Antimicrobial Use and Resistance (AUR) Module

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Introduction
This module contains two options, one focused on antimicrobial usage and the second on antimicrobial resistance. To participate in either option, facility personnel responsible for reporting antimicrobial use (AU) or resistance (AR) data to the National Healthcare Safety Network (NHSN) must coordinate with their laboratory and/or pharmacy information software providers to configure their system to enable the generation of standard formatted file(s) to be imported into NHSN. The format provided for data submission follows the Health Level (HL7) Clinical Document Architecture (CDA).[7] Manual data entry is not available for the AUR Module.

Purpose:
The goal of this National Healthcare Safety Network (NHSN) AUR Module is to provide a mechanism for facilities to report and analyze antimicrobial use and/or resistance as part of local or regional efforts to reduce antimicrobial resistant infections through antimicrobial stewardship efforts or interruption of transmission of resistant pathogens at their facility[6].

1. Antimicrobial Use (AU) Option

Introduction

Rates of resistance to antimicrobial agents continue to increase at hospitals in the United States.[1] The two main reasons for this increase are patient-to-patient transmission of resistant organisms and selection of resistant organisms because of antimicrobial exposure.[2] Previous studies have shown that feedback of reliable reports of rates of antimicrobial use and resistance to clinicians can improve the appropriateness of antimicrobial usage.[3-5]

Objectives: The primary objective of the Antimicrobial Use option is to facilitate risk-adjusted inter- and intra-facility benchmarking of antimicrobial usage. A secondary objective is to evaluate trends of antimicrobial usage over time at the facility and national levels.

Methodology: The primary antimicrobial usage metric reported to this module is antimicrobial days per 1000 days present. An antimicrobial day (also known as day of therapy) is defined by any amount of a specific antimicrobial agent administered in a calendar day to a particular patient as documented in the electronic medication administration record (eMAR) and/or bar coding medication record (BCMA) (refer to Numerator Data Section); all antimicrobial days for a specific agent administered across a population are summed in aggregate.[8-11] Days present are defined as the aggregate number of patients housed to a patient-care location or facility anytime throughout a day during a calendar month (refer to Denominator Data Section). For each facility, the numerator (i.e., antimicrobial days) is aggregated by month for each patient-care location and overall for inpatient areas facility-wide (i.e., facility-wide-inpatient). Similarly, the denominator (i.e., days present) is calculated for the corresponding patient-care-location-month or facility-wide-inpatient-month. A secondary antimicrobial usage metric for facility-wide-inpatient also reported to this module is antimicrobial days per 1000 admissions. The numerator and denominators are further defined below and must adhere to the data format prescribed by the HL7 CDA Implementation Guide developed by the CDC and HL7.[7]

Settings: NHSN encourages submission of all NHSN-defined inpatient locations, facility-wide-inpatient, and select outpatient acute-care settings (i.e., outpatient emergency department, pediatric emergency department, 24-hour observation area) at each facility (Table 1). The patient-care areas may include adult, pediatric, or neonatal units as defined by NHSN Codes (Chapter 15 CDC Locations and Descriptions). A comprehensive submission will enable a facility to optimize inter- and/or intra-facility comparisons among specific wards, combined wards, and hospital-wide data. The optional and minimal requirements for participation in the Antimicrobial Use option are listed in Table 1.

The minimal requirement for participation is submission of data for all four of the following locations (if applicable to facility): 1) all medical critical care units(s) and

surgical critical care units(s) [if combined units, then report as medical/surgical critical care unit(s)]; 2) all medical ward(s) and surgical ward(s) [if combined wards, then report as medical/surgical ward(s)]; 3) at least one specialty care area; and 4) facility-wide-inpatient (both days present and admissions must be reported for this location).

