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National Healthcare Safety Network Standardized Antimicrobial Administration Ratios (SAARs): A Progress Report and Risk Modeling Update Using 2017 Data

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Abstract

Background.—The Standardized Antimicrobial Administration Ratio (SAAR) is a risk-adjusted metric of antimicrobial use (AU) developed by the Centers for Disease Control and Prevention (CDC) in 2015 as a tool for hospital antimicrobial stewardship programs (ASPs) to track and compare AU with a national benchmark. In 2018, CDC updated the SAAR by expanding the locations and antimicrobial categories for which SAARs can be calculated and by modeling adult and pediatric locations separately.

Methods.—We identified eligible patient-care locations and defined SAAR antimicrobial categories. Predictive models were developed for eligible adult and pediatric patient-care locations using negative binomial regression applied to nationally aggregated AU data from locations reporting ≥9 months of 2017 data to the National Healthcare Safety Network (NHSN).

Results.—2017 Baseline SAAR models were developed for 7 adult and 8 pediatric SAAR antimicrobial categories using data reported from 2156 adult and 170 pediatric locations across 457 hospitals. The inclusion of step-down units and general hematology-oncology units in adult 2017 baseline SAAR models and the addition of SAARs for narrow-spectrum B-lactam agents, antifungals predominantly used for invasive candidiasis, antibacterial agents posing the highest risk for *Clostridioides difficile* infection, and azithromycin (pediatrics only) expand the role SAARs can play in ASP efforts. Final risk-adjusted models are used to calculate predicted antimicrobial days, the denominator of the SAAR, for 40 SAAR types displayed in NHSN.

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Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Disclaimer. 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.

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Conclusions.—SAARs can be used as a metric to prompt investigation into potential overuse or underuse of antimicrobials and to evaluate the effectiveness of ASP interventions.

Keywords

antimicrobial use; antibiotic stewardship; hospital; risk adjustment; standardized metric

Antimicrobial use (AU) measurement and tracking are essential parts of antimicrobial stewardship programs (ASPs) because AU summary measures enable stewards to evaluate prescribing practices quantitatively, identify opportunities for improvement, and assess the impact of interventions [1-3]. Standardized, risk-adjusted AU measures that take into account differences in patient populations and hospital factors are an advance over crude AU rates and provide a way for ASPs to compare AU at their healthcare facility or system with national benchmarks [4]. In 2015, the Centers for Disease Control and Prevention (CDC) introduced the initial version of the Standardized Antimicrobial Administration Ratio (SAAR), an AU summary measure developed using data submitted to CDC's National Healthcare Safety Network (NHSN) AU Option [5].

The SAAR compares observed antimicrobial days (often called antimicrobial days of therapy [DOT]) to predicted antimicrobial days for specific groups of antimicrobial agents used in specified patient-care locations [6]. SAAR predictive models, developed using nationally aggregated 2014 AU data submitted to NHSN from 350 locations in 77 acute-care hospitals, were the statistical lynchpin of the NHSN AU measure that the National Quality Forum first endorsed in 2015 for use in public health surveillance and quality improvement [7]. Hospital stewards have used the SAAR to identify patient-care locations requiring additional ASP support, to track AU changes after implementation of targeted interventions aimed at improving prescribing practices, and to evaluate how much a particular antibiotic or group of antibiotics contributes to higher than predicted AU [8, 9].

Reporting to NHSN's AU Option has grown rapidly since original predictive models (ie, 2014 baseline SAAR models) were developed in 2015, with over 1600 hospitals reporting 1 or more months as of February 2020. As participation grew, diversity in the types of hospitals and locations reporting also increased, prompting a SAAR models update aimed at reassessing AU risk differences among this larger, more diverse group of hospitals. In 2018, CDC developed a successor version of SAAR models (ie, 2017 baseline SAAR models) using nationally aggregated data reported to the AU Option during calendar year 2017. This article describes 2017 baseline SAAR predictive models and includes comparisons with 2014 baseline SAAR models.

