Measuring Antibiotic Use in NHSN

Jonathan R. Edwards, MStat.
Research Mathematical Statistician
Division of Healthcare Quality Promotion
National Center for Emerging and Zoonotic Infectious Diseases

SHEA Antimicrobial Stewardship Research Workshop
November 30, 2016
Learning Objectives

- Identify analytical methods for measuring antibiotic use
- Indicate the role of risk adjustment when analyzing antibiotic stewardship and use data
- Describe predictive models that produce the Standardized Antimicrobial Administration Ratio (SAAR), which is NHSN’s new AU clinical quality measure
Antimicrobial Use and Resistance (AUR) Module – The Basics

- Designed to support healthcare and public health efforts to:
  - (1) Monitor and improve antimicrobial prescribing
  - (2) Identify, understand, and respond to antimicrobial resistance patterns or trends
- Provides a common set of technical specifications and a single surveillance platform for hospitals to report AU and AR data
- All data must be submitted electronically to the AUR Module
- Data that are successfully transmitted are available immediately to NHSN users for analysis and visualization
- Summary data provide AU and AR benchmarks that hospitals, healthcare systems, and public health agencies can use for comparative purposes and as a guide for further analysis and action
AU Data Flow From Bedside to NHSN

Extract, transform and load AU data by means of a vendor or homegrown IT solution

- Monthly summary data
- 89 antimicrobials
- Location specific
- Days present and admissions

Submit AU data using standard file format

Local AU data access via NHSN’s web interface

Analysis, visualization, and reporting AU data

eMAR/BCMA and ADT Systems

NHSN Servers
Data Sources:
- Numerator: Electronic Medication Administration Record (eMAR) or Bar Coding Medication Administration (BCMA) systems for AU data
- Denominator: Admission/Discharge/Transfer (ADT) systems for patient location data

Participation:
- General acute care hospitals, long-term acute care hospitals, inpatient rehabilitation facilities, oncology hospitals, critical access hospitals
- Locations/units in which numerator & denominator can be accurately electronically captured
  - All NHSN-defined inpatient locations
  - Select outpatient locations: Emergency Department, Pediatric Emergency Department, 24-hour Observation Unit
NHSN AU Reporting Option: Operational Overview (continued)

- Monthly Numerator Data:
  - Antimicrobial days – Days of therapy for a specified antimicrobial agent administered in a patient care location
  - 89 antimicrobials are in scope - Antibacterial, antifungal, and anti-influenza agents,
    - Stratified by route of administration: intravenous, intramuscular, digestive, and respiratory

- Monthly Denominator Data:
  - Days present – Number of patients in a specific location or facility, per day, aggregated for a monthly total
  - Admissions – Number of patients admitted to the hospital
NHSN AU Option Submission Metrics

- 146 facilities submitted at least 1 month of data
  - From 31 states: AZ, CA, CO, CT, FL, IA, ID, IL, IN, KS, KY, MA, MI, MN, MO, NC, ND, NE, NM, NY, OH, OK, OR, PA, RI, SD, TN, TX, UT, VA, WI
  - Bed size:
    - Average = 233
    - Median = 217
    - Min/Max = 11,919
  - 59% teaching hospitals
    - 57% major teaching
  - Majority submission part of health system submission or large academic medical center
  - Using 6 vendors and ‘homegrown’ systems

- Data from 77 hospitals for 2014 were used for the NHSN AU measure submission to the National Quality Forum (NQF) in 2015

*As of August 2016*
The SAAR is the quantitative linchpin of the NHSN AU Measure; it summarizes AU in the form of an observed-to-predicted ratio:

- **Numerator** – Observed days of therapy reported by a healthcare facility for a specified category of antimicrobial agents used in a patient care location or group of locations
- **Denominator** – Days of therapy predicted for a healthcare facility’s use of a specified category of antimicrobial agents in a patient care location or group of locations, calculated by applying negative binomial regression modeling to nationally aggregated AU data

SAAR values can serve as a starting point for medication use evaluations by antimicrobial stewardship programs, but SAAR values are not definitive measures of judiciousness or appropriateness

Current and Planned Use of the Measure:

- [✓] Public health/disease surveillance
- [✓] Quality improvement (internal to the specific organization)
- [✓] Quality improvement (external benchmarking involving multiple organizations)
- [ ] Public reporting
- [ ] Payment program
- [ ] Regulatory and accreditation programs
- [ ] Professional certification or recognition program
Interpreting SAAR Values

SAAR values are always greater than 0, and a value of 1.0 suggests equivalency between observed and predicted antibiotic use.