Table 1. ***CDC Location[a]: Optional and Minimal Requirements for AU Option***

Inpatient Locations	Minimal Submission Requirements (if applicable for facility)
Adult Critical Care Units	**Requirement**: For facilities with only adult critical care unit(s): submit all medical critical care unit(s) and surgical critical care units(s) [if combined units, then report as medical/surgical critical care unit(s)]. For facilities with adult and pediatric critical care unit(s), the minimum requirement is the submission of data from all adult and pediatric critical care locations.
Pediatric Critical Care Units	**Requirement**: For facilities with only pediatric critical care unit(s): submit all medical critical care unit(s) and surgical critical care units(s) [if combined units, then report as medical/surgical critical care unit(s)]. For facilities with adult and pediatric critical care unit(s), the minimum requirement is the submission of data from all adult and pediatric critical care locations.
Neonatal Units	Optional (i.e., no minimal submission requirement)
Inpatient Specialty Care Areas	**Requirement:** At least one Specialty Care Area
Inpatient Adults Wards	**Requirement:** For facilities with only adult medical and surgical ward(s), submit all medical ward(s) and surgical ward(s) [if combined wards, then report as medical/surgical ward(s)]. For facilities with adult and pediatric medical and surgical ward(s), the minimum requirement is the submission of data from all adult and pediatric medical and surgical ward locations.
Inpatient Pediatric Wards	**Requirement:** For facilities with only pediatric medical and surgical ward(s), submit all medical ward(s) and surgical ward(s) [if combined wards, then report as medical/surgical ward(s)]. For facilities with adult and pediatric medical and surgical ward(s), the minimum requirement is the submission of data from all adult and pediatric medical and surgical ward locations.
Step Down Units	Optional (i.e., no minimal submission requirement)

Inpatient Locations	Minimal Submission Requirements (if applicable for facility)
Operating Rooms	Optional (i.e., no minimal submission requirement)
Long Term Care	Optional (i.e., no minimal submission requirement)
Facility-Wide	**Minimal Submission Requirements (if applicable for facility)**
Facility-wide-inpatient	**Requirement:** Facility-wide-inpatient
Outpatient Locations	**Minimal Submission Requirements (if applicable for facility)**
Select Acute Care Settings Outpatient Emergency Department Pediatric Emergency Department 24-Hour Observation Area	Optional (i.e., no minimal submission requirement)

[a]**CDC Location:** A CDC-defined designation given to a patient-care area housing patients who have similar disease conditions or who are receiving care for similar medical or surgical specialties. Each facility location that is monitored is "mapped" to one CDC Location. The specific CDC Location code is determined by the type of patients cared for in that area according to the **80% Rule**. That is, if 80% of patients are of a certain type (e.g., pediatric patients with orthopedic problems), then that area is designated as that type of location (in this case, an Inpatient Pediatric Orthopedic Ward). See Locations chapter for more information regarding location mapping.

Requirements:

An acceptable minimal month of data includes:
a. Data submitted for all four of the following locations (if applicable to facility): 1) all medical critical care unit(s) and surgical critical care unit(s) [if combined units, then report as medical/surgical critical care unit(s)]; 2) all medical ward(s) and surgical ward(s) [if combined wards, then report as medical/surgical ward(s)]; 3) at least one specialty care area; and 4) facility-wide-inpatient (both days present and admissions must be reported for this location).
b. Each month, the facility must choose to monitor antimicrobial use data on the *Patient Safety Monthly Reporting Plan* (CDC 57.106)
c. All data fields outlined in the *Table of Instructions* (Appendix A) for the AU option are completed via CDA for each location.

Numerator Data (Antimicrobial Days):

Antimicrobial Days (Days of Therapy): Defined as the aggregate sum of days for which any amount of a specific antimicrobial agent was administered to individual patients as documented in the eMAR and/or BCMA.[8-11] Appendix B provides a list of antimicrobial agents. Aggregate antimicrobial days are reported monthly for inpatient locations, facility-wide-inpatient, and select outpatient acute-care settings (e.g., outpatient emergency department, pediatric emergency department, 24-hour observation area) for select antimicrobial agents and stratified by route of administration (e.g., intravenous,

intramuscular, digestive and respiratory). Refer to Table 2 and Table 3 for definitions of drug-specific antimicrobial days and stratification based on route of administration. For example, a patient to whom 1 gram vancomycin is administered intravenously twice daily for three days will be attributed three "Vancomycin Days (total)" and three "Vancomycin Days (IV)" when stratified by intravenous route of administration. Appendix C provides additional examples for the calculation of antimicrobial days. Table 4 summarizes the data elements for numerator calculation. Please note that "zero" should be recorded when no aggregate usage occurred during a given reporting period for a specific antimicrobial agent at a facility in which the agent is used, while "not applicable" should be recorded when data are not available for a specific antimicrobial agent at a facility (e.g., the agent can't be electronically captured at that facility). A value (e.g., a specific number, "zero", or "not applicable") should be reported for every antimicrobial agent listed in Appendix B.