METHODS

SAAR Antimicrobial Agent Categories

We assessed AU reporting from adult and pediatric patient-care locations to the AU Option during 2017 and determined that reported data were sufficient to develop separate SAAR predictive models for adult and pediatric locations. We sought independent, simultaneous consultation from experts to assist with the development of SAAR antimicrobial agent

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categories that represent important stewardship targets. These consultants were SAAR-knowledgeable stewards, including infectious disease physicians and pharmacists and hospital epidemiologists, who represented individual hospital, hospital system, and state-level stewardship perspectives. Discussions with these experts produced strong support for revising SAAR antimicrobial categories as follows: (1) remove the 2014 baseline SAAR group "agents predominantly used for surgical site infection prophylaxis" and re-categorize individual agents into other SAAR categories, (2) add a narrow-spectrum B-lactam agent category, (3) add an antifungal group for agents often used to treat invasive candidiasis, (4) add a SAAR for azithromycin for pediatric locations, (5) add a group for antibiotics posing the highest risk for *Clostridioides difficile* infection (CDI), (6) rename the 2014 baseline "anti-MRSA" SAAR category, and (7) remove agents used to treat extensively antibiotic-resistant infections from the 2014 baseline "broad-spectrum antibacterial agents predominantly used for hospital-onset/MDRO infections" category. Additional detail can be found in Supplementary Table 1.

These changes resulted in 7 adult and 8 pediatric SAAR antimicrobial agent categories: (1) broad-spectrum antibacterial agents predominantly used for hospital-onset infections, (2) broad-spectrum antibacterial agents predominantly used for community-acquired infections, (3) antibacterial agents predominantly used for resistant gram-positive infections (eg, methicillin-resistant *Staphylococcus aureus* [MRSA]), (4) narrow-spectrum B-lactam agents, (5) antibacterial agents posing the highest risk for CDI, (6) azithromycin (pediatrics only), (7) antifungal agents predominantly used for invasive candidiasis, and (8) all antibacterial agents. Details on specific antimicrobial groupings can be found in Appendix E of the NHSN Antimicrobial Use and Resistance Module Protocol [6].

New Method for Calculating the "All Antibacterial Agents" SAAR

While both 2014 and 2017 baselines include an "all antibacterial agents" SAAR category, we updated the methods for calculating that SAAR metric. In the AU Option, 1 patient can contribute a maximum of 1 antimicrobial day for a specific agent on a given calendar day. As a result, for any month and any antibacterial agent, DOT cannot exceed days present. However, when patients are on multiple agents, a common occurrence in locations with high AU rates, summing antimicrobial days across all antibacterial agents to calculate the "all antibacterial agents" SAAR can lead to a pooled antimicrobial days value that exceeds days present. In 2017, for example, 7% of adult SAAR locations had pooled DOT (across all antibiotics) exceeding days present. While valid and correct from an AU-reporting standpoint, DOT values exceeding days present for any SAAR category violates the assumptions of the negative binomial distribution. For that reason, we developed a new method for calculating predicted antimicrobial days for the 2017 baseline "all antibacterial agents" SAAR.

The 2017 calculation uses observed and predicted DOT from all mutually exclusive SAAR antibacterial agent categories (ie, antibacterial agents predominantly used to treat hospital-onset, community-acquired, and resistant gram-positive infections, azithromycin (pediatric locations only), narrow-spectrum B-lactam agents, and complementary agents, which include all antibacterial agents not found in any of the other groups listed). Rates of use for

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complementary agents were assessed using the same modeling techniques as all other SAAR categories (described below). To produce the "all antibacterial agents" SAAR, observed DOT are summed across all mutually exclusive SAAR categories, including the complementary group, and then divided by the sum of predicted DOT for those same categories.

Eligible Patient-care Locations

Original 2014 baseline SAAR predictive models included NHSN-defined adult and pediatric medical, medical-surgical, and surgical intensive care units (ICUs) and wards [10]. We considered AU reporting volume and likely location targets for hospital ASP efforts in decisions about which patient-care locations to include in 2017 baseline SAAR models, which led us to add coverage of adult general hematology-oncology and adult step-down units.

Adult SAAR predictive models were developed using 2017 AU data from adult medical, medical-surgical, and surgical ICUs and wards; adult general hematology-oncology wards; and adult step-down units. Pediatric SAAR predictive models were developed using 2017 AU data from pediatric medical and medical-surgical ICUs and wards and surgical wards. In 2017, no pediatric surgical ICUs reported data to the AU Option; therefore, 2017 baseline SAARs cannot be calculated for pediatric surgical ICUs.

