THE NHSN STANDARDIZED ANTIMICROBIAL ADMINISTRATION RATIO (SAAR)

A Guide to the SAAR

NHSN·AU

NATIONAL HEALTHCARE SAFETY NETWORK
ANTIMICROBIAL USE OPTION

Centers for Disease Control and Prevention
National Center for Emerging and Zoonotic Infectious Diseases

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Intended Audience

- The Standardized Antimicrobial Administration Ratio (SAAR) is a risk-adjusted summary measure of antimicrobial use. The SAAR is available to acute care hospitals participating in the National Healthcare Safety Network (NHSN) Antimicrobial Use (AU) Option.
- Hospitals can use the SAAR to track AU, compare their AU to a national benchmark, and assess the impact of interventions aimed at improving prescribing practices.
- This document serves as guidance for hospital antimicrobial stewards and individuals at health departments or health systems interested in monitoring AU and understanding what the SAAR is, how NHSN develops SAARs, and how they can use the SAAR for antimicrobial stewardship.

Overview of the Standardized Antimicrobial Administration Ratio (SAAR)

What is the SAAR?

The Standardized Antimicrobial Administration Ratio (SAAR) is a summary measure of antimicrobial use (AU) available to acute care hospitals participating in the AU Option of the National Healthcare Safety Network (NHSN) Antimicrobial Use and Resistance (AUR) Module. NHSN originally developed the metric in 2015, using AU data reported in 2014, as a quantitative tool for hospitals and health systems to make comparisons of AU within and across facilities to help guide antimicrobial stewardship efforts. The SAAR compares observed antimicrobial days to predicted antimicrobial days for groups of antimicrobial agents used in specified patient care locations. A SAAR greater than 1.0 indicates more antimicrobial days were observed than predicted; conversely, a SAAR less than 1.0 indicates fewer antimicrobial days were observed than predicted.

How does NHSN calculate the SAAR?

NHSN calculates the SAAR by dividing the number of observed antimicrobial days (also called antimicrobial days of therapy [DOT]) by the number of predicted antimicrobial days. NHSN calculates predicted antimicrobial days by risk-adjusting for location- and facility-level factors found to be statistically significantly associated with differences in AU rates among the SAAR referent population. The referent population comes from nationally aggregated patient care location-level AU data reported to NHSN during the baseline time period.

$$SAAR = \frac{\textbf{Observed}\ antimicrobial\ days\ of\ therapy}{\textbf{Predicted}\ antimicrobial\ days\ of\ therapy}$$

- Observed AU: antimicrobial days reported to the AU Option by a facility for a SAAR antimicrobial agent category used in a specified patient care location or group of locations (SAAR-eligible locations).
- Predicted AU: antimicrobial days predicted for that same antimicrobial agent category used in the same location or group of locations. NHSN calculates predicted antimicrobial days using risk-adjusted SAAR predictive models.

Why risk-adjust?

A rate of antimicrobial use, defined in the AU Option as antimicrobial days divided by 1,000 days present, is the underlying metric on which SAARs are based. Many factors—patient-level, location-level, facility-level—may affect rates of AU in a given hospital or unit. To make fair comparisons of AU rates across entities, these factors must be considered (adjusted for). Unadjusted AU rates do not account for these differences and using them to make comparisons may result in invalid conclusions.

To make a fair comparison of AU across entities, we must know how the entities differ and whether any of those differences are associated with higher or lower AU rates. There are many factors accounting for differences in AU across patient care locations and facilities. Ideally, we could take all predictive factors into consideration when developing NHSN metrics like the SAAR, but there is a trade-off between the added burden on hospitals to collect such data and the potential improvement gained in the models' predictive abilities. At present, only patient care location type reported to the AU Option and select facility-level data reported in the NHSN Patient Safety Component Annual Hospital Survey are available for risk-adjustment in SAAR models. While illness severity and case-mix may affect a facility's AU rates, we must rely on location- and facility-level factors to serve as proxies for such factors because the AU Option does not collect patient-level information.

Why not use stratified rates to make AU comparisons?

NHSN has the ability to calculate national pooled mean AU rates by dividing total pooled antimicrobial days by total pooled days present and facilities could use this "national average" rate to make comparisons. However, pooled rates do not reflect differences in risk between populations and, therefore, lose comparability over time and across entities. One solution is stratified rates, which are pooled mean rates calculated separately for different types of locations or facilities. This method, however, only allows for rate comparisons within strata. The SAAR, on the other hand, allows users to summarize data by more than a single stratum by adjusting for AU rate differences between strata. Additionally, SAARs allow for comparisons to the national benchmark from a baseline time period and hospitals can use them to measure progress from a single time point. In other words, standardization permits comparisons between antimicrobial days experienced by a facility, group, or state to antimicrobial days predicted based on national data.

SAAR Model Development

Defining the referent population

A SAAR referent population, which NHSN uses to develop SAAR predictive models, is AU data aggregated from select patient care locations reporting to the AU Option for a particular year, specifically the baseline year. NHSN assesses reporting volume for each location type to ensure sample size is large enough for inclusion in SAAR models. Associations between AU rates and risk factors identified in the referent population are later applied to the larger universe of SAAR-eligible locations and if these associations were based on a small number of records, they may not be representative of all NHSN locations and facilities. The greater the sample size NHSN includes in SAAR predictive models, the more precise the SAAR estimates, or adjustments. SAAR referent populations include location types that are important to hospital antimicrobial stewardship, have adequate reporting volume during the baseline year, and report for at least nine months of the baseline year.

2017 baseline adult SAAR-eligible patient care locations:

- Adult medical intensive care units (ICUs) and wards
- Adult medical-surgical ICUs and wards
- Adult surgical ICUs and wards
- Adult step down units
- Adult general hematology-oncology wards

2017 baseline pediatric SAAR-eligible patient care locations:

- Pediatric medical ICUs and wards
- Pediatric medical-surgical ICUs and wards
- Pediatric surgical wards

2018 baseline neonatal SAAR-eligible patient care locations:

- Level II neonatal step down nurseries
- Level II/III neonatal intensive care units (NICUs)
- Level III NICUs
- Level IV NICUs*

*Prior to December 2019, facilities reported Level IV NICUs as Level III NICUs in NHSN. Beginning December 2019, NHSN created two distinct location types for Level III and Level IV NICUs, allowing facilities to report data for each separately.

What is a "baseline"?

In the context of the SAAR, the term "baseline" refers to the calendar year of the NHSN data used to develop SAAR models. For 2017 baseline adult and pediatric SAARs, NHSN developed predictive models using AU data reported from eligible adult and pediatric locations during calendar year 2017. For 2018 baseline neonatal SAARs, NHSN developed predictive models using AU data reported from eligible neonatal locations during calendar year 2018.

The original 2014 baseline SAAR models included select adult and pediatric locations reporting 2014 AU data. Users cannot compare 2014 and 2017 baseline SAARs because they include different baseline populations, risk adjustments, and SAAR agent categories.

NHSN develops new models every few years, a process NHSN refers to as "re-baselining." There is no set frequency for which this occurs, however, there are certain factors that inform NHSN's decision to develop updated models. Each year, NHSN adds and removes reportable AU Option antimicrobial agents. When excluded agents are no longer relevant in SAARs or when new agents are important enough for inclusion in SAARs, NHSN may decide to develop new models that take these changes in agents into account. NHSN may also develop new models to incorporate additional patient care locations, as completed in 2017 to add adult step down units and general hematology-oncology wards. In addition, as reporting to the AU Option increases over time, there may be shifts in the makeup of facilities reporting, and NHSN may decide to develop new models to ensure SAARs properly capture risk of AU among this larger subset of hospitals.

Defining SAAR antimicrobial agent categories

NHSN designed SAAR antimicrobial agent categories to enable hospitals and other entities to assess progress toward antimicrobial stewardship goals. These categories are generally mutually exclusive, meaning individual antimicrobials are found in only one SAAR category, except for the All antibacterial agents SAAR and the Antibacterial agents posing highest risk for *Clostridioides difficile* infection (CDI) SAAR, which include antimicrobials found in other SAAR categories. CDC worked with experts in antimicrobial stewardship, most of whom were familiar with the SAAR, to develop categories and decide which antimicrobials to include in each. Even though SAAR agent category names may be the same across baselines, the antimicrobials in those categories may differ. There are seven 2017 baseline adult SAAR antimicrobial agent categories, eight 2017 baseline pediatric SAAR categories, and seven 2018 baseline neonatal SAAR categories.

2017 baseline adult SAAR antimicrobial agent categories:

- Broad-spectrum antibacterial agents predominantly used for hospital-onset infections
- Broad-spectrum antibacterial agents predominantly used for community-acquired infections
- Antibacterial agents predominantly used for resistant Gram-positive infections (e.g., methicillin-resistant *Staphylococcus aureus* [MRSA])
- Narrow-spectrum beta-lactam agents
- Antifungal agents predominantly used for invasive candidiasis
- Antibacterial agents posing highest risk for CDI
- All antibacterial agents

2017 baseline pediatric SAAR antimicrobial agent categories:

- Broad-spectrum antibacterial agents predominantly used for hospital-onset infections
- Broad-spectrum antibacterial agents predominantly used for community-acquired infections
- Antibacterial agents predominantly used for resistant Gram-positive infections (e.g., MRSA)
- Narrow-spectrum beta-lactam agents
- Azithromycin
- Antifungal agents predominantly used for invasive candidiasis
- Antibacterial agents posing highest risk for CDI
- All antibacterial agents

2018 baseline neonatal SAAR antimicrobial agent categories:

- Ampicillin predominantly used for treatment of early-onset sepsis
- Aminoglycosides predominantly used for treatment of early-onset and late-onset sepsis
- Vancomycin predominantly used for treatment of late-onset sepsis
- 3rd generation cephalosporins
- Broad-spectrum antibacterial agents predominantly used for hospital-onset infections
- Fluconazole predominantly used for candidiasis (NICUs only)
- All antibacterial agents

You can find more information on SAAR agent categories in Appendix E of the NHSN AUR Module Protocol (https://www.cdc.gov/nhsn/PDFs/pscManual/11pscAURcurrent.pdf). You can find more information about the historical 2014 baseline adult and pediatric SAARs here: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/aur/saar-2014-508.pdf.

The SAAR predictive model development process

After defining referent populations and SAAR agent categories, NHSN identified candidate location- and facility-level factors to consider as risk-adjustments in SAAR predictive models by: 1) listing factors reported to NHSN by *all* hospitals, 2) consulting stewardship experts to identify which of these available and uniformly reported factors could explain differences in AU rates. Facility-level data are collected through the NHSN Patient Safety Component Annual Hospital Survey.