Table 2. ***Classification and Definitions of Route of Administrations for Antimicrobial Days***

Classification: Route of Administration[a]	**Definition**[b,c]
Intravenous	An intravascular route that begins with a vein.
Intramuscular	A route that begins within a muscle.
Digestive Tract	A route that begins anywhere in the digestive tract extending from the mouth through rectum.
Respiratory Tract	A route that begins within the respiratory tract, including the oropharynx and nasopharynx.

[a] Other routes of administration are excluded in this module (e.g., antibiotic locks, intraperitoneal, intraventricular, irrigation, topical).
[b]Definitions per SNOMED Reference Terminology
[c]Mapping of standardized terminology for route of administration are provided PHIN VADS

Table 3. ***Example Stratification of Antimicrobial Days by Route of Administration***

Month/ Year-Location	**Antimicrobial Agent**	**Drug-specific Antimicrobial Days**				
		Total[a]	**IV**	**IM**	**Digestive**[b]	**Respiratory**
Month-Year/ Location	Tobramycin	Tobramycin Days (Total)	Tobramycin Days (IV)	Tobramycin Days (IM)	Tobramycin Days (Digestive)	Tobramycin Days (Respiratory)

[a]Drug-specific antimicrobial days (total) attributes one antimicrobial day for any route of administration. For example, a patient to whom tobramycin was administered intravenously and via a respiratory route on the same day would be attributed "one Tobramycin Day (Total)"; the stratification by route of administration would be "one Tobramycin Day (IV)" and "one Tobramycin Day (Respiratory)".
[b] For purposes of example of route stratification only (tobramycin not FDA approved for administration via the digestive route).

Table 4. ***Data Elements for Antimicrobial Days***

	Antimicrobial Days
Antimicrobial Agents	Defined as select antimicrobial agents and stratified by route of administration (i.e., intravenous, intramuscular, digestive and respiratory). Refer to Appendix B for a complete list of antimicrobial agents. The list of select antimicrobial agents will evolve with time as new agents become commercially available. *Topical antimicrobial agents are not included in this module option.*
Data source	Antimicrobial days are derived from administered data documented in the eMAR and/or BCMA only. Usage derived from other data sources (e.g., pharmacy orders, doses dispensed, doses billed) cannot be submitted.
Location	Antimicrobial days are aggregated for inpatient locations, facility-wide-inpatient, and select outpatient acute-care settings (i.e., outpatient emergency department, pediatric emergency department, 24-hour observation area) per NHSN location definitions.
Time Unit	Antimicrobial days for a specific antimicrobial agent and stratification by route of administration are aggregated monthly per location.

Denominator Data (Days Present and Admissions): The numerator will be analyzed against the denominator of days present and also admissions for facility-wide-inpatient only. The denominators are further defined below.

Days present: Defined as time period during which a given patient is at risk for antimicrobial exposure for a given patient location. The definition of days present differs from conventional definition of patient days used in other NHSN modules and that recommended by the SHEA/HIPAC guidance for surveillance of multidrug-resistant organisms.[12] Days present is further defined below in context of calculation for patient care location specific analyses and facility-wide-inpatient analyses. Please note that a separate calculation for days present is required for patient-care location compared to facility-wide-inpatient.

> For patient-care location-specific analyses, days present is calculated as the number of patients who were present for any portion of each day of a calendar month for a patient-care location; the aggregate measure is calculated by summing up all of the days present for that location and month. The day of admission, discharge, and transfer to and from locations will be included in days present. For example, a patient admitted to the medical ward on Monday and discharged two days later on Wednesday will be attributed three days present on that medical ward. Another example, on the day a patient is transferred from a medical critical-care unit to a medical ward; the patient will be attributed one day present on the medical critical care unit as well as one day present on the medical ward. Similarly, a patient's exposure to the operating room or emergency department will be included in days present for these types of units. However, one patient can account for only one day present for a specific location per calendar day (e.g., one patient cannot contribute more than 1 day present to any one unique location on the same day, but can contribute a day present to two different locations on the same day). For example, a

patient transferred from the surgical ward to the operating room and back to the surgical ward in a calendar day contributes one day present to the surgical ward and one day present to the operating room.