- A SAAR that is not statistically different from 1.0 indicates antibiotic use is equivalent to the referent population’s antibiotic use.
- A high SAAR (above 1.0) that achieves statistical significance (i.e., different from 1.0) may indicate excessive antibiotic use.
- A low SAAR (below 1.0) that achieves statistical significance (i.e., different from 1.0) may indicate antibiotic under use.

Note: A SAAR above 1.0 that does not achieve statistical significance may still be associated with excessive AU and warrant further investigation. Also, a SAAR that differs statistically from 1.0 does not assure that further investigation will be productive.
The NHSN AU Measure is comprised of 16 SAARs, each of which summarizes AU for a specified combination of patient care locations and antimicrobial agents. SAARs are generated for six specified groupings of adult and pediatric patient care locations:

1. Adult medical, surgical, and medical/surgical intensive care units
2. Adult medical, surgical, and medical/surgical wards
3. Pediatric medical, surgical, and medical/surgical intensive care units
4. Pediatric medical, surgical, and medical/surgical wards
5. All adult medical, medical/surgical, and surgical intensive care units and wards
6. All pediatric medical, medical/surgical, and surgical intensive care units and wards
Antimicrobial Agent Categories Used for SAARs Metrics

High value targets for antimicrobial stewardship programs:

1. **Broad spectrum agents predominantly used for hospital-onset/multi-drug resistant bacteria** – aminoglycosides, 4\textsuperscript{th} and 5\textsuperscript{th} gen. cephalosporins, penicillin B-lactam/b-lactamase inhibitor combinations, carbapenems (except ertapenem)

2. **Broad spectrum agents predominantly used for community-acquired infection** – ertapenem, some cephalosporins, and fluoroquinolones

3. **Anti-MRSA agents** – ceftaroline, dalbavancin, daptomycin, linezolid, oritavancin, quinupristin/dalfopristin, tedizolid, telavancin, and vancomycin

4. **Agents predominantly used for surgical site infection prophylaxis** – cefazolin, cefotetan, cefoxitin, cefuroxime

High level indicators for antimicrobial stewardship programs:

5. **All antibiotic agents** – All agents included in NHSN AUR protocol

*A complete list of all antimicrobials used in each SAAR can be found here: [http://www.cdc.gov/nhsn/pdfs/pscmanual/11pscaurcurrent.pdf](http://www.cdc.gov/nhsn/pdfs/pscmanual/11pscaurcurrent.pdf)*
Predictive Modeling

- **Data:**
  - 2014 NHSN AU data
  - 77 hospitals: 350 adult locations, 33 pediatric locations
  - Each Antimicrobial SAAR category was modeled separately
  - Patient care location and facility-level data, no patient level data

- **Modeling details:**
  - Forward stage-wise Negative Binomial Regression
  - Binary or Nominal variables
  - Estimates the number of predicted antimicrobial days
SAAR Predictive Models Include Hospital and Patient Location Variables

Broad Spectrum Agents Predominantly Used for Hospital-Onset/multi-drug resistant infections
- ICU, 4-way location-type variable (Levels: Medical Unit, Medical/Surgical Unit, Surgical Unit, Pediatric Unit*)

Broad Spectrum Agents Predominantly Used for Community Acquired infections
- Teaching Status, ICU, Pediatric Location

Anti-MRSA Agents
- ICU, 4-way location-type variable (Levels: Medical Unit, Medical/Surgical Unit, Surgical Unit, Pediatric Unit*), Interaction Term: ICU and 4 way location-type variable