Factors assessed in 2017 baseline adult and pediatric SAAR predictive models:

- Patient care location type
- Facility type
- Hospital teaching status
- Hospital bed-size
- Number of ICU beds
- Percentage of ICU beds, calculated as (ICU beds/total hospital beds) x 100
- Average facility length of stay (LOS), calculated as annual patient days/annual admissions

Factors assessed in 2018 baseline neonatal SAAR predictive models:

- Patient care location type
- Facility type
- Hospital teaching status
- Hospital bed-size
- Annual number of neonatal admissions[a]
- Annual number of inborn[b] neonatal admissions
- Annual number of outborn[c] neonatal admissions
- Percentage of outborn admissions, calculated as (outborn admissions/neonatal admissions) x 100
- Levels of neonatal care provided by the facility[d]
- Whether a facility accepts neonates as transfers for various specified complex procedures[e]

- Number and percentage of neonatal admissions with birthweight in the following five categories: a) ≤750g, b) 751-1000g, c) 1001-1500g, d) 1501-2500g, e) >2500g

[a]From Annual Hospital Survey question: "Excluding Level I units (well newborn nurseries), record the number of neonatal admissions to Special Care Nurseries (Level II) and Intensive Care Units (Level II/III, Level III, Level IV)". Annual neonatal admissions equal the summation of inborn and outborn admissions.

[b]Inborn admission: Admission of an infant delivered in your facility.

[c]Outborn admission: Admission of an infant delivered outside of your facility.

[d]Describes location type for patient care location in question, plus information on what other neonatal location types the facility mapped and reported to the AU Option. For example, NHSN assessed whether AU rates for each SAAR agent category differed between 1) a Level II unit in a facility that only reports AU data from one or more Level II unit and 2) a Level II unit in a facility that reports AU data from one or more Level II unit plus one or more Level II/III, III, or IV NICUs.

[e]Procedures include omphalocele repair, ventriculoperitoneal shunt, tracheoesophageal fistula (TEF)/esophageal atresia repair, bowel resection/reanastomosis, meningomyelocele repair, and cardiac catheterization.

After identifying factors to assess, NHSN began the SAAR model development process to determine which factors (and in what form) were associated with AU rates for each SAAR agent category. NHSN used negative binomial regression to assess these associations; first, by assessing each factor alone in univariate models and then, by assessing factors that statistically significantly predicted AU rates in univariate models together in multivariate models. NHSN used forward selection, a stepwise method of fitting regression models, to identify a final predictive model that risk adjusted for all factors predictive of AU for each SAAR agent category.

NHSN assessed variables in multiple forms and grouped some levels with similar risk estimates together. For example, in the 2017 baseline adult broad-spectrum hospital-onset agent SAAR model, teaching status was associated with AU rates—with non-teaching, graduate, and major teaching facilities having similar rates. NHSN grouped these levels together and created a two-level risk-adjustment variable: undergraduate teaching facilities vs. non-teaching, graduate, and major teaching facilities. Additionally, NHSN combined factors if rates varied among only certain strata or to prevent risk estimations based on a small subset of locations. For example, in the 2018 baseline neonatal SAAR model for 3rd generation cephalosporins, NHSN found that teaching status, facility type, and hospital bed-size predicted AU rates in univariate and multivariate models. However, when all three variables were included in the model together, stratified sample sizes were low, and NHSN decided to combine these factors based on risk estimates (specifically, NHSN combined groups with similar estimates).

You can find details about SAAR models and model development in the following NHSN published manuscripts:

- 2014 baseline adult and pediatric: https://academic.oup.com/cid/article/67/2/179/4835069
- 2017 baseline adult and pediatric: https://academic.oup.com/cid/article/71/10/e702/5812159
- 2018 baseline neonatal: https://publications.aap.org/hospitalpediatrics/article/12/2/190/184513/National-Healthcare-Safety-Network-2018-Baseline

SAARs in NHSN

Finding and reading SAAR reports

NHSN offers reports for three SAAR baselines, each applicable to a select set of patient care locations and time periods: 2014 baseline adult and pediatric SAARs, 2017 baseline adult and pediatric SAARs, and 2018 baseline neonatal SAARs. SAARs cannot be compared across baselines. Even though 2017 baseline adult and pediatric SAARs have the same baseline year, because they were modeled separately and have slightly different antimicrobial agent categories, 2017 baseline adult SAARs cannot be compared to 2017 baseline pediatric SAARs.

2014 Baseline Adult and Pediatric SAARs:

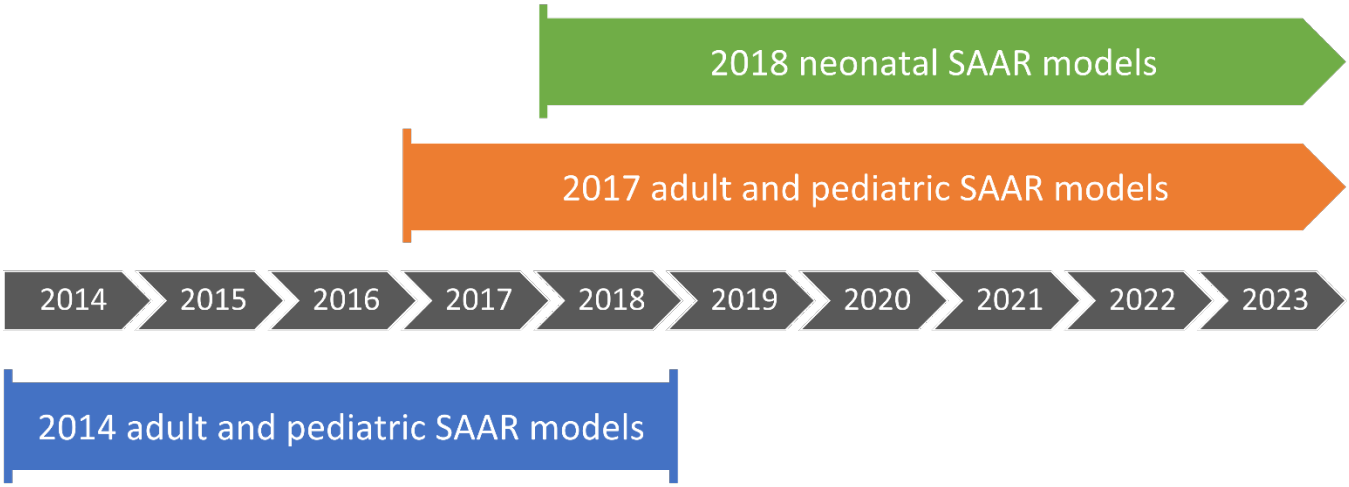
- Available for 6 adult and 6 pediatric location types (all 12 modeled together)
- 5 antimicrobial categories
- Users can generate for AU data reported January 2014 through December 2018

2017 Baseline Adult and Pediatric SAARs:

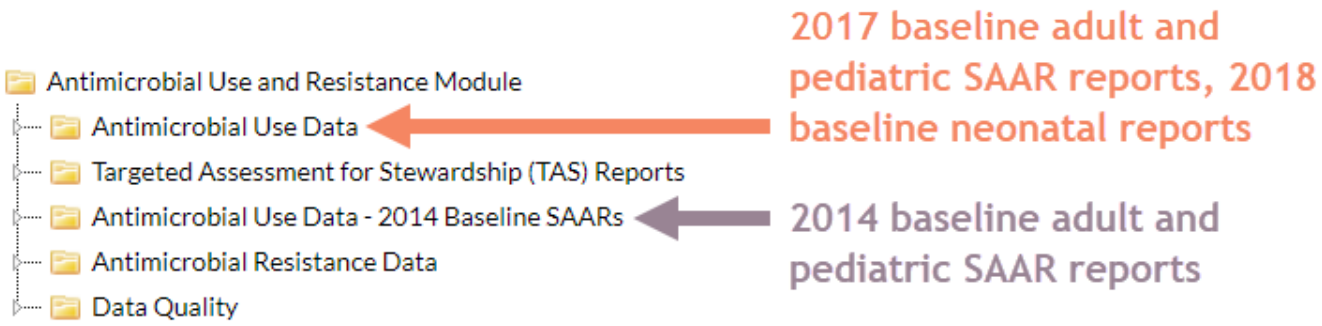
- Available for 8 adult and 5 pediatric location types (modeled separately)
- 7 adult and 8 pediatric antimicrobial categories
- Users can generate for AU data reported January 2017 through present day

2018 Baseline Neonatal SAAR:

- Available for 4 neonatal location types
- 7 antimicrobial categories
- Users can generate for AU data reported January 2018 through present day



Users can find reports based on each of the SAARs in the NHSN Analysis Reports within the Antimicrobial Use and Resistance (AUR) Module folder.



All SAAR reports share the following variables: SAAR Type (SAARType), Antimicrobial Days (antimicrobialDays), Predicted Antimicrobial Days (numAUDaysPredicted), Days Present (numDaysPresent), SAAR, SAAR p-value (SAAR_pval), and 95% Confidence Interval (SAAR95CI). The 2017 baseline adult and pediatric SAAR by location and 2018 baseline neonatal SAAR by location reports have an additional variable: SAAR Percentile (SAAR_pctl).

- **SAAR Type:** The SAAR type variable indicates the abbreviated name of the SAAR type. You can find the full name in the report or table title.
- **Antimicrobial Days:** Antimicrobial days include any amount of a specific antimicrobial agent administered in a calendar day to a particular patient as reported in the electronic medication administration record (eMAR) or bar-coding medication administration record (BCMA). Antimicrobial days are the SAAR numerator.
- **Predicted Antimicrobial Days:** Predicted antimicrobial days are the days of therapy predicted for each SAAR agent category and location, or group of locations, through predictive modeling applied to nationally aggregated AU data. Predicted antimicrobial days are the SAAR denominator.
- **Days Present:** Days present include the aggregate number of patients housed in a patient care location or facility anytime throughout the day during a calendar month. Users should verify the accuracy of their days present counts because NHSN uses days present to calculate predicted values.
- **SAAR:** The SAAR is a ratio comparing observed antimicrobial days to antimicrobial days predicted by a referent, or baseline, population (specifically, predicted antimicrobial days).
- **SAAR p-value:** The SAAR p-value is a statistical measure that indicates if observed antimicrobial use is statistically significantly different from predicted antimicrobial use.
- **95% Confidence Interval:** The 95% confidence interval is the range of values in which NHSN has a high degree of confidence that the true SAAR value lies. However, the SAAR is the most likely value.

- **SAAR Percentile:** The percentile a SAAR falls into based on the distribution of location-specific SAARs found in the NHSN AU Option Report Data Tables: https://www.cdc.gov/nhsn/datastat/aur-reports.html.

Interpreting the SAAR

The SAAR is a ratio comparing observed AU to AU predicted by a referent, or baseline, population. In general:

- A SAAR > 1.0 indicates greater antimicrobial use than predicted.
- A SAAR = 1.0 indicates antimicrobial use equivalent to predicted use.
- A SAAR < 1.0 indicates less antimicrobial use than predicted.