For facility-wide-inpatient analyses, days present is calculated as the number of patients who were present for any portion of each day of a calendar month at the facility-wide-inpatient location; the aggregate measure is calculated by summing up all of the days present for facility-wide-inpatient for a given month. Thus, a sum of days present from location-specific analyses would be higher than days present for the facility, because transfers between wards can account for multiple location "days present" for a given patient. Therefore, the individual summing of days present for location-specific analyses to achieve facility-wide-inpatient is not permissible. The calculation must be a separate summation for facility-wide-inpatient analyses.

Admissions: Admissions are defined as the aggregate number of patients admitted to the facility (i.e., facility-wide-inpatient) starting on first day of each calendar month through the last day of the calendar month. This is the same definition for admissions utilized in the NHSN MDRO/CDI Module. In the AU option, admissions are reported only for facility-wide-inpatient.

Table 5. ***Location-specific and Facility-wide-inpatient Metrics***

Metric Collected	Metric Definition	Comments
Inpatient Care Location-Specific Analyses		
Antimicrobial Days/Days present	Drug-specific antimicrobial days per patient-care location per month/Days present per patient-care location per month	One patient can contribute only one day present per calendar day for each specific location. Summed total may be higher when compared to facility-wide measure (reflecting transfers between locations).
Facility-wide-inpatient Analyses		
Antimicrobial Days/Days present	Drug-specific antimicrobial days for a facility per month/Days present per facility-wide-inpatient per month	One patient can contribute only one day present per calendar day for a facility. Thus, one denominator is obtained for an entire facility. The day present measure for facility-wide-inpatient may be lower when compared to sum total from location-specific comparison.
Antimicrobial Days/Admissions	Drug-specific antimicrobial days for a facility per month/Admissions per facility-wide-inpatient per month	Only calculated for facility-wide-inpatient for AU Option.

Data Analyses:
Antimicrobial use data are expressed as incidence density rates of antimicrobial days per days present stratified by patient-care location and facility-wide-inpatient. Antimicrobials may be grouped during analysis by route of administration, spectrum of activity, therapeutic indication, or drug classification.
A secondary metric, antimicrobial days per admissions, will also be analyzed for facility-wide-inpatient.

References

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Appendix A. Table of Instructions: Antimicrobial Use

Data Field	Instructions for CDA of Antimicrobial Use Data
Facility identifier	Required. Must be assigned to facility and included in the importation file prior to submission to CDC.
Month	Required. Record the 2-digit month during which the data were collected for this location.
Year	Required. Record the 4-digit year during which the data were collected for this location.
Location	Required. Record location; must be (if applicable to facility): 1) all medical critical care unit(s) and surgical critical care unit(s) [if combined units, then report as medical/surgical critical care unit(s)]; 2) all medical ward(s) and surgical ward(s) [if combined wards, then report as medical/surgical ward(s)]; 3) at least one specialty care area; and 4) facility-wide-inpatient
Numerator: Antimicrobial days per month per location	Required. Antimicrobial days are defined as the aggregate sum of the days of exposure for which a specific antimicrobial was administered. These are required to be extracted from electronic medication administration record (eMAR) and/or bar coding medication record (BCMA). Antimicrobials days will be collected for select antimicrobial agents (refer to Appendix B) and stratified by route of administration.
Denominator: Days present Admissions	Required. Days present is defined as risk for antimicrobial exposure per time unit of analysis stratified by location. For patient-care location-specific analyses, days present is calculated as the number of patients who were present for any portion of each day of a calendar month for a patient-care location. For facility-wide-inpatient analyses, days present is calculated as the number of patients who were present for any portion of each day of a calendar month at the facility-wide-inpatient location Admissions are defined as the aggregate number of patients admitted to the facility (i.e., facility-wide-inpatient) starting on first day of each calendar month through the last day of the calendar month. In the AUR Use Option, admissions are only reported for facility-wide-inpatient.

Appendix B. List of Antimicrobials

Please note that mapping of standardized terminology (RXNORM) are provided PHIN Vocabulary Access and Distribution System (VADS).