Data Validation

We reviewed AU data reported from eligible locations during 2017 and flagged records if potential errors were identified. Common errors are described in the NHSN Annual AU Option Data Validation Protocol [11]. Facilities with flagged records were contacted to verify data and/or correct potential errors. Flagged records with definite or highly probable errors were excluded from further analyses if uncorrected. Only locations reporting 9 or more months of validated 2017 data were eligible for inclusion in SAAR predictive models.

We used hospital responses to the 2017 NHSN Patient Safety Component Annual Hospital Survey to characterize hospitals that submitted AU data from eligible patient-care locations. Survey data were validated using the same outreach process described above, and if errors could not be corrected or verified and data reported in the previous year's survey were correct, 2016 survey data were used.

Predictive Modeling

We created adult and pediatric datasets by pooling DOT across agents within each SAAR category, then summing days present and pooled DOT across all months. These datasets included an individual record for each SAAR antimicrobial agent category and location.

Antimicrobial use rates were modeled separately for each SAAR agent category, for both adult and pediatric locations, using forward stage-wise negative binomial regression. We assessed associations between AU rates and select location-level and facility-level factors; patient-level data are not reported to the AU Option. Factors assessed in predictive models were (1) reported by all hospitals and (2) thought by consulted stewardship experts to

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potentially explain differences in AU rates. Candidate risk factors included location type, facility type facility teaching status, hospital beds (number), ICU beds (number and as a percentage of all beds), and average hospital stay (annual hospital patient days divided by annual hospital admissions). All continuous variables were additionally assessed as deciles, quintiles, quartiles, tertiles, and at the median. Covariates were assessed for multicollinearity.

To maximize objectivity during model development, 2 analysts worked independently to develop each of the 15 SAAR predictive models. Once each analyst selected a best model, results were compared, and any differences identified were discussed among an internal CDC team of statisticians and analysts until a consensus was reached to achieve a final SAAR predictive model. Additionally, final SAAR predictive models were discussed with CDC subject matter experts to ensure risk adjustments were clinically sound. All models were evaluated using Akaike and Bayesian information criteria and Wald and likelihood ratio chi-square tests. Sample sizes of model strata were assessed and SAAR models resulting in more than 30% of strata with only 1 location were reconsidered to promote adequate data support and improve precision of AU rates that support improved model estimates. Final SAAR predictive models were tested for influential observations—which were excluded from the model if identified—and validated using bootstrap resampling methods. All analyses were conducted using SAS version 9.4 software (SAS Institute, Inc, Cary, NC).

RESULTS

Adult SAAR predictive models were developed using 2017 AU Option data from 2156 adult patient-care locations from 449 acute-care hospitals spanning 49 states/districts/territories (Table 1). Pediatric SAAR predictive models were developed using 2017 AU Option data from 170 pediatric patient-care locations from 106 acute-care hospitals across 29 states (Table 1). Hospitals varied in size, teaching status, and geographical location (Table 1). The 449 hospitals in the adult referent population included all hospitals in the pediatric referent population, except for 6 children's hospitals and 2 women's and children's hospitals, which only reported pediatric data. In total, 457 unique hospitals contributed data to 2017 baseline SAAR models (Table 2).

As of February 2020, 1511 hospitals reported 1 or more months of data to the AU Option from a SAAR-eligible location (AU ever-reporters) and 4668 hospitals actively participating in NHSN had 1 or more SAAR-eligible location (all-reporters) (Table 2). AU ever-reporters are similar to hospitals contributing data to SAAR models in their size and teaching status (median bed size, 164 vs 177; percentage teaching, any level, 71.7% vs 71.3%) (Table 2). There is a greater proportion of Veterans Affairs (VA) facilities among the SAAR referent group (16.4%) compared with AU ever-reporters (7.2%) and all-reporters (2.5%) and a greater proportion of critical access hospitals among all-reporters (19.1%) compared with AU ever-reporters (8.9%) and the SAAR referent group (6.1%). Compared with the SAAR referent group and AU ever-reporters, all-reporters are more likely to be small (≤50 beds: 36.0% of all-reporters vs 15.3% of SAAR referent group and 19.1% of AU ever-reporters), and nonteaching (44.9% of all-reporters vs 28.7%, 28.3% of referent group and AU ever-

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reporters, respectively) with fewer ICU beds (median, 10 vs 20 and 18, respectively) (Table 2).

Variation in the distribution of SAAR values differs by location type and SAAR agent category (Table 3). SAAR categories with higher rates of pooled AU, such as the "all antibacterial agents" category, generally had narrower SAAR distributions than categories with lower rates of pooled use, such as the "antifungals predominantly used for invasive candidiasis" group.