Two statistical measures, the SAAR p-value and the SAAR 95% confidence interval, accompany the SAAR and aid in its interpretation. The SAAR p-value and 95% confidence interval will always indicate the same statistical significance and users can interpret them interchangeably. Additionally, the SAAR percentile can be used to contextualize the interpretation of SAARs in the 2017 baseline adult and pediatric SAAR by location and 2018 baseline neonatal SAAR by location reports.

SAAR p-value: The SAAR p-value indicates if observed or reported antimicrobial use is statistically significantly different from predicted antimicrobial use. Due to the large number of days present reported each month, most SAAR p-values are less than or equal to 0.05 (a commonly used, yet arbitrary cut-point). Users should interpret SAAR p-values with caution, as statistical significance does not necessarily translate to clinical significance.

- A SAAR p-value ≤ 0.05 indicates reported antimicrobial days are statistically significantly different from predicted antimicrobial days.
- A SAAR p-value > 0.05 indicates reported antimicrobial days are **not** statistically significantly different from predicted antimicrobial days.

SAAR 95% confidence interval: The SAAR 95% confidence interval is the range of values in which we have a high degree of confidence the true SAAR value lies. However, the SAAR is the most likely value.

- If the 95% confidence interval does not include 1.0 (for example: 95% CI = [0.85, 0.92]), the SAAR is statistically significantly different than 1.0 (specifically, the reported antimicrobial days are statistically significantly different from predicted antimicrobial days) and the p-value will be ≤ 0.05.
- If the 95% confidence interval does include 1.0 (for example: 95% CI = [0.85, 1.24]), the SAAR is not statistically significantly different than 1.0 (specifically, the reported antimicrobial days are not statistically significantly different from predicted antimicrobial days) and the p-value will be > 0.05.

SAAR percentile: The SAAR percentile is the percentile a SAAR falls into based on the distribution of location specific SAARs found in the NHSN AU Option Report Data Tables (https://www.cdc.gov/nhsn/datastat/aur-reports.html). In the AU Option Report Data Tables, SAARs are calculated for each SAAR location reporting nine or more months of data in the given year and among them the distributions of location-specific SAAR values are

shown in percentiles. For example, a SAAR for a medical ICU location with a SAAR percentile of 90 indicates 89% of SAAR values reported from medical ICU locations are less than that SAAR and 10% of SAAR values reported from medical ICU locations are higher than it based on data reported into the AU Option.

The SAAR percentile is not generated if the SAAR is not generated (see Circumstances under which NHSN cannot generate SAAR reports or SAAR values below), nor is it generated for locations where the aggregate sample size was too small for analysis (<20 locations nationwide reporting at least nine months of data). Pediatric medical ICUs and pediatric surgical wards did not have enough locations reporting at least 9 months of data in 2021 for inclusion in the SAAR percentile calculations.

The SAAR, p-value, 95% confidence interval, and percentile are not definitive measures of the appropriateness or judiciousness of antimicrobial use. Any SAAR may warrant further investigation and a SAAR statistically different from 1.0 may not lead to productive investigation. Always take clinical judgement into account when interpreting SAAR values.

Additionally, SAARs were created for hospital reporters to compare their use of antimicrobials in each SAAR category against the national benchmark. The groupings of antimicrobials for SAAR categories were based on expert opinions to optimize the usefulness for antimicrobial stewardship. Higher SAARs were not meant to indicate a definitive clinical consequence. For example, the agents included in the Antibacterial Agents Posing Highest Risk for CDI grouping were those associated with higher risk of developing CDI at the individual patient level according to clinical literatures. However, when looking at patient care locations, this SAAR is not necessarily associated with same-time CDI incidence. This could be because CDI is typically attributed to multiple factors and the same-time observation of the same patient care location cannot fully reflect the time lag of CDI incidence.

Circumstances under which NHSN *cannot* generate SAAR reports or SAAR values:

NHSN does not generate a SAAR when the number of predicted antimicrobial days is less than 1.0 to enforce a minimum precision criterion and avoid statistically imprecise SAARs, which typically have extreme values. Small hospitals, such as critical access hospitals, may want to analyze their SAAR data at a higher level of aggregation than month (i.e., quarter, half year, year, or cumulative) to ensure they meet the minimum precision criteria.

For additional circumstances under which NHSN cannot generate SAAR reports or SAAR values, which are listed below, users will receive either a “No Records Met Your Criteria” error message or a missing SAAR value (SAAR = “.”).

All SAARs:

- Locations reporting zero days present for the selected time period.
- Locations reporting more antimicrobial days than days present for any SAAR agent category (except for adult and pediatric All Antibacterial Agents SAARs).

Adult SAARs:

- Adult SAAR locations in a long-term acute care (LTAC), orthopedic, psychiatric, or rehabilitation hospital. The 2017 SAAR baseline adult referent population does not include these facility types.

Pediatric SAARs:

- Pediatric SAAR locations in a critical access, LTAC, oncology, orthopedic, pediatric LTAC, psychiatric, rehabilitation, surgical, women's, or Veterans Affairs (VA) hospital. The 2017 SAAR baseline pediatric referent population does not include these facility types.

Neonatal SAARs:

- Neonatal Fluconazole SAARs are not available for Level II neonatal step down nurseries.
- Neonatal SAAR locations in a critical access, LTAC, oncology, orthopedic, pediatric LTAC, psychiatric, rehabilitation, surgical, or VA hospital. The 2018 SAAR baseline neonatal referent population does not include these facility types.
- Facilities reporting on the NHSN Patient Safety Component Annual Hospital Survey that they do not care for neonates. Specifically, facilities that respond: "N/A, my facility does not provide neonatal or newborn patient care services at any level."
- Facilities reporting zero inborn and zero outborn admissions on the NHSN Patient Safety Component Annual Hospital Survey.

Example SAAR interpretation

As an example, here is an interpretation of one row of a sample SAAR report for broad-spectrum antibacterial agents predominantly used for hospital-onset infections (BSHO) used in adult SAAR ICUs.

National Healthcare Safety Network
SAARs Table - All Adult and Pediatric Standardized Antimicrobial Administration Ratios (SAARs) High-Level Indicators and High-Value Targets by Location (2017 Baseline)
As of: November 3, 2021 at 4:29 PM
Date Range: AU_SAAR_2017 summaryYQ 2021Q2 to 2021Q2

Broad spectrum antibacterial agents predominantly used for hospital-onset infections used in adult SAAR ICUs

orgID	SAARType_2017	location	summaryYQ	locCDC	antimicrobialDays	numAUDaysPredicted	numDaysPresent	SAAR	SAAR_pval	SAAR95CI	SAAR_pctl
33617	Adult_BSHO_ICU_2017	MICU	2021Q2	IN:ACUTE:CC:M	91	99.352	315	0.916	0.4054	0.742, 1.119	41
33617	Adult_BSHO_ICU_2017	MSICU	2021Q2	IN:ACUTE:CC:MS	132	143.774	517	0.918	0.3477	0.771, 1.085	39
[illegible]											60

Note: Data for example only.

During the second quarter (Q2) of 2021, this facility reported 91 BSHO antimicrobial days for patients contributing 315 days present in their medical ICU (MICU). NHSN applied risk-adjustments based on the 2017 baseline adult BSHO SAAR predictive model to calculate 99.352 predicted antimicrobial days for the MICU during 2021Q2. NHSN calculated the SAAR as 91 divided by 99.352, for a SAAR value of 0.916. With a p-value of 0.4054 and a 95% confidence interval that contains 1.0 (0.742, 1.119), observed AU was NOT statistically significantly different from predicted AU for the MICU location during 2021Q2. The SAAR percentile of 41 indicates that the SAAR value of 0.916 falls within the 41st percentile for medical ICUs. In other words, the MICU's SAAR is higher than 40% of medical ICUs and lower than 59% of medical ICUs reporting to NHSN.

Example SAAR calculation

NHSN uses negative binomial regression for AU risk adjustment. The model uses a set of fixed parameters (adjustment variables) for each SAAR type to predict the risk of AU in a set of SAAR-locations. Below is the general formula for a negative binomial model:

$log\ (\lambda) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_i X_i$, where:

α = Intercept
β_i = Parameter estimate
X_i = Value of risk factor (categorical variables: 1 if present, 0 if not present)
i = Number of predictors

Exponentiating the solution (specifically, $e^{log\ (\lambda)}$), and multiplying by the number of days present provides an estimate for predicted antimicrobial days.

As an example, the two tables below represent the negative binomial regression models used to calculate the number of predicted antimicrobial days for adult broad-spectrum antibacterial agents predominantly used for hospital-onset infections under the 2017 adult SAAR baseline (Table 1) and neonatal vancomycin predominantly used for treatment of late-onset sepsis under the 2018 neonatal SAAR baseline (Table 2).

Table 1. Risk factors used in the 2017 baseline adult SAAR predictive model for broad-spectrum antibacterial agents predominantly used for hospital-onset infections.

Factor	Parameter Estimate	P-value
Intercept	-2.3357	<.0001
Location type = Medical ICU	1.0084	<.0001
Location type = Medical-Surgical ICU, Surgical ICU	0.8825	<.0001
Location type = General Hematology-Oncology Ward	0.3795	<.0001
Location type = Step down Unit	0.2197	<.0001
Location type = Medical Ward	0.0781	0.0041
Veteran's Affairs hospital (facility type = HOSP-VA)	-0.1821	<.0001
Critical access hospital (facility type = HOSP-CAH)	-0.2465	0.0049
Military hospital (facility type = HOSP-MIL)	-0.6278	<.0001
Women's hospital (facility type = HOSP-WOM)	-1.1920	0.0003
≥8 ICU beds	0.1734	0.0003
≥3.6 average length of stay, facility-wide (in days)	0.1091	<.0001

Undergraduate teaching facility	0.1394	<.0001

Note: Location types (adult medical-surgical and surgical wards), facility types (general acute care, oncology, surgical, women's and children's), and other groups (hospitals with <8 ICU beds, with average length of stay <3.6 days, and non-teaching, graduate teaching, and major academic facilities) NOT shown in the table above are part of a referent group (parameter estimate= 0.0000).

We can put the model details from Table 1 into the negative binomial regression model formula:

 # predicted DOT = Exp [-2.3357
+ 1.0084 (Location type: Medical ICU)
+ 0.8825 (Location type: Med-Surg ICU, Surgical ICU)
+ 0.3795 (Location type: Hematology-Oncology Ward)
+ 0.2197 (Location type: Step-down Unit)
+ 0.0781 (Location type: Medical Ward)
+ -0.1821 (Facility type: VA hospital)
+ -0.2465 (Facility type: Critical access hospital)
+ -0.6278 (Facility type: Military hospital)
+ -1.1920 (Facility type: Women's hospital)
+ 0.1734 (ICU beds: ≥8)
+ 0.1091 (Average length of stay: ≥3.6 days)
+ 0.1394 (Teaching status: undergraduate) **] x # days present**

For each variable shown in parentheses above, replace the variable name with (and, therefore, multiply each parameter estimate by) a "1" or "0" depending on whether that factor is present (Yes="1", No="0").