Antimicrobial Agent	Antimicrobial Category	Antimicrobial Class[a]	Antimicrobial Subclass[a]
AMANTADINE	Anti-influenza	M2 ion channel inhibitors	
AMIKACIN	Antibacterial	Aminoglycosides	
AMOXICILLIN	Antibacterial	Penicillins	Aminopenicillin
AMOXICILLIN/ CLAVULANATE	Antibacterial	Penicillins	B-lactam/ B-lactamase inhibitor combination
AMPHOTERICIN B	Antifungal	Polyenes	
AMPHOTERICIN B LIPOSOMAL	Antifungal	Polyenes	
AMPICILLIN	Antibacterial	Penicillins	Aminopenicillin
AMPICILLIN/ SULBACTAM	Antibacterial	Penicillins	B-lactam/ B-lactamase inhibitor combination
ANIDULAFUNGIN	Antifungal	Echinocandins	
AZITHROMYCIN	Antibacterial	Macrolides	
AZTREONAM	Antibacterial	Monobactams	
CASPOFUNGIN	Antifungal	Echinocandins	
CEFACLOR	Antibacterial	Cephalosporins	Cephalosporin 2rd generation
CEFADROXIL	Antibacterial	Cephalosporins	Cephalosporin 1st generation
CEFAZOLIN	Antibacterial	Cephalosporins	Cephalosporin 1st generation
CEFDINIR	Antibacterial	Cephalosporins	Cephalosporin 3rd generation
CEFDITOREN	Antibacterial	Cephalosporins	Cephalosporin 3rd generation
CEFEPIME	Antibacterial	Cephalosporins	Cephalosporin 4th generation
CEFIXIME	Antibacterial	Cephalosporins	Cephalosporin 3rd generation
CEFOTAXIME	Antibacterial	Cephalosporins	Cephalosporin 3rd generation
CEFOTETAN	Antibacterial	Cephalosporins	Cephamycin
CEFOXITIN	Antibacterial	Cephalosporins	Cephamycin
CEFPODOXIME	Antibacterial	Cephalosporins	Cephalosporin 3rd generation
CEFPROZIL	Antibacterial	Cephalosporins	Cephalosporin 2rd generation
CEFTAROLINE	Antibacterial	Cephalosporins	Cephalosporin 5th generation
CEFTAZIDIME	Antibacterial	Cephalosporins	Cephalosporin 3rd generation
CEFTIBUTEN	Antibacterial	Cephalosporins	Cephalosporin 3rd generation
CEFTIZOXIME	Antibacterial	Cephalosporins	Cephalosporin 3rd generation
CEFTRIAXONE	Antibacterial	Cephalosporins	Cephalosporin 3rd generation

Antimicrobial Agent	Antimicrobial Category	Antimicrobial Class[a]	Antimicrobial Subclass[a]
CEFUROXIME	Antibacterial	Cephalosporins	Cephalosporin 2rd generation
CEPHALEXIN	Antibacterial	Cephalosporins	Cephalosporin 1st generation
CHLORAMPHENICOL	Antibacterial	Phenicols	
CIPROFLOXACIN	Antibacterial	Fluoroquinolones	
CLARITHROMYCIN	Antibacterial	Macrolides	
CLINDAMYCIN	Antibacterial	Lincosamides	
COLISTIMETHATE	Antibacterial	Polymyxins	
DAPTOMYCIN	Antibacterial	Lipopeptides	
DICLOXACILLIN	Antibacterial	Penicillins	Penicillinase-stable penicillins
DORIPENEM	Antibacterial	Carbapenems	
DOXYCYCLINE	Antibacterial	Tetracyclines	
ERTAPENEM	Antibacterial	Carbapenems	
ERYTHROMYCIN	Antibacterial	Macrolides	
ERYTHROMYCIN/ SULFISOXAZOLE	Antibacterial	Folate pathway inhibitors/ Sulfonamides	
FIDAXOMICIN	Antibacterial	Macrocyclic	
FLUCONAZOLE	Antifungal	Azoles	
FOSFOMYCIN	Antibacterial	Fosfomycins	
GEMIFLOXACIN	Antibacterial	Fluoroquinolones	
GENTAMICIN	Antibacterial	Aminoglycosides	
IMIPENEM/ CILASTATIN	Antibacterial	Carbapenems	
ITRACONAZOLE	Antifungal	Azoles	
LEVOFLOXACIN	Antibacterial	Fluoroquinolones	
LINEZOLID	Antibacterial	Oxazolidinones	
MEROPENEM	Antibacterial	Carbapenems	
METRONIDAZOLE	Antibacterial	Nitroimidazoles	
MICAFUNGIN	Antifungal	Echinocandins	
MINOCYCLINE	Antibacterial	Tetracyclines	
MOXIFLOXACIN	Antibacterial	Fluoroquinolones	
NAFCILLIN	Antibacterial	Penicillins	Penicillinase-stable penicillins
NITROFURANTOIN	Antibacterial	Nitrofurans	
OSELTAMIVIR	Anti-influenza	Neuraminidase inhibitors	