All 2017 baseline SAAR predictive models, except for the pediatric SAAR for complementary agents, risk-adjust for location type, and all models risk-adjust for at least 1 facility-level factor, except for the pediatric model for agents used for resistant gram-positive infections (Table 4). Model details, including parameter estimates, standard errors, Wald 95% confidence limits, chi-square values, and *P* values for intercepts and risk adjustments can be found in Supplementary Table 2.

DISCUSSION

The SAAR provides NHSN AU Option users with the quantitative means to compare their AU with a national baseline for a specified set of patient-care locations and antimicrobial agent categories. The larger sample size used to develop 2017 baseline SAAR models, compared with 2014 baseline models, allowed for adult and pediatric locations to be modeled separately, new location types to be included, and more precise estimates of risk to be made.

The new "antibacterial agents posing the highest risk for CDI" SAAR category includes high-risk broad-spectrum agents— third- and fourth-generation cephalosporins, fluoroquinolones, and clindamycin—and enables hospitals to compare use of these agents in their facility with a national benchmark. Although other antibiotics increase the risk for CDI, agents included in this SAAR category are considered the primary targets for most stewardship interventions addressing CDI. Most hospitals that report AU data to NHSN also report CDI laboratory-identified events, which provides opportunities for hospitals with relatively high CDI rates, as measured by standardized infection ratios, to assess these 2 standardized metrics to investigate whether overuse of high-risk agents could be a contributing factor to high CDI rates.

Antifungals are not a traditional ASP focus area. *Candida* species, however, are important healthcare-associated pathogens and recent reports suggest an increase in antifungal resistance among various *Candida* species, including *Candida auris*, particularly to echinocandins [12, 13]. The addition of a SAAR category for antifungals predominantly used for invasive candidiasis enables individual hospital comparisons to a national benchmark for fluconazole and echinocandin use, which, in turn, contributes to efforts aimed at combatting antifungal resistance.

The SAAR can be used both for internal and external benchmarking purposes—allowing a hospital to compare AU with itself over time and to compare AU with a national benchmark. The SAAR can be a valuable indicator to help hospitals identify patient-care locations or

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groups of antimicrobials that require more robust antibiotic stewardship, and outlying SAAR values are intended to prompt further investigation into potential antimicrobial overuse or underuse. Given this, a SAAR value does not necessarily measure appropriateness and should be used in combination with other information to make clinical decisions regarding antimicrobial prescribing. As use of the SAAR by ASPs increases, we expect reports from users will provide new insights into the measure's practical value, including comparisons with DOT as quantitative guides for improving prescribing practices.

Although some variability in AU is explained by hospital and location factors, patient-level data could improve SAAR models' predictive abilities. The CDC, working with external partners, is investigating whether additional factors, such as patient-level characteristics, improve SAAR models sufficiently to justify additional data collection. Diagnosis-related group, presence of infection on admission, and unit type were strong AU predictors across inpatient and outpatient settings (excluding emergency department and newborn locations) in 1 study [14]. The CDC will continue to investigate potential sources and methods for collecting additional data—for example, indications for AU, case-mix index, and infectious disease burden and rates of antimicrobial resistance (AR) obtained from the NHSN AR Option.

Since SAAR risk adjustments are limited to location- and facility-level characteristics, use of these factors in SAAR models places a premium on hospitals' correct reporting of those characteristics. The CDC encourages hospitals to validate their location mappings and survey data. Even with correct location mapping, patient mix within any location type, such as within general hematology-oncology units, may differ across hospitals and across time. In 2017 baseline SAAR models, large sample size helps dampen the effect such variation could have on model estimates and CDC hopes this limitation is further mitigated in future iterations of the SAAR as additional distinguishing information are collected via the AU Option and/or the annual hospital survey and incorporated into predictive models.

Seasonality was not assessed as a potential risk factor for AU when developing 2017 baseline SAAR models. To properly investigate the association between seasonality and inpatient antimicrobial prescribing, a minimum of 24 consecutive months of AU data are needed from a large number of hospitals. The sample size of hospitals reporting consistently before 2017 was too low to investigate seasonality. As reporting to the AU Option increases, CDC plans to reassess seasonality and inpatient antibiotic prescribing rates.