Let's walk through an example of calculating predicted broad-spectrum hospital-onset antimicrobial days for an adult surgical ward reporting AU data in January 2019. This surgical ward is in a hospital enrolled in NHSN as a non-teaching critical access hospital with 2 ICU beds and an average length of stay of 4 days. The hospital reported 3 antimicrobial days and 30 days present for this location and month.

In our location example, the completed formula looks like this:

 # predicted DOT = Exp [-2.3357
+ 1.0084 (Location type: Medical ICU) → (0)
+ 0.8825 (Location type: Med-Surg ICU, Surgical ICU) → (0)
+ 0.3795 (Location type: Hematology-Oncology Ward) → (0)
+ 0.2197 (Location type: Step-down Unit) → (0)
+ 0.0781 (Location type: Medical Ward) → (0)
+ -0.1821 (Facility type: VA hospital) → (0)
+ -0.2465 (Facility type: Critical access hospital) → (1)
+ -0.6278 (Facility type: Military hospital) → (0)
+ -1.1920 (Facility type: Women's hospital) → (0)
+ 0.1734 (ICU beds: ≥8) → (0)
+ 0.1091 (Average length of stay: ≥3.6 days) → (1)
+ 0.1394 (Teaching status: undergraduate) → (0)
] x # days present

= $e^{[-2.3357 + -0.2465 + 0.1091]}$ x 30 days present
= $e^{[-2.4731]}$ x 30 days present
= 0.0843 **x 30 days present**
= 2.5297 predicted antimicrobial days

Because the location is a surgical ward (referent group), the formula did not include associated location type parameters (all received 0). Because the location was in a facility that is not a VA, military, or women's facility, does not have ≥8 ICU beds, and is not an undergraduate teaching hospital, those facility-level variables were multiplied by 0. This location received an adjustment of -0.2465 for being in a critical access hospital and an adjustment of 0.1091 for having an average length of stay ≥3.6 days. To calculate predicted antimicrobial days, sum the adjustments (-0.2465 and 0.1091) and intercept (-2.3357), exponentiate that sum, and multiply by 30 days present, which results in 2.5297 predicted BSHO antimicrobial days for this adult surgical ward for January 2019. To calculate the SAAR, divide observed antimicrobial days by predicted antimicrobial days. In our example:

$$SAAR = \frac{3\ Observed\ antimicrobial\ days\ of\ therapy}{2.530\ Predicted\ antimicrobial\ days\ of\ therapy} = 1.186$$

Table 2. Risk factors used in the 2018 baseline neonatal SAAR predictive model for vancomycin predominantly used for treatment of late-onset sepsis.

Factor	Parameter Estimate	P-value
Intercept	-7.4328	<.0001
Percentage of annual admissions with birthweight <1500g: ≥4.0%	1.6873	<.0001
Percentage of annual admissions with birthweight <1500g: 1.3 - 3.9%	1.0009	0.0008
Level II/III, III, or IV NICU in facility that accepts neonates as transfers for various specified complex procedures	2.1816	<.0001
Level II/III, III, or IV NICU in facility that does NOT accept neonates as transfers for various specified complex procedures	1.3515	<.0001

Note: Hospitals with <1.3% of annual neonatal admissions weighing <1500g and those with only Level II neonatal step down units are part of a referent group (parameter estimate= 0.0000).

We can put the model details from Table 2 into the negative binomial regression model formula:

 # predicted DOT = Exp [-7.4328
+ 1.6873 (% annual admissions with birthweight <1500g: ≥4.0%)
+ 1.0009 (% annual admissions with birthweight <1500g: 1.3-3.9%)
+ 2.1816 (Location type: Level II/III, III, IV and neotransfer: 'Y')
+ 1.3515 (Location type: Level II/III, III, IV and neotransfer: 'N' **] x # days present**

For each variable shown in parentheses above, replace the variable name with (and, therefore, multiply each parameter estimate by) a "1" or "0" depending on whether that factor is present (Yes="1", No="0").

Let's walk through an example to calculate predicted vancomycin antimicrobial days for a Level IV NICU reporting AU data in January 2019. This NICU is in a children's hospital with 6.1% of neonatal admissions with birthweight <1500g. This hospital accepts neonates as transfers for one or more complex procedures specified in the NHSN Patient Safety Component Annual Hospital Survey and reports 7 antimicrobial days and 350 days present for this location/month.

In our location example, the formula looks like this:

 # predicted DOT = Exp [-7.4328
+ 1.6873 (% annual admissions with birthweight <1500g: ≥4.0%) ⟶ (1)
+ 1.0009 (% annual admissions with birthweight <1500g: 1.3-3.9%) ⟶ (0)
+ 2.1816 (Location type: Level II/III, III, IV and neotransfer: 'Y') ⟶ (1)
+ 1.3515 (Location type: Level II/III, III, IV and neotransfer: 'N') ⟶ (0)
] x # days present

= $e^{[-7.4328 + 1.6873 + 2.1816]}$ x 350 days present
= $e^{[-3.5639]}$ x 350 days present
= 0.0283 x 350 days present
= 9.9148 predicted antimicrobial days

Because the location is in a facility with ≥4.0% of neonatal admissions having birthweights <1500g, it received an adjustment of 1.6873, and because it's a Level IV NICU in a hospital that accepts neonates as transfers for various complex procedures (neotransfer='Y'), it receives an adjustment of 2.1816. To calculate predicted antimicrobial days, we sum the adjustments (1.6873 and 2.1816) and the intercept (-7.4328), exponentiate that sum, and multiply by 350, which results in 9.9148 predicted vancomycin antimicrobial days for this Level IV NICU in January 2019. To calculate the SAAR, divide observed antimicrobial days by predicted antimicrobial days. In our example:

$$SAAR = \frac{7\ Observed\ antimicrobial\ days\ of\ therapy}{9.915\ Predicted\ antimicrobial\ days\ of\ therapy} = 0.706$$

Additional notes regarding risk-adjustment:

- NHSN separates some risk-adjustment variables into different levels, or categories. For example, NHSN breaks down continuous variables into categories based on decile, quintile, quartile, tertile, and median values. NHSN may group levels further if risk estimates are not statistically significantly different.
- For variables with more than one level, one level is the referent category (specifically, the category to which all other levels are compared). The analyst developing the model can select the referent group. For risk of AU, it is often easier to understand which factors are associated with increased use, rather than decreased use and, when possible, we select the group with the lowest AU risk as the referent category.
- Parameter estimates reflect the nature of the relationship between the variable and the risk of AU. A positive estimate means the risk of AU for the associated group is higher than the referent group. A negative estimate means the risk of AU for the associated group is lower than the referent group.
- Standard errors reflect the precision of parameter estimates, where smaller standard errors indicate a greater level of precision than larger standard errors.
- You can find model details for the 2017 baseline adult and pediatric and 2018 neonatal models at the end of this document.

Analysis Guidance and Using the SAAR for Action

Defining your benchmark

A benchmark is a point of reference against which comparisons can be made. Hospitals can use the SAAR to benchmark both internal and external antimicrobial use by comparing their AU over time and to a national benchmark. Hospitals can assess whether they're using antimicrobials at higher or lower rates than the national average by comparing their SAARs to the nominal benchmark value of 1.0. SAAR values other than 1.0 may be helpful benchmarks for hospitals, depending on their stewardship goals or patient population.

When using Standardized Infection Ratios (SIRs), the target value is always 0 because facilities strive to prevent all hospital acquired infections (HAIs). When using the SAAR, the target value is less clear because patients need antimicrobials and a goal of zero antimicrobial days is unsafe in most cases. There are many factors to consider when defining target SAAR values, and those values may differ across SAAR agent categories and location types. Because patient mix and severity of illness within any NHSN-defined location type may vary, benchmark values may also vary. Hospitals can conduct medication use evaluations to assess courses of therapy for select antimicrobials or infections, which can help identify opportunities to improve use and inform candidate benchmark SAAR values.

National SAAR distributions can help further inform SAAR benchmarking decisions by allowing hospitals to see how their SAARs compare to others. NHSN developed the AU Data Reports and accompanying data tables to provide hospitals with SAAR distributions within SAAR antimicrobial agent categories in adult, pediatric, and neonatal locations to help hospitals set benchmarks. For example, the 50th percentile (i.e., median) BSHO SAAR value for adult medical wards is 0.889 according to 2021 data, so a facility may want to set that value as their benchmark rather than the nominal 1.0 value. The SAAR percentile column in the SAAR by location reports can be used to track progress toward a goal or benchmark.

A SAAR value of 1.0 does not necessarily mean AU is ideal or even good. Clinical judgement and patient information should be considered when interpreting SAAR values and setting SAAR benchmarks. You can find 2017 baseline adult and pediatric SAAR distributions from referent populations in Table 3 of our published SAAR manuscript: https://academic.oup.com/cid/article/71/10/e702/5812159.

Similarly, you can find 2018 baseline neonatal SAAR distributions from reference populations in Table 3 of our published neonatal SAAR manuscript: https://publications.aap.org/hospitalpediatrics/article/12/2/190/184513/National-Healthcare-Safety-Network-2018-Baseline.

You can find SAAR distributions for adult, pediatric, and neonatal SAAR locations in the AU Report data tables here: https://www.cdc.gov/nhsn/datastat/aur-reports.html.

In 2022, CDC released Targeted Assessment for Antimicrobial Stewardship (TAS) reports for NHSN users. TAS is a framework for quality improvement developed to use NHSN AU Option data for action to optimize AU at facilities. The TAS Reports use a metric called the AU cumulative attributable difference (AU-CAD). The AU-CAD represents the difference between the observed days and a selected SAAR target. The TAS Reports allow for ranking facilities within groups, or location groups and locations within individual facilities, by the AU-CAD, to identify where stewardship efforts may have the greatest impact. TAS reports may provide further insight into what SAAR benchmarks are achievable and make the most sense for specific location types and SAAR agent categories. See

the NHSN TAS Guide for more information on TAS reports: https://www.cdc.gov/nhsn/ps-analysis-resources/tas/tas-guide-508.pdf.

Comparing two SAAR values

Hospitals can compare two SAAR values to assess whether they are statistically significantly different from each other, track progress toward meeting specific stewardship targets, or compare a SAAR to a benchmark value. NHNS users can use the NHSN Statistics Calculator within the NHSN application, to conduct statistical tests and determine if there is a statistically significant difference between two SAAR values. Please note that you cannot directly compare SAAR values calculated under different baselines because NHSN risk-adjusts each baseline differently. The NHSN AUR Team provided training on how to use the NHSN Statistics Calculator to compare a SAAR to a nominal value and compare two SAARs during the 2022 NHSN Annual Training session on advanced AU Option analysis (slides: https://www.cdc.gov/nhsn/pdfs/training/2022/AU-Option-Advanced-Analysis-508.pdf; recording: https://youtu.be/yp97BZkVT-0).