Antimicrobial Agent	Antimicrobial Category	Antimicrobial Class[a]	Antimicrobial Subclass[a]
OXACILLIN	Antibacterial	Penicillins	Penicillinase-stable penicillins
PENICILLIN G	Antibacterial	Penicillins	Penicillin
PENICILLIN V	Antibacterial	Penicillins	Penicillin
PIPERACILLIN	Antibacterial	Penicillins	Ureidopenicillin
PIPERACILLIN/ TAZOBACTAM	Antibacterial	Penicillins	B-lactam/ B-lactamase inhibitor combination
POLYMYXIN B	Antibacterial	Polymyxins	
POSACONAZOLE	Antifungal	Azoles	
QUINUPRISTIN/ DALFOPRISTIN	Antibacterial	Streptogramins	
RIFAMPIN	Antibacterial	Rifampin	
RIMANTADINE	Anti-influenza	M2 ion channel inhibitors	
SULFAMETHOXAZOLE/ TRIMETHOPRIM	Antibacterial	Folate pathway inhibitors	
SULFISOXAZOLE	Antibacterial	Folate pathway inhibitors	
TELAVANCIN	Antibacterial	Lipo-glycopeptides	
TELITHROMYCIN	Antibacterial	Ketolides	
TETRACYCLINE	Antibacterial	Tetracyclines	
TICARCILLIN/ CLAVULANATE	Antibacterial	Penicillins	B-lactam/ B-lactamase inhibitor combination
TIGECYCLINE	Antibacterial	Glycylcyclines	
TINIDAZOLE	Antibacterial	Nitroimidazoles	
TOBRAMYCIN	Antibacterial	Aminoglycosides	
VANCOMYCIN	Antibacterial	Glycopeptides	
VORICONAZOLE	Antifungal	Azoles	
ZANAMIVIR	Anti-influenza	Neuraminidase inhibitors	

[a] Adapted from CLSI January 2010

Appendix C. Example Calculations of Antimicrobial Days

Example 1. Example eMAR and Calculation of Antimicrobial Days
This example illustrates the calculation of antimicrobial days from a patient receiving meropenem 1gram intravenously every 8 hours and amikacin 1000mg intravenously every 24 hours in the medical ward. Table 1 provides an example of administered doses for this patient documented in eMAR. Table 2 illustrates the calculation of meropenem and amikacin days by drug-specific (total) and stratified by route of administration based upon the administered doses of meropenem and amikacin documented in eMAR. Table 3 illustrates the contribution of this patient's antimicrobial days to the aggregate monthly report per patient-care location.

Table 1. ***Example eMAR for Patient housed in Medical Ward***

Medical Ward	Monday December 28	Tuesday December 29	Wednesday December 30
Meropenem 1gram intravenously every 8 hours	Given: 2300	Given: 0700 Given: 1500 Given: 2300	Given: 0700
Amikacin 1000mg intravenously every 24 hours	Given: 2300	Given: 2300	

Table 2. ***Example of calculation of antimicrobial days***

Calculation	Monday December 28	Tuesday December 29	Wednesday December 30
Drug-specific Antimicrobial Days (total)	Meropenem Days = 1 Amikacin Days = 1	Meropenem Days = 1 Amikacin Days = 1	Meropenem Days = 1 Amikacin Days = 0
Drug-specific Antimicrobial Days by Stratification of Route of Administration	Meropenem Days (IV) = 1 Amikacin Days (IV) = 1	Meropenem Days (IV) = 1 Amikacin Days (IV) = 1	Meropenem Days (IV) = 1 Amikacin Days (IV) = 0

Table 3. ***Example of antimicrobial days per month per patient-care location***

Month/ Year-Location	Antimicrobial Agent	Drug-specific Antimicrobial Days				
		Total	IV	IM	Digestive	Respiratory
December Medical Ward	Meropenem	3	3	0	0	0
December Medical Ward	Amikacin	2	2	0	0	0