As more hospitals report to the AU Option, diversity in facility and location characteristics increases as well. Currently, the percentage of small and critical access hospitals represented in AU ever-reporters is smaller than the percentage represented among all NHSN hospitals with SAAR-eligible locations. Whether AU risk adjustments would differ if AU ever-reporter facility characteristics were proportional to the larger group of NHSN hospitals cannot be determined without AU data from facilities that have not yet submitted those data.

The CDC continues to assess whether sample sizes are large enough for new location types to be considered in SAAR models. In 2019, CDC developed SAARs for neonatal locations and is exploring the idea of developing SAARs for emergency departments. We encourage

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hospitals to report AU data for all eligible patient-care locations, so new location types can be considered for inclusion in SAAR models and the precision of model estimates is maximized over time.

Over 1600 acute-care hospitals have voluntarily submitted data to the AU Option, which demonstrates the value that hospitals and ASPs place on electronic AU surveillance and the SAAR. In NHSN, users can calculate 2014 baseline SAARs for data reported in 2014–2018 and 2017 baseline SAARs for data reported in 2017 or later. Because SAAR agent categories and referent populations differ between baselines, 2014 baseline SAARs cannot be directly compared with 2017 baseline SAARs.

Sample size and diversity of hospital characteristics represented in 2017 baseline SAARs enabled marked improvements over original 2014 baseline SAAR models, and location- and facility-level factors account for a large portion of variation in AU rates. The 2017 baseline SAARs provide summary results that hospitals, health systems, and states can use in ASP efforts to quantify and track AU, compare their AU with a national baseline, initiate investigations into potential overuse or underuse of antimicrobials, and monitor and evaluate the effect of ASP interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Characteristics of Hospitals and Patient-Care Locations Reporting at Least 9 Months of Validated Data to the NHSN Antimicrobial Use Option in Calendar Year 2017 From SAAR-Eligible Locations

	Hospital-level, No. Hospitals (%)		Location-level, No. Locations (%)	
	Adult (n = 449)	**Pediatric (n = 106)**	**Adult (n = 2156)**	**Pediatric (n = 170)**
Facility type				
General acute care	320 (71.3)	91 (85.8)	1723 (79.9)	130 (76.5)
Veterans Affairs	75 (16.7)	0 (0.0)	325 (15.1)	0 (0.0)
Critical access	28 (6.2)	0 (0.0)	39 (1.8)	0 (0.0)
Military	19 (4.2)	5 (4.7)	57 (2.6)	8 (4.7)
Children's	0 (0.0)	6 (5.7)	0 (0.0)	23 (13.5)
Women's and children's	2 (0.5)	4 (3.8)	3 (0.1)	9 (5.3)
Surgical	3 (0.7)	0 (0.0)	5 (0.2)	0 (0.0)
Oncology	1 (0.2)	0 (0.0)	2 (0.1)	0 (0.0)
Women's	1 (0.2)	0 (0.0)	2 (0.1)	0 (0.0)
Teaching status[a]				
None	131 (29.2)	13 (12.3)	436 (20.2)	14 (8.2)
Undergraduate	71 (15.8)	19 (17.9)	281 (13.0)	24 (14.1)
Graduate	102 (22.7)	27 (25.5)	530 (24.6)	37 (21.8)
Major	145 (32.3)	47 (44.3)	909 (42.2)	95 (55.9)
Other characteristics, median (IQR)				
Total number of beds	176 (86, 307)	312 (228, 418)	258 (148, 406)	324 (250, 455)
Number of ICU beds	20 (10, 41)	53 (32, 82)	33 (17, 62)	72 (38, 106)
Percentage ICU beds[b]	13.0 (8.7, 17.6)	16.6 (13.0, 22.6)	14.5 (10.2, 18.4)	18.6 (15.2, 24.7)
Ave. length of stay[c]	4.3 (3.4, 5.0)	4.5 (3.8, 5.1)	4.6 (3.8, 5.3)	4.6 (3.9, 5.3)
Location type				
Medical ICU	125 (27.8)[d]	4 (3.8)[d]	131 (6.1)	4 (2.4)
Medical-surgical ICU	279 (62.1)[d]	46 (43.4)[d]	318 (14.7)	46 (27.1)
Surgical ICU	70 (15.6)[d]	…	73 (3.4)	…

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	Hospital-level, No. Hospitals (%)		Location-level, No. Locations (%)	
	Adult (n = 449)	**Pediatric (n = 106)**	**Adult (n = 2156)**	**Pediatric (n = 170)**
Medical ward	250 (55.7)[d]	19 (17.9)[d]	472 (21.9)	21 (12.4)
Medical-surgical ward	295 (65.7)[d]	83 (78.3)[d]	554 (25.7)	94 (55.3)
Surgical ward	185 (41.2)[d]	5 (4.7)[d]	247 (11.5)	5 (2.9)
General hematology-oncology ward	58 (12.9)[d]	…	68 (3.2)	…
Step-down unit	197 (43.9)[d]	…	293 (13.6)	…

Facility characteristics are self-reported through NHSN's annual hospital survey.