For example, a hospital that worked to decrease antifungal agent use for invasive candidiasis in their adult wards wants to assess the impact of their efforts. They want to compare SAAR values for this antimicrobial category across two points in time: the second and third quarters of 2019.

orgID	summaryYQ	SAARType_2017	antimicrobialDays	numAUDaysPredicted	numDaysPresent	SAAR
13860	2019Q1	Adult_Antifungal_Ward_2017	113	41.815	2718	2.702
13860	2019Q2	Adult_Antifungal_Ward_2017	180	66.861	4346	2.692
13860	2019Q3	Adult_Antifungal_Ward_2017	55	28.046	1823	1.961

Note: Data for example only.

The hospital found the SAAR decreased from 2.692 in 2019Q2 to 1.961 in 2019Q3. The hospital can use the NHSN Statistics Calculator, entering observed and predicted antimicrobial days for each quarter, to find out if this a statistically significant decrease in their SAAR value.

National Healthcare Safety Network
NHSN Statistics Calculator: Comparing Two SAARs
As of: March 23, 2020 at 11:07 AM

	2019Q2	2019Q3
Observed	180	55
Expected	66.861	28.046
SIR	2.692	1.961

Relative ratio of SIRs (data column 2 / data column 1): 1.961/2.692 = 0.728 (72.8%)
Two-tailed p-value: 0.0361
95% Conf. Interval: 0.535, 0.98

Note: Data for example only.

Since the p-value 0.0361 is less than 0.05, and the 95% confidence interval (0.535, 0.980) does not contain 1.0, the change in SAAR value from 2.692 to 1.961 is statistically significant. It is important to keep in mind that SAARs often have large denominators and increased power to find differences statistically significant. While statistical significance is important, it does not mean findings are clinically significant or meaningful.

Scalability of the SAAR – how to aggregate SAAR data

Scalability means that hospitals can calculate SAARs at various levels of aggregation. For example, in pre-filtered reports, NHSN calculates SAARs at the location/month-level and the SAAR Location Type/month-level. Users can modify reports to display quarterly or yearly SAARs. NHSN does not have a built-in option to generate SAARs for multiple facilities or combinations of select locations, however, users can manually pool data to calculate SAARs at different levels of aggregation.

Examples of how users can aggregate SAAR data within any individual baseline year:

- Across time (months, quarters, or years)
- Across SAAR-eligible locations (within any baseline population, specifically, 2017 baseline adult data and pediatric data should not be combined)
- Across facilities, health systems, or health department jurisdictions

To calculate a pooled SAAR for aggregation levels not available in NHSN, users can export their SAAR data and manually sum observed antimicrobial days across desired levels of aggregation, sum predicted antimicrobial days across those same levels, and then divide the pooled observed antimicrobial days by pooled predicted antimicrobial days. For example, you can calculate a pooled SAAR for broad-spectrum antibacterial agents predominantly used for hospital-onset infections in adult ICUs across three different facilities.

Broad spectrum antibacterial agents predominantly used for hospital-onset infections used in adult SAAR ICUs

orgID	summaryYM	SAARType_2017	antimicrobialDays	numAUDaysPredicted	numDaysPresent	SAAR	SAAR_pval	SAAR95CI
10229	2018M07	Adult_BSHO_ICU_2017	573	124.580	1111	4.599	0.0000	4.234, 4.988
13860	2018M07	Adult_BSHO_ICU_2017	411	268.873	927	1.529	0.0000	1.386, 1.682
15269	2018M07	Adult_BSHO_ICU_2017	131	99.352	315	1.319	0.0027	1.107, 1.559

Note: Data for example only.

For July 2018, you can calculate a pooled adult BSHO ICU SAAR for these three hospitals using the following formula:

$$\textbf{\textit{Pooled BSHO SAAR}} = \frac{orgID\ 10229\ observed\ DOT + orgID\ 13860\ observed\ DOT + orgID\ 15269\ observed\ DOT}{orgID\ 10229\ predicted\ DOT + orgID\ 13860\ predicted\ DOT + orgID\ 15269\ predicted\ DOT}$$

$$\textbf{\textit{Pooled BSHO SAAR}} = \frac{573 + 411 + 131}{124.580 + 268.873 + 99.352}$$

$$\textbf{\textit{Pooled BSHO SAAR}} = \mathbf{2.263}$$

Note: This example is an appropriate use of aggregation because we are pooling within the same SAAR agent category (BSHO) and the same patient population (2017 baseline adult locations). We would NOT want to pool adult BSHO data with pediatric BSHO data. Alternatively, we would NOT want to pool across SAAR agent categories such as adult BSHO data with adult NSBL data.

As a reminder, the SAARs generated in NHSN only include the SAAR eligible location types (see Table 5 in the AUR Module Protocol: https://www.cdc.gov/nhsn/pdfs/pscmanual/11pscaurcurrent.pdf). None of the SAARs contain AU data from all inpatient locations in a given facility. Specifically, NHSN does not offer a facility-wide SAAR because not all location types are SAAR eligible. The closest alternative is the All Antibacterial Agents SAAR, which users can pool across all SAAR-eligible locations within any baseline year and baseline population. For example, you can pool observed and predicted antimicrobial days for All Antibacterial Agents across all 2017 baseline adult SAAR-eligible locations. You can do the same separately for 2017 baseline pediatric SAAR-eligible locations or 2018 baseline neonatal SAAR-eligible locations.

While scaling SAAR data can be useful for many antimicrobial stewardship efforts, there are limitations that users must keep in mind. For example, you cannot aggregate data across baseline populations (specifically, observed and predicted antimicrobial days should not be pooled across adult, pediatric, and neonatal locations) or baseline years. The more scaling that occurs, the more uncertainty you introduce and the greater the likelihood that additional factors (not included in risk adjustments) will account for observed changes. The more you aggregate, the more likely the groups you are comparing will differ in certain factors, leading to a loss in proportionality. This concept of proportionality can be found in the 2nd Volume of Breslow and Day's Statistical Methods in Cancer

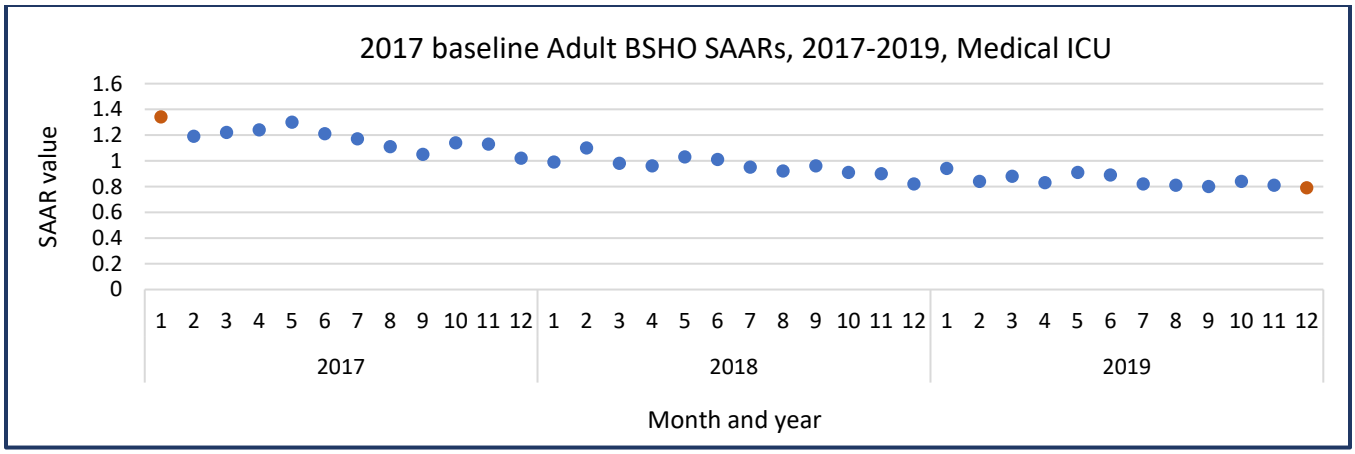
Research: https://publications.iarc.fr/Book-And-Report-Series/Iarc-Scientific-Publications/Statistical-Methods-In-Cancer-Research-Volume-II-The-Design-And-Analysis-Of-Cohort-Studies-1986.

State, territorial, and local health departments, as well as hospital systems, can generate SAARs for all hospitals in their jurisdiction using the NHSN Group Function The NHSN Group Function allows users to access multiple facilities' NHSN data with their permission or, in the case of state, territorial and local health departments, through a data use agreement. The Group is managed centrally and, while facilities share data with the group, individual facilities cannot see data from other group members. You can find more information about the NHSN Group Function on the NHSN Group Function website: https://www.cdc.gov/nhsn/group-users/index.html. State, territorial, and local health departments can find more information on obtaining NHSN data from facilities in their jurisdiction on the Data Use Agreement (DUA) website: https://www.cdc.gov/nhsn/about-nhsn/dua.html. The NHSN AUR Team provides training on setting up and using the NHSN Group Function for AUR data, running SAAR reports at the group level, and aggregating SAARs across multiple facilities (slides: https://www.cdc.gov/nhsn/pdfs/training/2022/AUR-508.pdf; recording: https://www.youtube.com/watch?v=JyjG7SjZLgg).

Additionally, states can find state-specific SAAR distributions in the AU Option Report Data Tables (https://www.cdc.gov/nhsn/datastat/aur-reports.html) and the CDC's Antimicrobial Resistance & Patient Safety Portal (https://arpsp.cdc.gov/profile/inpatient-antibiotic-use/all).