Agents Predominantly Used for Surgical Site Infection Prophylaxis
- ICU, Surgical Location

All Agents
- ICU, 4 way location-type variable (Levels: Medical Unit, Medical/Surgical Unit, Surgical Unit, Pediatric Unit*)

*Referent group in a multi-way variable
Antimicrobial Agent Categories Used for SAARs Metrics

High value targets for antimicrobial stewardship programs:

1. **Broad spectrum agents predominantly used for hospital-onset/multi-drug resistant bacteria** – aminoglycosides, 4th and 5th gen. cephalosporins, penicillin B-lactam/b-lactamase inhibitor combinations, carbapenems (except ertapenem)

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## Model 1: Broad Spectrum HO/MDRO

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Wald 95% Confidence Limits</th>
<th>Wald Chi-square</th>
<th>Chi-square p-value</th>
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<tbody>
<tr>
<td>Intercept</td>
<td>-2.669</td>
<td>0.081</td>
<td>-2.827 - 2.511</td>
<td>1092.18</td>
<td>&lt;.0001</td>
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<tr>
<td>ICU</td>
<td>0.971</td>
<td>0.052</td>
<td>0.868 - 1.074</td>
<td>343.77</td>
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<td>Location Type: MEDICAL UNIT</td>
<td>0.522</td>
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<td>34.98</td>
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<tr>
<td>Location Type: MEDICAL/SURGICAL UNIT</td>
<td>0.444</td>
<td>0.090</td>
<td>0.266 - 0.621</td>
<td>24.05</td>
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<tr>
<td>Location Type: SURGICAL UNIT</td>
<td>0.406</td>
<td>0.098</td>
<td>0.213 - 0.598</td>
<td>17.02</td>
<td>&lt;.0001</td>
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<tr>
<td>Location Type: PEDIATRIC UNIT</td>
<td>REF</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
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</table>
# SAAR Distributions

**Broad Spectrum for HO/MDR Infections Category**

<table>
<thead>
<tr>
<th>NQF Reporting Measure</th>
<th>N*</th>
<th>Median SAAR</th>
<th>SAAR statistically lower than 1 N (%)</th>
<th>SAAR statistically higher than 1 N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult ICUs</td>
<td>100</td>
<td>0.914</td>
<td>52 (52%)</td>
<td>37 (37%)</td>
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<tr>
<td>Adult Wards</td>
<td>250</td>
<td>0.983</td>
<td>108 (43%)</td>
<td>99 (40%)</td>
</tr>
<tr>
<td>Pediatric ICUs</td>
<td>7</td>
<td>0.881</td>
<td>4 (57%)</td>
<td>1 (14%)</td>
</tr>
<tr>
<td>Pediatric Wards</td>
<td>26</td>
<td>1.119</td>
<td>13 (50%)</td>
<td>8 (31%)</td>
</tr>
</tbody>
</table>

* Locations
SAAR Distributions—ICUs vs. Wards

- Median SAAR values differ greatly between ICUs and wards for broad spectrum community onset agents (ICU median=0.78, Ward median=0.94). This may relate to the spread and skew of predicted DOT.
SAAR Output in NHSN*