Abbreviations: Ave., average; ICU, intensive care unit; IQR, interquartile range; NHSN, National Healthcare Safety Network; SAAR, Standardized Antimicrobial Administration Ratio.

[a]Undergraduate teaching: facility has a program for medical/nursing students only. Graduate teaching: facility has a program for postgraduate medical training (ie, residency and/or fellowships). Major teaching: facility has a program for medical students and postgraduate medical training.

[b]Calculated as number of ICU beds divided by total number of beds, multiplied by 100.

[c]Calculated as annual patient days divided by annual admissions.

[d]Number and percentage of hospitals contributing antimicrobial use data for each patient-care location type. For example, 125 hospitals among the 449 represented in the adult referent group, or 27.8%, reported data from a medical ICU for ≥9 months in 2017

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Table 2.

Comparison of Hospitals Represented in 2017 Baseline Adult and Pediatric SAAR Referent Populations, Hospitals Reporting at Least 1 Month of Data to the NHSN Antimicrobial Use Option From a SAAR-Eligible Location, and Hospitals Enrolled in NHSN With at Least 1 Active SAAR-Eligible Location, as of February 2020

	Hospitals in Adult and/or Pediatric SAAR Referent Population[a] (n = 457)	Hospitals Reporting ≥1 Month of AU Option Data From SAAR-Eligible Location[b] (n = 1511)	Hospitals Enrolled in NHSN With ≥1 Active SAAR-Eligible Location[c] (n = 4668)
Facility type, no. hospitals (%)			
General acute care	320 (70.0)	1172 (77.6)	3378 (72.4)
Veterans Affairs	75 (16.4)	109 (7.2)	117 (2.5)
Critical access	28 (6.1)	134 (8.9)	893 (19.1)
Military	19 (4.2)	46 (3.0)	49 (1.1)
Children's	6 (1.3)	27 (1.8)	81 (1.7)
Women's and children's	4 (0.9)	7 (0.5)	15 (0.3)
Surgical	3 (0.7)	9 (0.6)	111 (2.4)
Oncology	1 (0.2)	3 (0.2)	18 (0.4)
Women's	1 (0.2)	4 (0.3)	6 (0.1)
Teaching status,[d] no. hospitals (%)			
None	131 (28.7)	428 (28.3)	2098 (44.9)
Undergraduate	71 (15.5)	250 (16.5)	742 (15.9)
Graduate	104 (22.8)	258 (17.1)	647 (13.9)
Major	151 (33.0)	575 (38.1)	1181 (25.3)
Hospital bed size, no. hospitals (%)			
1–50 beds	70 (15.3)	288 (19.1)	1679 (36.0)
51–200 beds	180 (39.4)	579 (38.3)	1628 (34.9)
201–500 beds	178 (38.9)	507 (33.6)	1119 (24.0)
>500 beds	29 (6.3)	137 (9.1)	242 (5.2)
Other characteristics, median (IQR)			
Total number of beds	177 (86, 305)	164 (73, 306)	99 (28, 226)
Number of ICU beds	20 (10, 42)	18 (8, 46)	10 (2, 29)
% of ICU beds among all beds[e]	13.2 (8.9, 179)	12.7 (8.0, 18.1)	10.5 (4.6, 16.0)

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	Hospitals in Adult and/or Pediatric SAAR Referent Population[a] (n = 457)	Hospitals Reporting ≥1 Month of AU Option Data From SAAR-Eligible Location[b] (n = 1511)	Hospitals Enrolled in NHSN With ≥1 Active SAAR-Eligible Location[c] (n = 4668)
Average hospital length of stay[f]	4.3 (3.4, 5.0)	4.1 (3.3, 5.0)	4.0 (3.1,4.9)

Abbreviations: AU, antimicrobial use; ICU, intensive care unit; IQR, interquartile range; NHSN, National Healthcare Safety Network; SAAR, Standardized Antimicrobial Administration Ratio.