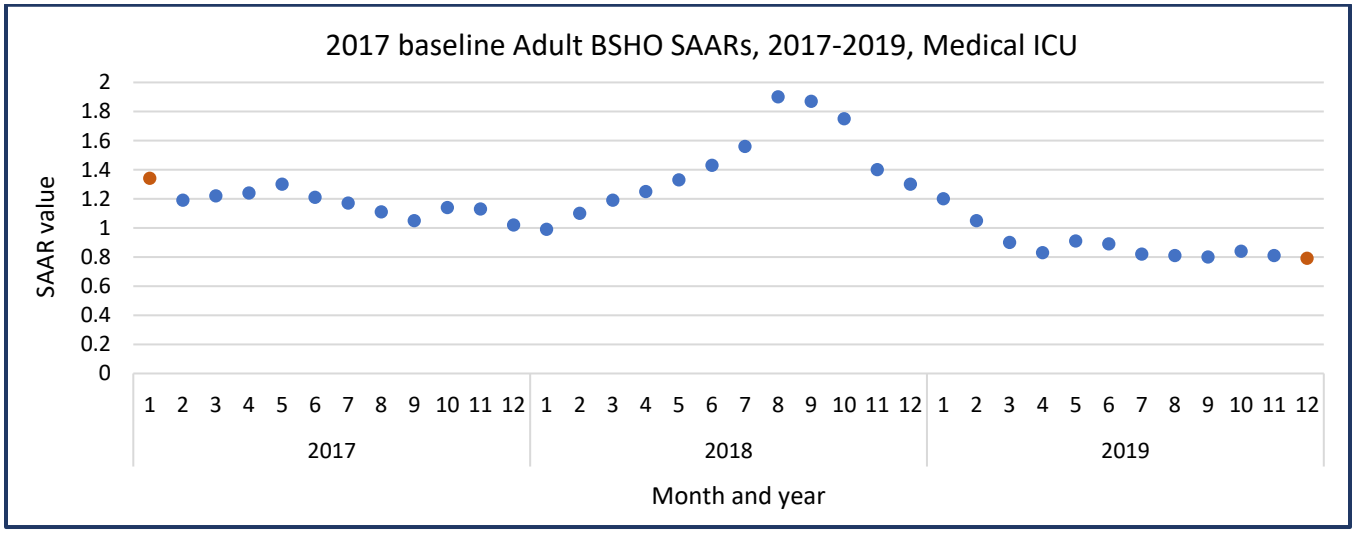
Assessing AU data over time

Tracking AU over time is an integral part of antimicrobial stewardship. However, tracking AU over time using SAARs should be limited to comparing two SAAR values across two points in time (as discussed in the Comparing Two SAAR values section). You should **not** use SAARs for trend analyses, where SAAR values are simultaneously compared across many points in time to determine whether there is a statistically significant change in AU, as the proportionality assumption discussed above is unlikely to hold across a large number of time points. Instead, hospitals interested in assessing AU over many time points may use crude rates and risk-adjust for factors included in the SAAR models and should work with their local statistician to develop methods that fit the analysis question of interest.



Note: Data for example only.

In the plot above, this example hospital can visualize their medical ICU's 2017 baseline Adult BSHO SAAR values from January 2017 through December 2019. If they are interested in knowing whether there is a statistically significant change in Adult BSHO use in this location between January 2017 and December 2019, they can use the NHSN Statistics calculator to compare the SAAR values (two orange dots) for these two points. This type of analysis simply compares the start and end values but does not consider all data points in between. In the plot below, the start and end values are the same as those above, but you can see SAAR values increase greatly in 2018 and the overall pattern of SAARs across the three years looks very different.



Note: Data for example only.

A true trend analysis assesses each data point at a specific aggregation level (e.g., monthly, quarterly, etc.) in the time period of interest. As mentioned, SAARs should **not** be used in trend analyses to determine whether there has been a statistically significant change in AU across many points in time. Rates, on the other hand, can be used for trend analyses. Work with a local statistician to further understand the proportionality assumption and how to use AU rates to assess long term trends in antimicrobial use in your facility.

NHSN now includes the ability to produce SAAR plots to visually display SAARs over time. The steps for running and interpreting this report type are here: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/aur/AU-QRG-SAARDotPlot-508.pdf.

Survey data and risk-adjustment

NHSN uses Patient Safety Component Annual Hospital Survey data for facility-level risk-adjustment in SAAR models; survey year is matched to the year of the AU data (specifically 2021 survey values are used when risk adjusting 2021 AU data). However, because hospitals complete surveys annually while reporting AU data monthly, there is a period of 12+ months where NHSN risk-adjusts SAARs using the previous year's survey data. For example, facilities completed their 2022 surveys in early 2023 using data from the complete 2022 calendar year. If a facility completes their survey each March, their 2022 survey would be completed March 2023. If the facility reports AU data monthly, in February 2023, NHSN calculates their 2022 and 2023 SAARs using 2021 survey data (specifically, the most recent survey data available). Then in March 2023, when they complete their 2022 survey, save it in NHSN, and generate new datasets, NHSN updates the 2022 and 2023 SAARs to use 2022 survey data for calculations. 2023 SAARs will use 2022 survey data for risk-adjustment until the facility completes its 2023 survey in March 2024.

Many hospitals and health systems track SAARs on an ongoing basis and may notice shifts in their SAAR values once current survey data replace old survey data for risk-adjustment in SAAR calculations. Of the 1,082 hospitals reporting 2018 AU data from adult SAAR-eligible locations, 58% had a change in survey data (between 2017 and 2018 surveys) that changed at least one of their SAARs. The likelihood and magnitude of shifts in SAARs due to survey updates depends on the number and types of risk-adjustments made in each predictive model. For example, the pediatric SAAR model for antibacterial agents predominantly used for resistant Gram-positive infections only includes location-level risk adjustment and is, therefore, not affected by survey updates, while the adult model for the same SAAR category risk-adjusts for location type, facility type, number of hospital beds, and average LOS, and is therefore susceptible to shifts in SAAR calculations if a hospital changes one or more facility-level factors that cause it to shift risk-adjustment categories.

Example: *How changes to surveys can affect 2017 baseline adult narrow spectrum beta-lactam (NSBL) SAARs*

The adult SAAR model for NSBL agents risk-adjusts for location type, length of stay, percentage of ICU beds, and number of hospital beds.

Adult Narrow spectrum beta-lactam agents	Estimate
Intercept	-3.2228
Location type	
Surgical ICU, Surgical Ward	1.1285
Medical-Surgical ICU, Medical-Surgical Ward	0.5004
Step-down Unit	0.2857
Medical ICU, Medical Ward	0.2145
General Hematology-Oncology Ward	REF
Average length of stay, facility-wide (in days)	
<3.5	0.2612
≥5.8	0.1726
3.5 - 5.7	REF
ICU beds (as a percentage of total beds)	
≥8.6%	0.1633
<8.6%	REF
Number of hospital beds, facility-wide	
≥222	0.1112
<222	REF

In 2018, the facility reports:

- Length of stay – 3.6 days
- % ICU beds – 4.0%
- Number of beds – 225 beds

In 2019, the facility reports:

- Length of stay – 3.4 days
- % ICU beds – 4.2%
- Number of beds – 220 beds

Based on changes in the facility's average LOS and bed size between 2018 and 2019, they can expect changes in their 2019 adult NSBL SAARs once their 2019 survey data replaces their 2018 survey data for SAAR calculations. For LOS, they reported 3.6 days in 2018, which falls in the lowest risk category (3.5-5.7 days), and 3.4 days in 2019, which falls in the highest risk category (<3.5 days). For bed-size, they reported 225 beds in 2018, which falls in the highest risk category (≥222 beds), and 220 beds in 2019, which falls in the lowest-risk category (<222 beds). While their % ICU beds increased from 4.0% to 4.2%, that change was not large enough to move them to the higher risk group (≥8.6%). Only changes in LOS and bed-size will affect estimates for predicted antimicrobial days and total risk-adjustment will be lower using 2019 survey data compared with 2018 survey data:

- LOS estimate 2018 vs. 2019: 0.0000 → 0.2612
- Bed estimate 2018 vs. 2019: 0.1112 → 0.0000
- Predicted antimicrobial days using 2019 survey data will decrease by:
  - $= e^{(0.2612 - 0.1112)}$ x number of days present
  - $= e^{(0.15)}$ x number of days present
  - = 1.16 x number of days present
- Because 1.16 is greater than 1.0, this change in estimation will result in a *larger* number of predicted antimicrobial days and, therefore, a lower SAAR value

Using the SAAR for stewardship

Antimicrobial stewardship is the effort to measure and improve how clinicians prescribe antimicrobials. Improving antimicrobial prescribing and use is critical to effectively treat infections, protect patients from harm caused by unnecessary AU, and combat antimicrobial resistance. Though a SAAR is not a definitive measure of the appropriateness or judiciousness of AU, it can be a great tool to inform and benchmark antimicrobial stewardship efforts. CDC offers several resources to help facilities use AU data for action.

AU Option Case Examples

CDC collaborated with hospitals that report data to the AU Option to provide several AU Option Case Examples (https://www.cdc.gov/nhsn/au-case-examples/index.html) documenting success stories from hospitals that used their SAAR data to improve provider practices. Examples include:

- Using the SAAR to Track Impact of Multiple Concurrent Antimicrobial Stewardship Interventions
- Targeting a Reduction in Fluoroquinolone Use within a Community Hospital

Strategies to Assess Antibiotic Use to Drive Improvements in Hospitals

CDC and The PEW Charitable Trusts collaborated to create Strategies to Assess Antibiotic Use to Drive Improvements in Hospitals (https://www.cdc.gov/antibiotic-use/healthcare/pdfs/Strategies-to-assess-antibiotic-use-in-hospitals-508.pdf). The suggestions outlined in this document help antibiotic stewardship programs (ASPs) in hospitals assess antimicrobial use to see if there are opportunities for improvement. Hospitals can use this assessment tool in conjunction with the SAAR to target assessments in areas with unexpectedly high AU.

Core Elements of Antibiotic Stewardship

CDC documents antimicrobial stewardship best practices in the Core Elements of Hospital ASPs (https://www.cdc.gov/antibiotic-use/core-elements/index.html). CDC provides resources for implementing Core Elements in a variety of healthcare settings. The SAAR can fulfill both tracking and reporting elements.

