resources to expand stewardship programs should be able to provide written support to bolster their work.

Of note, California had the highest percent of hospitals that reported implementing all 7 elements. This likely reflects the impact of the 2009 mandate in California that hospitals engage in efforts to improve antibiotic use. A previous survey of California hospitals showed that a significant percentage of hospitals were considering starting stewardship programs in response to the mandate [19]. In 2014, this mandate was expanded to become more specific about the types of stewardship programs that hospitals must implement and it will be interesting to see what impact this has on the results of this survey in future years. The results demonstrate the important role that state-based efforts can play in advancing antibiotic stewardship. In addition to new policies, state public health departments are expanding their efforts to promote ASPs as an essential part of a comprehensive, regional approach to preventing antibiotic resistance [33].

The strength of our study is its representation of nearly all acute care hospitals in the United States. The study, however, is subject to limitations, the most significant of which is that the data were self-reported and responses were not externally validated. This could have influenced the results in both directions. In most hospitals, infection preventionists were responsible for completing the survey and encouraged by CDC to work with others to complete the stewardship questions. If respondent infection preventionists chose not to consult others and were unaware of stewardship activities in the hospital, the results would

be lower. On the other hand, some respondents might have provided answers they felt were socially desirable, which would have led to higher percentages. Many statebased HAI prevention efforts have strong relationships with individual hospitals that reported ASP information on the NHSN survey. Such partnerships are a potential means to validate the responses and CDC is exploring these and other options for such validation work. Another limitation is that the survey only assessed the presence of CDC-defined core elements of hospital ASPs; it was not intended to measure the effectiveness of those programs. There may be stewardship programs that are highly successful but have not implemented all of the elements. Likewise, there might be individual elements that are more strongly associated with better stewardship results. For example, a recently published meta-analysis of 145 articles of stewardship interventions showed that guideline-directed empirical therapy, de-escalation of therapy, and use of a list of restricted antibiotics, and bedside consultation had significant benefits on clinical outcomes, adverse events, and costs [34]. CDC intends to use the data in this survey in combination with other data being reported to NHSN, such as *Clostridium difficile* rates and antibiotic use and resistance data, to better assess the impact of stewardship program elements. Finally, the questions about a designated pharmacist and program leader do not explore specific competencies for stewardship.

The National Action Plan for Combating Antibiotic Resistant Bacteria calls for expanding hospital antibiotic stewardship in US hospitals as part of a comprehensive approach to prevent resistance [35]. The importance of antibiotic stewardship was further highlighted in June of 2015 when the White House hosted a forum on antibiotic stewardship, which brought together key stakeholders to identify gaps and make commitments to improving stewardship in the United States [36]. CDC and many partners are actively taking steps to help hospitals implement robust stewardship programs. For example, in November of 2015 The Joint Commission released proposed accreditation standards for hospital ASPs that are largely based on the CDC core elements [37]. ASPs will be key to improving prescribing to improve patient outcomes and combating resistance, but the presence of such programs alone will not be enough to fully address resistance. To be most effective, we believe antibiotic stewardship can benefit from the model of infection control where a strong program fits within a broader context of measurement, improvement interventions and policy actions. This survey provides important new information on current status and gaps in antibiotic stewardship. CDC plans to continue asking antibiotic stewardship questions on the NHSN Annual Hospital Survey in order to monitor progress towards national implementation of ASPs. Just as important, we identified important gaps in the implementation of hospital ASPs that can now be addressed. CDC is committed to ongoing work with partners to help all hospitals implement effective ASPs and future years of this survey will help monitor progress towards that goal.