[a]Hospitals included in adult and/or pediatric referent populations. All hospitals comprising the pediatric SAAR referent group also contribute to the adult SAAR referent group, except for 6 children's hospitals and 2 women's and children's hospitals, which report from pediatric SAAR locations but not adult SAAR locations.

[b]Hospitals ever-reporting at least 1 month of data to the AU Option from at least 1 SAAR-eligible location.

[c]NHSN facilities eligible to participate in the AU Option and eligible to receive 2017 baseline SAARs. To be included, hospitals must meet the following criteria: have at least 1 active SAAR-eligible location mapped to their facility, have an NHSN annual hospital survey completed within the past 2 years, be 1 of the 9 facility types represented in our 2017 baseline referent population.

[d]Undergraduate teaching: facility has a program for medical/nursing students only. Graduate teaching: facility has a program for postgraduate medical training (ie, residency and/or fellowships). Major teaching: facility has a program for medical students and postgraduate medical training.

[e]Calculated as total number of ICU beds divided by total number of beds, multiplied by 100.

[f]Calculated as total number of annual patient days divided by total number of annual admissions.

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Table 3.

Distribution of Adult and Pediatric 2017 Baseline SAARs, by SAAR Agent Category and Location Type

			Percentile					
	SAAR Location Type	**No.**[a]	**10th**	**25th**	**50th**	**75th**	**90th**	**Quartile Coefficient of Dispersion**
Adult SAAR agent category								
All antibacterial agents	All adult SAAR locations	2156	0.71	0.86	1.00	1.15	1.28	0.14
BSHO antibacterial agents	Med, med-surg, surg ICUs	522	0.59	0.79	0.99	1.19	1.41	0.20
	Med, med-surg, surg wards	1273	0.43	0.71	1.00	1.26	1.56	0.28
	Step-down units	293	0.43	0.64	0.97	1.29	1.60	0.34
	General hem-onc wards	68	0.55	0.74	0.90	1.23	1.58	0.25
BSCA antibacterial agents	Med, med-surg, surg ICUs	522	0.64	0.79	0.96	1.18	1.42	0.20
	Med, med-surg, surg wards	1273	0.58	0.78	1.00	1.21	1.41	0.22
	Step-down units	293	0.52	0.72	1.02	1.24	1.45	0.27
	General hem-onc wards	68	0.65	0.83	0.97	1.15	1.41	0.17
GramPos antibacterial agents	Med, med-surg, surg ICUs	522	0.61	0.78	0.96	1.20	1.42	0.21
	Med, med-surg, surg wards	1273	0.52	0.72	0.97	1.23	1.50	0.26
	Step-down units	293	0.50	0.73	0.97	1.30	1.56	0.28
	General hem-onc wards	68	0.63	0.77	1.03	1.28	1.73	0.25
NSBL antibacterial agents	Med, med-surg, surg ICUs	522	0.43	0.59	0.84	1.19	1.57	0.34
	Med, med-surg, surg wards	1273	0.47	0.64	0.89	1.28	1.71	0.33
	Step-down units	293	0.49	0.63	0.87	1.14	1.66	0.29
	General hem-onc wards	68	0.38	0.59	0.96	1.32	1.61	0.38
Antifungal[b] agents	Med, med-surg, surg ICUs	521[c]	0.33	0.55	0.86	1.33	1.80	0.41
	Med, med-surg, surg wards	1273	0.31	0.54	0.89	1.28	1.79	0.40
	Step-down units	293	0.26	0.48	0.86	1.30	1.96	0.46
	General hem-onc wards	68	0.24	0.39	0.65	1.05	1.85	0.45
CDI agents	Med, med-surg, surg ICUs	522	0.63	0.77	0.95	1.16	1.37	0.20
	Med, med-surg, surg wards	1273	0.59	0.78	1.01	1.21	1.42	0.22
	Step-down units	293	0.55	0.75	1.01	1.22	1.42	0.24
	General hem-onc wards	68	0.68	0.76	0.93	1.17	1.81	0.21
Pediatric SAAR agent category								