*Synthetic data, for example only

```plaintext
<table>
<thead>
<tr>
<th>orgID</th>
<th>summaryYO</th>
<th>SAARType</th>
<th>antimicrobialDays</th>
<th>numAUDaysPredicted</th>
<th>numDaysPresent</th>
<th>SAAR</th>
<th>SAAR_pval</th>
<th>SAAR95CI</th>
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<tbody>
<tr>
<td>13860</td>
<td>2014Q1</td>
<td>TAR-Adult-2</td>
<td>151</td>
<td>381.046</td>
<td>3526</td>
<td>0.396</td>
<td>0.0000</td>
<td>0.337, 0.463</td>
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<tr>
<td>13860</td>
<td>2014Q2</td>
<td>TAR-Adult-2</td>
<td>176</td>
<td>373.157</td>
<td>3453</td>
<td>0.469</td>
<td>0.0000</td>
<td>0.403, 0.542</td>
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<tr>
<td>13860</td>
<td>2014Q3</td>
<td>TAR-Adult-2</td>
<td>131</td>
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<td>3426</td>
<td>0.354</td>
<td>0.0000</td>
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<tr>
<td>13860</td>
<td>2014Q4</td>
<td>TAR-Adult-2</td>
<td>680</td>
<td>618.920</td>
<td>4751</td>
<td>1.118</td>
<td>0.0089</td>
<td>1.029, 1.212</td>
</tr>
<tr>
<td>13860</td>
<td>2015Q1</td>
<td>TAR-Adult-2</td>
<td>769</td>
<td>542.163</td>
<td>4656</td>
<td>1.540</td>
<td>0.0000</td>
<td>1.436, 1.651</td>
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<tr>
<td>13860</td>
<td>2015Q2</td>
<td>TAR-Adult-2</td>
<td>60</td>
<td>122.332</td>
<td>1132</td>
<td>0.490</td>
<td>0.0000</td>
<td>0.378, 0.627</td>
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</tbody>
</table>

Observed Use (SAAR Denominator)
Predicted Use (SAAR Denominator)
Calculated Rate
SAAR Values

Includes data for January 2014 and forward.
Data restricted to medical, medical/surgical and surgical locations.
Source of aggregate data: 2014 NHSN AU Data
Data contained in this report were last generated on March 15, 2016 at 10:33 AM.
```
Using the SAAR to Evaluate Stewardship

Facility-level Standardized Antimicrobial Administration Ratios (SAAR), 2013-2015

Livorsi DJ, et al. Using the SAAR to monitor the influence of antimicrobial stewardship activities. Poster presented at: IDWeek 2016; October 2016; New Orleans, LA.
Summary

- SAAR is new and unlike any AU measure currently available
- Takes into account some but not all factors that are known sources of variability in antimicrobial use.
  - Next steps: continued risk adjustment and patient level factors
- Provides benchmarks that antibiotic stewardship programs can use in their efforts to monitor and improve the use of antibiotics in acute care hospitals
  - Next steps: SAAR assessment tool
  - Relationship of the SAAR with stewardship practices
ADDITIONAL METHODS AND RESULTS
### Spectrum of Agents

<table>
<thead>
<tr>
<th>Narrower</th>
<th>Broader</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>• Penicillin G</td>
<td>• Tetracycline</td>
</tr>
<tr>
<td>• Penicillin V</td>
<td>• Doxycycline</td>
</tr>
<tr>
<td>• Oxacillin</td>
<td>• Minocycline</td>
</tr>
<tr>
<td>• Dicloxacillin</td>
<td>• Azithromycin</td>
</tr>
<tr>
<td>• Ampicillin</td>
<td>• Clarithromycin</td>
</tr>
<tr>
<td>• Amoxicillin</td>
<td>• Erythromycin</td>
</tr>
<tr>
<td>• Cefazolin</td>
<td>• Sulfamethoxazole/Trimethoprim</td>
</tr>
<tr>
<td>• Cephalexin</td>
<td>• Cefoxitin</td>
</tr>
<tr>
<td>• Nitrofurantoin</td>
<td>• Cefuroxime</td>
</tr>
<tr>
<td>• Metronidazole</td>
<td>• Clindamycin</td>
</tr>
</tbody>
</table>

#### Narrower Spectrum of Agents

- penicillin G
- penicillin V
- oxacillin
- dicloxacillin
- ampicillin
- amoxicillin
- cefazolin
- cephalexin
- nitrofurantoin
- metronidazole

#### Broader Spectrum of Agents

- tetracycline
- doxycycline
- minocycline
- azithromycin
- clarithromycin
- erythromycin
- sulfamethoxazole/trimethoprim
- cefoxitin
- cefuroxime
- clindamycin
- amoxicillin/clavulanate
- ampicillin/sulbactam
- ceftriaxone
- ciprofloxacin
- gemifloxacin
- levofloxacin
- moxifloxacin
- aztreonam
- ceftazidime
- ertapenem
- vancomycin
- ceftaroline
- imipenem/cilastatin
- meropenem
- piperacillin/tazobactam
- ticarcillin/clavulanate
- daptomycin
- linezolid
- tigecycline
- colistimethate
SAAR Visual Output*
(Coming January 2017)