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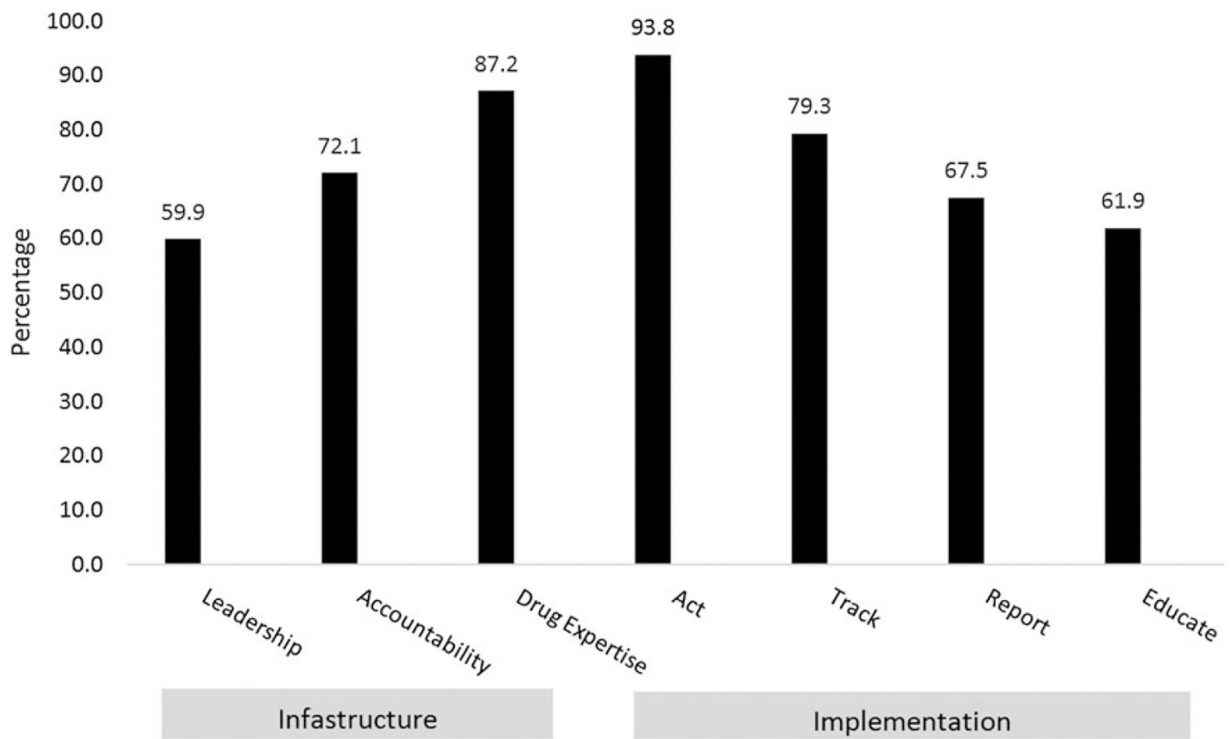


Figure 1. Percentage of US acute care hospitals (n = 4184) reporting implementation of antibiotic stewardship programs by core element, National Healthcare Safety Network, 2014.

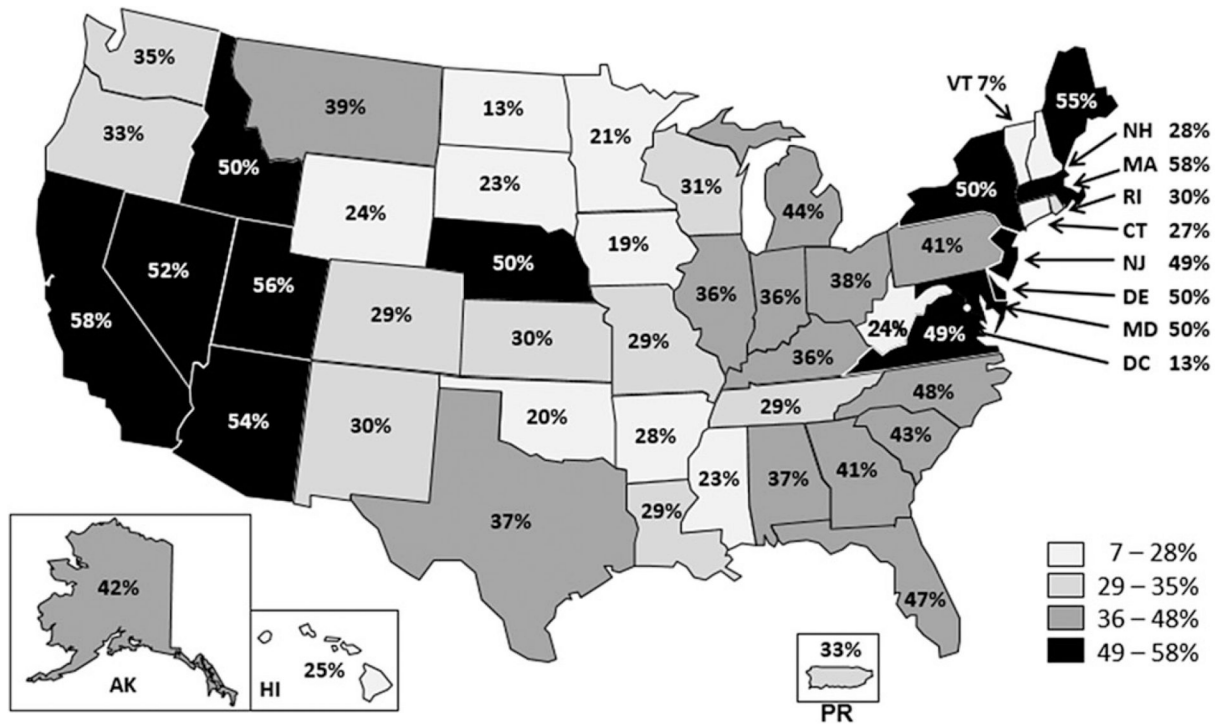


Figure 2. Percentage of US acute care hospitals (n = 4184) implementing all 7 core elements of hospital antibiotic stewardship programs by State, National Healthcare Safety Network, 2014. Note: European and Pacific Armed Forces, American Samoa, Guam, and Virgin Island data are not shown due to 7 or fewer hospital respondents but are included in the overall percentage.