Additional Resources

General AU Option Materials:

AUR Module Protocol:
https://www.cdc.gov/nhsn/PDFs/pscManual/11pscAURcurrent.pdf

FAQs for the Antimicrobial Use Option:
https://www.cdc.gov/nhsn/faqs/faq-au.html

NHSN AUR Module Training Presentations:
https://www.cdc.gov/nhsn/training/patient-safety-component/aur.html
AU Option Case Examples:
https://www.cdc.gov/nhsn/au-case-examples/index.html

SAAR Specific Materials:

SAAR Quick Reference Guide - AU SAAR Table:
https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/aur/AU-QRG-SAARTables.pdf

SAAR Quick Reference Guide - AU SAAR Table by Location:
https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/aur/AU-QRG-SAARTables-Location.pdf

SAAR Quick Reference Guide - AU SAAR Bar Chart by Location:
https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/aur/au-qrg-saar-bartable-location-508.pdf

SAAR Quick Reference Guide – AU SAAR Plot:
https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/aur/AU-QRG-SAARDotPlot-508.pdf

SAAR Quick Learn Series:

- Part One: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/aur/saar-p1-508.pdf
- Part Two: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/aur/saar-p2-508.pdf

Keys to Success with the SAAR:
https://www.cdc.gov/nhsn/ps-analysis-resources/keys-to-success-saar.html

2014 baseline SAAR manuscript:
https://academic.oup.com/cid/article/67/2/179/4835069

2017 baseline adult and pediatric SAAR manuscript:
https://academic.oup.com/cid/article/71/10/e702/5812159

2018 baseline neonatal SAAR manuscript:
https://publications.aap.org/hospitalpediatrics/article/12/2/190/184513/National-Healthcare-Safety-Network-2018-Baseline

Antimicrobial Use Option Data Reports:
https://www.cdc.gov/nhsn/datastat/aur-reports.html

Antibiotic Resistance and Patient Safety Portal Inpatient Antibiotic Use:
https://arpsp.cdc.gov/profile/inpatient-antibiotic-use/all

General NHSN Materials:

NHSN Location Mapping:
https://www.cdc.gov/nhsn/pdfs/pscmanual/15locationsdescriptions_current.pdf

NHSN Annual Hospital Survey:
https://www.cdc.gov/nhsn/forms/57.103_pshospsurv_blank.pdf

Instructions for NHSN Annual Hospital Survey:
https://www.cdc.gov/nhsn/forms/instr/57_103-toi.pdf

NHSN Codes and Variables and Statistical Tools:

https://www.cdc.gov/nhsn/ps-analysis-resources/index.html

NHSN Data Dictionary:
https://www.cdc.gov/nhsn/xls/analysis/nhsn-data-dictionary.xlsx

NHSN Group Function:
https://www.cdc.gov/nhsn/group-users/index.html

NHSN Data Use Agreement (DUA):
https://www.cdc.gov/nhsn/about-nhsn/dua.html

Appendix: SAAR Model Details

NHSN included adult and pediatric 2017 and neonatal 2018 baseline Standardized Antimicrobial Administration Ratio (SAAR) risk models, by SAAR antimicrobial agent category below.

Adult: Broad-spectrum antibacterial agents predominantly used for hospital-onset infections

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-2.336	0.05	-2.43	-2.24	2260.98	<0.001
Location type						
Medical ICU	1.008	0.04	0.92	1.09	531.59	<0.001
Medical-surgical ICU, surgical ICU	0.883	0.03	0.83	0.94	982.03	<0.001
General hematology-oncology ward	0.380	0.06	0.27	0.49	43.13	<0.001
Step down unit	0.220	0.03	0.16	0.28	49.33	<0.001
Medical ward	0.078	0.03	0.02	0.13	8.25	0.004
Medical-surgical ward, surgical ward	REF	.	.	.	.	.
Facility type						
Veterans Affairs (VA)	-0.182	0.03	-0.24	-0.12	37.96	<0.001
Critical access	-0.247	0.09	-0.42	-0.07	7.92	0.005
Military	-0.628	0.06	-0.75	-0.50	99.86	<0.001
Women's	-1.192	0.33	-1.83	-0.55	13.25	<0.001
General acute, oncology, surgical, women's and children's	REF	.	.	.	.	.
Number of ICU beds, facility-wide						
≥8	0.173	0.05	0.08	0.27	13.07	<0.001
<8	REF	.	.	.	.	.
Average length of hospital stay (in days)						
≥3.6	0.109	0.03	0.06	0.16	18.02	<0.001
<3.6	REF	.	.	.	.	.
Teaching Status						
Undergraduate only	0.139	0.03	0.08	0.20	22.09	<0.001
None, graduate, major	REF	.	.	.	.	.

Adult: Broad-spectrum antibacterial agents predominantly used for community-acquired infections

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-3.949	0.18	-4.31	-3.59	472.89	<0.001

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Location type						
Medical ICU, medical ward, general hematology-oncology ward	0.360	0.03	0.31	0.41	197.15	<0.001
Medical-surgical ICU, medical-surgical ward	0.294	0.03	0.24	0.34	136.88	<0.001
Step down unit	0.208	0.03	0.15	0.27	46.93	<0.001
Surgical ICU, surgical ward	REF	.	.	.	.	.
Facility type						
Critical access, general acute care, oncology	1.538	0.18	1.19	1.89	73.19	<0.001
Surgical, Veterans Affairs	1.281	0.18	0.92	1.64	49.42	<0.001
Military	1.078	0.19	0.71	1.44	33.36	<0.001
Women's, women's and children's	REF	.	.	.	.	.
Average length of hospital stay (in days)						
<4.5	0.171	0.02	0.13	0.21	63.64	<0.001
4.5 - 5.1	0.113	0.02	0.07	0.16	23.95	<0.001
≥5.2	REF	.	.	.	.	.
Number of hospital beds, facility-wide						
<135	0.251	0.03	0.20	0.30	99.39	<0.001
135 - 330	0.155	0.02	0.12	0.19	65.90	<0.001
≥331	REF	.	.	.	.	.
ICU beds (as a percentage of total beds)						
<7.6%	0.120	0.02	0.07	0.17	23.20	<0.001
≥7.6%	REF	.	.	.	.	.

Adult: Antibacterial agents predominantly used for resistant Gram-positive infections (e.g., MRSA)

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-4.002	0.20	-4.39	-3.61	402.38	<0.001
Location type						
Medical ICU, medical-surgical ICU, surgical ICU	0.838	0.03	0.77	0.90	667.29	<0.001
Medical ward, medical-surgical ward, hematology-oncology ward, step down unit	0.144	0.03	0.09	0.20	24.78	<0.001
Surgical ward	REF	.	.	.	.	.
Facility type						
Critical access, general acute, oncology, surgical, VA	1.129	0.19	0.75	1.51	33.69	<0.001
Military	0.701	0.20	0.30	1.10	12.02	<0.001
Women's, women's and children's	REF	.	.	.	.	.
Number of hospital beds, facility-wide						
≥66	0.162	0.04	0.09	0.23	19.98	<0.001

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
<66	REF	.	.	.	.	.
Average length of hospital stay (in days)						
≥3.3	0.191	0.03	0.14	0.24	51.19	<0.001
<3.3	REF	.	.	.	.	.

Adult: Narrow-spectrum beta-lactam agents

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-3.223	0.07	-3.36	-3.09	2101.80	<0.001
Location type						
Surgical ICU, surgical ward	1.129	0.07	1.00	1.26	276.13	<0.001
Medical-surgical ICU, medical-surgical ward	0.500	0.06	0.37	0.63	60.55	<0.001
Step down unit	0.286	0.07	0.15	0.42	17.51	<0.001
Medical ICU, medical ward	0.215	0.07	0.09	0.34	10.85	0.001
General hematology-oncology ward	REF	.	.	.	.	.
Average length of hospital stay (in days)						
<3.5	0.261	0.03	0.20	0.32	75.22	<0.001
≥5.8	0.173	0.03	0.11	0.24	26.40	<0.001
3.5 - 5.7	REF	.	.	.	.	.
ICU beds (as a percentage of total beds)						
≥8.6%	0.163	0.03	0.11	0.22	30.48	<0.001
<8.6%	REF	.	.	.	.	.
Number of hospital beds, facility-wide						
≥222	0.111	0.02	0.07	0.16	23.37	<0.001
<222	REF	.	.	.	.	.

Adult: Antifungal agents predominantly used for invasive candidiasis

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-6.739	0.36	-7.44	-6.04	352.37	<0.001
Location type						
Surgical ICU, general hematology-oncology ward	1.264	0.06	1.15	1.38	440.72	<0.001
Medical ICU, medical-surgical ICU	0.899	0.04	0.83	0.97	609.34	<0.001
Step down unit	0.164	0.04	0.08	0.25	14.45	<0.001
Medical ward, medical-surgical ward, surgical ward	REF	.	.	.	.	.
Number of ICU beds, facility-wide						
≥78	0.761	0.07	0.62	0.90	113.16	<0.001

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
15 - 77	0.480	0.07	0.35	0.61	53.60	<0.001
8 - 14	0.331	0.07	0.19	0.47	21.62	<0.001
<8	REF	.	.	.	.	.
Number of hospital beds, facility-wide						
176 - 306	0.161	0.04	0.09	0.23	20.69	<0.001
<176 or ≥307	REF	.	.	.	.	.
Facility type						
Oncology	3.537	0.59	2.38	4.70	35.74	<0.001
Critical access, general acute care, surgical	1.924	0.35	1.23	2.62	29.42	<0.001
Military, Veterans Affairs	1.539	0.36	0.84	2.24	18.53	<0.001
Women's, women's and children's	REF	.	.	.	.	.
Average length of hospital stay (in days)						
≥5.2	0.384	0.06	0.28	0.49	48.45	<0.001
4.5 - 5.1	0.255	0.05	0.15	0.36	21.86	<0.001
3.0 - 4.4	0.169	0.05	0.07	0.27	10.56	0.001
<3.0	REF	.	.	.	.	.

Adult: Complementary group of antibacterial agents

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-2.555	0.05	-2.66	-2.45	2343.21	<0.001
Location type						
Medical ICU	0.498	0.04	0.42	0.57	163.19	<0.001
Medical-surgical ICU	0.332	0.03	0.27	0.39	120.09	<0.001
Surgical ICU, medical ward, medical-surgical ward	0.215	0.03	0.17	0.26	73.30	<0.001
General hematology-oncology ward, step down unit	0.148	0.03	0.09	0.21	25.14	<0.001
Surgical Ward	REF	.	.	.	.	.
Average length of hospital stay (in days)						
<3	0.185	0.03	0.14	0.23	54.60	<0.001
≥3	REF	.	.	.	.	.
Facility type						
Critical access, general acute, oncology, surgical, women's, women's and children's	0.376	0.05	0.28	0.47	59.71	<0.001
Veterans Affairs	0.271	0.05	0.17	0.37	26.75	<0.001
Military	REF	.	.	.	.	.

Adult: Antibacterial agents posing the highest risk for CDI

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-2.675	0.06	-2.78	-2.57	2323.70	<0.001
Location type						
Medical ICU, medical-surgical ICU, general hematology-oncology ward	0.492	0.03	0.44	0.55	309.10	<0.001
Medical ward	0.339	0.03	0.28	0.40	141.54	<0.001
Surgical ICU, medical-surgical ward, step down unit	0.269	0.03	0.22	0.32	107.26	<0.001
Surgical ward	REF	.	.	.	.	.
Facility type						
Critical access, general acute, oncology, surgical	0.501	0.05	0.41	0.59	109.63	<0.001
Veterans Affairs	0.243	0.05	0.14	0.34	21.85	<0.001
Military, women's, women's and children's	REF	.	.	.	.	.
Teaching status						
None, undergraduate, graduate	0.081	0.02	0.05	0.12	21.04	<0.001
Major	REF	.	.	.	.	.
Average length of hospital stay (in days)						
<5.2	0.077	0.02	0.04	0.12	15.87	<0.001
≥5.2	REF	.	.	.	.	.
Number of hospital beds, facility-wide						
<442	0.147	0.02	0.10	0.19	46.73	<0.001
≥442	REF	.	.	.	.	.
Number of ICU beds, facility-wide						
<15	0.063	0.02	0.02	0.10	9.60	0.002
≥15	REF	.	.	.	.	.