DOTs per 1,000 patient days

Customizable agents list

*Synthetic data, for example only
Does Cefepime, Vancomycin, and Piperacillin/Tazobactam use increase following October 1, 2015 Sepsis Measure?
Piperacillin/Tazobactam Use
(Days of Therapy per 1000 day present)

Days of therapy per 1,000 days present

Sepsis measure took effect
Percent of Hospitals with Antibiotic Stewardship Programs by State, 2015*

*N: A hospital stewardship program is defined as a program following all 7 of CDC’s Core Elements of Hospital Antibiotic Stewardship Programs.

Source: CDC’s National Healthcare Safety Network (NHSN) Survey

Nationally, 48.1% of all hospitals have stewardship programs (2,199 of 4,540); the national goal is 100% of hospitals by 2020.
Next Steps for the NHSN AU Measure

- Maintain collaborations—and develop additional partnerships—with hospitals and healthcare systems that submit AU data to NHSN and use the data in their antimicrobial stewardship programs
- Participate in AU and antimicrobial stewardship studies that use AU data and stewardship survey data submitted to NHSN
- Use field experience with the SAAR, additional AU data collection and analysis, and other studies to enhance the SAAR predictive models
- Work on a second iteration of the NHSN AU Measure that will enable the measure to be used for public reporting and other accountability purposes
Thank You!

NHSN@cdc.gov


For more information please contact Centers for Disease Control and Prevention

1600 Clifton Road NE, Atlanta, GA 30333
Telephone, 1-800-CDC-INFO (232-4636)/TTY: 1-888-232-6348
E-mail: cdcinfo@cdc.gov Web: www.cdc.gov

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.
EXTRA SLIDES
Available SAARs

- 16 specific SAARs can be generated in NHSN
  - Specific location types
  - Specific antimicrobial groups
    - Broad Spectrum Agents Predominantly Used for Hospital Onset/MDRO infections
    - Broad Spectrum Agents Predominantly Used for Community Onset infections
    - Anti MRSA Agents
    - Agents Predominantly Used for Surgical Site Prophylaxis Agents
    - All Antibiotics

NHSN AU Measure - SAARs for High Value Targets

SAARs for broad spectrum antibacterial agents predominantly used for hospital-onset/multidrug resistant infections:
1. Adult medical, medical/surgical, and surgical ICUs
2. Adult medical, medical/surgical, and surgical wards
3. Pediatric medical, medical/surgical, and surgical ICUs
4. Pediatric medical, medical/surgical, and surgical wards

SAARs for broad spectrum antibacterial agents predominantly used for community-acquired infections:
5. Adult medical, medical/surgical, and surgical ICUs
6. Adult medical, medical/surgical, and surgical wards
7. Pediatric medical, medical/surgical, and surgical ICUs
8. Pediatric medical, medical/surgical, and surgical wards

Note: All patient care locations are according to CDC location definitions
SAARs for anti-MRSA antibacterial agents:
9. Adult medical, medical/surgical, and surgical ICUs
10. Adult medical, medical/surgical, and surgical wards
11. Pediatric medical, medical/surgical, and surgical ICUs
12. Pediatric medical, medical/surgical, and surgical wards

SAARs for antibacterial agents predominantly used for surgical site infection prophylaxis:
13. Adult ICUs and wards (medical, medical/surgical, and surgical)
14. Pediatric ICUs and wards (medical, medical/surgical, and surgical)

Note: All patient care locations are according to CDC location definitions
NHSN AU Measure - High Level Indicator SAARs

SAARs for all antibacterial agents:

15. Adult ICUs and wards (medical, medical/surgical, and surgical)
16. Pediatric ICUs and wards (medical, medical/surgical, and surgical)

Note: All patient care locations are according to CDC location definitions