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Table 1. Number and Percentage of US Acute Care Hospitals Reporting Implementation of Core Elements of Hospital Antibiotic Stewardship Programs, National Healthcare Safety Network, 2014

Core Element	NHSN ASP Question ^a	N	%
Infrastructure for antibiotic stewardship			
1. Hospital leadership commitment: Dedicate human, financial, and IT resources		2298	54.9
23	Written statement of support	2508	59.9
26	Salary support	2199	52.6
23, 26	Both	1326	31.7
926		22.1	
2. Program leadership (Accountability): Person responsible for outcomes		3016	72.1
24	Pharmacist	1540	36.8
24	Physician	1258	30.1
24	Other	218	5.2
3648		87.2	
3. Drug expertise: At least 1 pharmacist responsible for improving antibiotic use		2112	50.5
3926		93.8	
Implementation			
4. Act: Performance of at least one prescribing improvement action		3232	77.3
28	Facility-specific treatment recommendations	3100	74.1
31	Audit with feedback	2652	63.4
30	Prior-approval	1105	26.4
27	Requirement to document antibiotic indication	979	23.4
29	Antibiotic time out	3318	79.3
5. Track: Monitor prescribing and antibiotic resistance patterns.		2881	68.9
32	Monitor antibiotic use (consumption)	2203	52.7
28 ^b	Facility-specific treatment recommendations and monitor adherence to facility-specific treatment recommendations	736	17.6
27 ^b	Requirement to document antibiotic indication and monitor adherence to indication documentation policy	2822	67.5
6. Report: Regularly report to staff prescribing and resistance patterns		2478	59.2
33	Feedback to providers on how they can improve prescribing	1861	44.5
32 ^b	Reports on antibiotic use shared with prescribers	2589	61.9
7. Educate about antibiotic resistance and improving prescribing practices			
34	Education provided to clinicians and other relevant staff		

Core Element	N	%
Hospitals reporting all 7 core elements of hospital antibiotic stewardship programs	1642	39.2

N = 4184.

Abbreviations: ASP, Antibiotic Stewardship Practices; IT, information technology; NHSN, National Healthcare Safety Network.

^a ASP questions on the 2014 NHSN Patient Safety Component-Annual Hospital Survey (CDC 57.103). Available at: http://www.cdc.gov/nhsn/forms/mstr/57_103-TOI.pdf.

^b Referenced question was followed by a contingent question asking if adherence to [recommendation/ requirement] has been monitored (27, 28) or if reports on antibiotic use are shared with prescribers (32).

Table 2.

Characteristics of US Acute Care Hospitals Reporting Implementation of All 7 Core Elements of Hospital Antibiotic Stewardship Programs^a, National Healthcare Safety Network, 2014

Characteristic	No. of Respondents (N = 4184)	Meeting All 7 Core Elements N (%)	P Value
Facility type			
Children's hospital	76	38 (50.0)	<.001
General acute care hospital	3385	1450 (42.8)	
Surgical specialty hospital	146	48 (32.8)	
Critical access hospital	577	106 (18.4)	
Bed size			
>200 beds	1320	741 (56.1)	<.001
51–200 beds	1571	611 (38.9)	
0–50 beds	1293	290 (22.4)	
Medical school affiliation			
Major teaching (major, graduate)	1121	602 (53.7)	<.001
Nonteaching/undergraduate	3063	1040 (33.9)	

N = 1642.

^aCenters for Disease Control and Prevention. Core Elements of Hospital Antibiotic Stewardship Programs. Available at: <http://www.cdc.gov/getsmart/healthcare/implementation/core-elements.html>.

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Table 3.

Adjusted Risk Ratios of Hospitals Meeting All 7 Core Elements of Hospital Antibiotic Stewardship, by Infrastructure Leadership and Program Support, National Healthcare Safety Network, 2014

Final Model Elements	Meeting All 7 Core Elements of Hospital Antibiotic Stewardship Risk Ratio (95% CI)	P Value
Written Support (Leadership) vs None	7.2 (6.1, 8.4)	<.0001
Salary support (Leadership) vs None	1.5 (1.4, 1.6)	<.0001
Major/Graduate Teaching status vs Undergraduate/None	1.1 (1.0, 1.1)	.029

Abbreviation: CI, confidence interval.

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