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	SAAR Location Type	No.[a]	Percentile					Quartile Coefficient of Dispersion
			10th	25th	50th	75th	90th	
All antibacterial agents	All pediatric SAAR locations	170	0.62	0.80	0.98	1.20	1.40	0.20
BSHO antibacterial agents	Med, med-surg ICUs	50	0.38	0.55	0.90	1.37	1.82	0.43
	Med, med-surg, surg wards	120	0.27	0.44	0.84	1.30	2.13	0.49
BSCA antibacterial agents	Med, med-surg ICUs	50	0.65	0.85	0.95	1.15	1.46	0.15
	Med, med-surg, surg wards	120	0.50	0.74	0.93	1.26	1.51	0.26
GramPos antibacterial agents	Med, med-surg ICUs	50	0.48	0.66	0.98	1.26	1.60	0.31
	Med, med-surg, surg wards	120	0.36	0.55	0.89	1.38	1.83	0.43
NSBL antibacterial agents	Med, med-surg ICUs	50	0.54	0.71	0.84	1.09	1.67	0.21
	Med, med-surg, surg wards	120	0.59	0.76	0.98	1.23	1.53	0.24
Azithromycin	Med, med-surg ICUs	50	0.31	0.43	0.81	1.45	2.06	0.55
	Med, med-surg, surg wards	120	0.24	0.46	0.78	1.31	1.85	0.48
Antifungal[b] agents	Med, med-surg ICUs	50	0.06	0.27	0.69	1.37	2.40	0.67
	Med, med-surg, surg wards	118[d]	0.00	0.22	0.75	1.28	2.50	0.70
CDI agents	Med, med-surg ICUs	50	0.61	0.77	0.95	1.23	1.49	0.23
	Med, med-surg, surg wards	120	0.46	0.64	0.94	1.28	1.66	0.33

Abbreviations: BSCA, broad-spectrum antibacterial agents predominantly used for community-acquired infections; BSHO, broad-spectrum antibacterial agents predominantly used for hospital-onset infections; CDI, antibacterial agents posing highest risk for *Clostridioides difficile* infection; GramPos, antibacterial agents predominantly used for resistant gram-positive infections; hem-onc, hematology-oncology; ICU, intensive care unit; Med, medical; med-surg, medical-surgical; NSBL, narrow-spectrum B-lactam; SAAR, Standardized Antimicrobial Administration Ratio; surg, surgical.

[a]Number of patient-care locations; numerator and denominator data are pooled across all months reported by each location for 2017 so each location has 1 SAAR value calculated for the year and 1 data point contributing to SAAR distributions.

[b]Antifungals predominantly used for invasive candidiasis.

[c]One influential observation excluded from adult antifungal SAAR model.

[d]One influential observation excluded from pediatric antifungal SAAR model and 1 ward with predicted antimicrobial days <1.0 excluded from distribution.

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Table 4.

Risk-adjustment Summary for 2017 Baseline Adult and Pediatric SAAR Models

Risk-adjustment Factor	BSHO	BSCA	GramPos	NSBL	Azithro	Fungal[a]	CDI	Complemen[b]
Adult SAAR models								
Location type	✓	✓	✓	✓	n/a	✓	✓	✓
Facility type	✓	✓	✓		n/a	✓	✓	✓
Teaching status	✓				n/a		✓	
Number of hospital beds		✓	✓	✓	n/a	✓	✓	
Number of ICU beds	✓				n/a	✓	✓	
Percent ICU beds		✓		✓	n/a			
Average length of stay	✓	✓	✓	✓	n/a	✓	✓	✓
Pediatric SAAR models								
Location type		✓	✓		✓	✓	✓	
Facility type		✓					✓	
Location type/facility type	✓			✓				
Teaching status								
Number of hospital beds		✓		✓	✓		✓	✓
Number of ICU beds								
Percentage of ICU beds	✓					✓		✓
Average length of stay							✓	✓

Abbreviations: Azithro, azithromycin; BSCA, broad-spectrum antibacterial agents predominantly used for community-acquired infections; BSHO, broad-spectrum antibacterial agents predominantly used for hospital-onset infections; CDI, antibacterial agents posing highest risk for *Clostridioides difficile* infection; GramPos, antibacterial agents predominantly used for resistant gram-positive infections; ICU, intensive care unit; n/a, not applicable; NSBL, narrow-spectrum B-lactam; SAAR, Standardized Antimicrobial Administration Ratio.

[a]Antifungals predominantly used for invasive candidiasis.

[b]Complementary antibacterial agents not found in other mutually exclusive SAAR categories.