Pediatric: Broad-spectrum antibacterial agents predominantly used for hospital-onset infections

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-3.004	0.16	-3.32	-2.69	354.40	<0.001
ICU beds (as a percentage of total beds)						
≥16.6%	0.295	0.12	0.06	0.53	5.99	0.014
<16.6%	REF	.	.	.	.	.
Location/Facility type combination						
Medical-surgical ICU in children's, general acute, military, women's and children's hospitals**;** Medical ward in children's hospitals	0.756	0.18	0.40	1.11	17.30	<0.001
Medical-surgical ward in children's, general acute, military, women's and children's hospitals	0.406	0.16	0.08	0.73	6.11	0.013

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Medical ICU in general acute care hospitals; Medical ward in general acute, military, women's and children's hospitals; Surgical ward in children's, general acute care hospitals	REF	.	.	.	.	.

Pediatric: Broad-spectrum antibacterial agents predominantly used for community-acquired infections

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-2.886	0.12	-3.12	-2.65	596.67	<0.001
Number of hospital beds, facility-wide						
<450	0.476	0.08	0.32	0.63	34.87	<0.001
≥450	REF	.	.	.	.	.
Facility Type						
General acute care, women's and children's	0.548	0.09	0.37	0.73	36.23	<0.001
Children's, military	REF	.	.	.	.	.
Location type						
Medical-surgical ICU, medical ICU	0.263	0.08	0.12	0.41	12.28	<0.001
Medical-surgical ward, medical ward, surgical ward	REF	.	.	.	.	.

Pediatric: Narrow-spectrum beta-lactam agents

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-2.470	0.04	-2.56	-2.39	3261.86	<0.001
Location/Facility type combination						
Medical-surgical ICU in children's hospitals; Surgical ward in children's, general acute care hospitals	0.657	0.13	0.40	0.91	24.98	<0.001
Medical and medical-surgical wards in children's, general acute, military, women's and children's hospitals; Medical-surgical ICU in general acute, military, women's and children's; Medical ICU in general acute care hospitals	REF	.	.	.	.	.
Number of hospital beds, facility-wide						
<204 or ≥450	0.316	0.06	0.19	0.44	25.19	<0.001
204 - 449	REF	.	.	.	.	.

Pediatric: Antibacterial agents predominantly used for resistant Gram-positive infections (e.g., MRSA)

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-2.552	0.05	-2.65	-2.45	2436.92	<0.001
ICU location	0.461	0.10	0.27	0.65	23.35	<0.001

Pediatric: Azithromycin

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-6.232	0.39	-6.99	-5.47	258.24	<0.001
Location type						
Medical-surgical ICU, medical ICU	2.350	0.39	1.59	3.11	36.79	<0.001
Medical-surgical ward, medical ward	1.969	0.38	1.22	2.71	26.82	<0.001
Surgical ward	REF	.	.	.	.	.
Number of hospital beds, facility-wide						
<204	0.383	0.19	0.02	0.75	4.28	0.039
204 - 276	1.346	0.19	0.98	1.71	51.91	<0.001
277 - 449	0.803	0.15	0.51	1.09	29.23	<0.001
≥450	REF	.	.	.	.	.

Pediatric: Antifungal agents predominantly used for invasive candidiasis

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-5.579	0.14	-5.85	-5.31	1608.54	<0.001
ICU beds (as a percentage of total beds)						
≥16.6%	0.957	0.17	0.62	1.29	31.25	<0.001
<16.6%	REF	.	.	.	.	.
Location type						
Medical-surgical ICU, medical ICU	1.136	0.17	0.80	1.48	42.61	<0.001
Medical-surgical ward, medical ward, surgical ward	REF	.	.	.	.	.

Pediatric: Complementary group of antibacterial agents

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-3.338	0.09	-3.51	-3.17	1467.30	<0.001
ICU beds (as a percentage of total beds)						
≥16.6%	0.638	0.09	0.47	0.81	54.01	<0.001
<16.6%	REF	.	.	.	.	.

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Average length of hospital stay (in days)						
≥4.5	0.238	0.09	0.07	0.41	7.49	0.006
<4.5	REF	.	.	.	.	.
Number of hospital beds, facility-wide						
≥450	0.237	0.10	0.05	0.43	5.99	0.014
<450	REF	.	.	.	.	.

Pediatric: Antibacterial agents posing the highest risk for CDI

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 *P* value
Intercept	-2.275	0.12	-2.51	-2.04	371.36	<0.001
Location type						
Medical-surgical ICU, medical ICU	0.271	0.08	0.11	0.43	11.33	<0.001
Medical-surgical ward, medical ward, surgical ward	REF	.	.	.	.	.
Number of hospital beds, facility-wide						
<386	0.315	0.08	0.16	0.47	15.72	<0.001
≥386	REF	.	.	.	.	.
Average length of stay (in days)						
4.1 - 4.7	0.214	0.08	0.05	0.38	6.65	0.01
<4.1 or ≥4.8	REF	.	.	.	.	.
Facility type						
General acute care, women's and children's	0.366	0.10	0.17	0.56	13.36	<0.001
Children's, military	REF	.	.	.	.	.

Neonatal: Vancomycin predominantly used for treatment of late-onset sepsis

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 P value
Intercept	-7.433	0.26	-7.93	-6.93	847.31	<.0001
Percentage of annual neonatal admissions that are very low birthweight (≤1500g)						
≥4.0%	1.687	0.23	1.23	2.15	51.95	<.0001
1.3 - 3.9%	1.001	0.30	0.41	1.59	11.15	0.0008
<1.3%	REF	.	.	.	.	.
Unit type (level of neonatal care) and facility capabilities (Level IV capabilities)						
Level II/III, III, or IV NICU in facility that accepts neonates as transfers for various specified complex procedures[3]	2.182	0.20	1.79	2.57	120.75	<.0001

Level II/III, III, or IV NICU in facility that does NOT accept neonates as transfers for various specified complex procedures[3]	1.352	0.18	1.00	1.71	55.40	<.0001
Level II neonatal step-down unit	REF	.	.	.	.	.

Neonatal: Broad spectrum antibacterial agents predominantly used for hospital-onset infections

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 P value
Intercept	-9.746	0.56	-10.85	-8.64	301.22	<.0001
Percentage of annual neonatal admissions that are very low birthweight (≤1500g)						
≥5.7%	3.627	0.54	2.57	4.68	45.32	<.0001
1.3 - 5.6%	2.693	0.56	1.59	3.80	22.79	<.0001
<1.3%	REF	.	.	.	.	.
Unit type (level of care) and facility capabilities (Level IV capabilities)						
Level III or IV NICU in facility that accepts neonates as transfers for various specified complex procedures[3]	2.660	0.32	2.04	3.28	70.12	<.0001
Level II/III NICU; Level III or IV NICU in facility that does NOT accept neonates as transfers for various specified complex procedures[3]	1.377	0.27	0.85	1.91	26.06	<.0001
Level II neonatal step-down unit	REF	.	.	.	.	.

Neonatal: 3rd generation cephalosporins

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 P value
Intercept	-5.860	0.23	-6.30	-5.41	666.10	<.0001
Facility demographics (facility type, medical school affiliation, bed size)						
All children's, women's, and women's children's facilities; General acute care and military facilities with medical school affiliation and >=469 beds	1.830	0.28	1.28	2.38	43.10	<.0001
General acute care and military facilities with medical school affiliation and <469 beds	0.708	0.26	0.20	1.21	7.60	0.0058
General acute care and military facilities with NO medical school affiliation	REF	.	.	.	.	.

Neonatal: Ampicillin predominantly used for treatment of early-onset sepsis

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 P value
Intercept	-2.508	0.05	-2.61	-2.41	2546.04	<.0001
Number of annual outborn admissions						
0 outborn admissions	0.387	0.09	0.21	0.57	18.03	<.0001
1 or more outborn admissions	REF	.	.	.	.	.
Percentage of annual neonatal admissions that are very low birthweight (≤1500g)						
<11.3%	0.375	0.07	0.25	0.50	32.14	<.0001
≥11.3%	REF	.	.	.	.	.

Neonatal: Aminoglycosides predominantly used for treatment of early-onset and late-onset sepsis

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 P value
Intercept	-2.766	0.05	-2.87	-2.66	2568.30	<.0001
Number of annual outborn admissions						
0 outborn admissions	0.414	0.10	0.22	0.61	17.06	<.0001
1 or more outborn admissions	REF	.	.	.	.	.
Percentage of annual neonatal admissions that are very low birthweight (≤1500g)						
<11.3%	0.360	0.07	0.22	0.50	24.57	<.0001
≥11.3%	REF	.	.	.	.	.

Neonatal: Fluconazole predominantly used for candidiasis

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 P value
Intercept	-7.010	0.24	-7.48	-6.54	864.20	<.0001
Percentage of annual neonatal admissions with birthweight ≤750g						
≥1.3%	2.592	0.26	2.08	3.10	98.85	<.0001
0.2 - 1.2%	1.173	0.30	0.58	1.76	15.20	<.0001
<0.2%	REF	.	.	.	.	.

Neonatal: All antibacterial agents

Parameter	Estimate	SE[1]	Wald 95% CLs[2]		Wald χ2	χ2 P value
Intercept	-1.736	0.06	-1.86	-1.61	775.02	<.0001
Level of neonatal care and overall neonatal reporting to AU Option						
Level III or IV unit in a facility with Level II and/or II/III unit(s) reporting[4]	0.486	0.12	0.24	0.73	15.54	<.0001
Level II or II/III unit OR Level III/IV unit in a facility without Level II or II/III unit(s) reporting[4]	REF	.	.	.	.	.
Number of annual outborn admissions						
0 outborn admissions	0.315	0.08	0.17	0.46	17.70	<.0001
1 or more outborn admissions	REF	.	.	.	.	.
Percentage of annual neonatal admissions that are normal birthweight (>2500g)						
≥54.1%	0.243	0.06	0.13	0.35	18.75	<.0001
<54.1%	REF	.	.	.	.	.
Total number of annual neonatal admissions						
≥268 annual admissions	0.179	0.06	0.07	0.29	9.93	0.0016
<268 annual admissions	REF	.	.	.	.	.

Abbreviations:
[1]SE=standard error
[2]CLs=confidence limits
[3]Procedures include: Omphalocele repair; ventriculoperitoneal shunt; tracheoesophageal fistula/esophageal atresia repair; bowel resection/reanastomosis; meningomyelocele repair; cardiac catheterization
[4]Neonatal units present within a facility AND for which data is being reported to the AU Option

Appendix: Revision History

Revised Date	Version	Description
02/01/2023	1.0	Added neonatal SAAR model details, information about TAS, and updates for 2023.
03/17/2023	1.1	Technical Writer review; added sections: Revision History and Intended Audience.