Example 2. Differences in Calculation for Patient-Care Location and Facility-Wide-Inpatient for a Patient Transferred Between Patient-Care Locations

This example illustrates the calculation of antimicrobial days from a patient receiving vancomycin 1gram every 8 hours that was transferred from the MICU to a medical ward on December 1. Table 1 provides an example of doses documented in eMAR administered to this patient in the MICU and medical ward. Table 2 illustrates the calculation of vancomycin days by drug-specific (total) and stratified by route of administration based upon the administered doses of vancomycin documented in eMAR. Table 3 illustrates the contribution of this patient's vancomycin days to the aggregate monthly report per patient-care location and facility-wide-inpatient.

Table 1. ***Example eMAR for Patient transferred from MICU to Medical Ward on December 1.***

	Tuesday December 1 Location: MICU	**Tuesday December 1 Location: Medical Ward**
Vancomycin 1gram intravenously every 8 hours	Given: 0700	Given: 1500 Given: 2300

Table 2. ***Example of calculation of antimicrobial days for December 1***

Calculation	**Tuesday, December 1 Location: MICU**	**Tuesday December 1Location: Medical Ward**
Drug-specific Antimicrobial Days (total)	Vancomycin Days = 1	Vancomycin Days = 1
Drug-specific Antimicrobial Days by Stratification of Route of Administration	Vancomycin Days (IV) = 1	Vancomycin Days (IV) = 1

Table 3. ***Example of antimicrobial days per month per patient-care location and facility-wide inpatient contributed from December 1***

Month/ Year-Location	**Antimicrobial Agent**	**Drug-specific Antimicrobial Days**				
		Total	**IV**	**IM**	**Digestive**	**Respiratory**
December MICU	Vancomycin	1	1	0	0	0
December Medical Ward	Vancomycin	1	1	0	0	0
December Facility-wide-inpatient	Vancomycin	1	1	0	0	0

Example 3. Calculation of Antimicrobial Days for a Patient-Care Location when a Patient Admission extends over Two Different Months

This example illustrates the calculation of antimicrobial days from a patient receiving ceftriaxone 1gram intravenously every 24 hours for two days in the surgical ward (but spanning different months). Table 1 provides an example of administered doses for this patient documented in eMAR. Table 2 illustrates the calculation of ceftriaxone days by drug-specific (total) and stratification of route of administration based upon the administered doses of ceftriaxone documented in eMAR. Table 3 illustrates the contribution of this patient's ceftriaxone days to the aggregate monthly report per patient-care location.

Table 1. ***Example eMAR for Patient housed in Surgical Ward***

	Thursday December 31 Location: Surgical Ward	**Friday January 1 Location: Surgical Ward**
Ceftriaxone gram intravenously every 24 hours	Given: 0800	Given: 0800

Table 2. ***Example of calculation of antimicrobial days***

Calculation	**Thursday December 31 Location: Surgical Ward**	**Friday January 1 Location: Surgical Ward**
Drug-specific Antimicrobial Days (total)	Ceftriaxone Day = 1	Ceftriaxone Day = 1
Drug-specific Antimicrobial Days by Stratification of Route of Administration	Ceftriaxone Day (IV) = 1	Ceftriaxone Day (IV) = 1

Table 3. ***Example of antimicrobial days per month per patient-care location***

Month/ Year-Location	**Antimicrobial Agent**	**Drug-specific Antimicrobial Days**				
		Total	**IV**	**IM**	**Digestive**	**Respiratory**
December/ Surgical Ward	Ceftriaxone	1	1	0	0	0
January/ Surgical Ward	Ceftriaxone	1	1	0	0	0

2. Antimicrobial Resistance (AR) Option

Introduction

Common measures of antimicrobial resistance include the proportion of isolates resistant to specific antimicrobial agents. This proportion resistant (%R) is used to aid in clinical decision making (hospital antibiograms) as well as for assessing impact of cross transmission prevention success or antimicrobial stewardship success, although the measure may not be very sensitive to measuring success of efforts in the short term. An additional value of measuring the proportion resistant includes a local or regional assessment of progression or improvement of a particular resistance problem, to guide local or regional cross-transmission prevention efforts. By utilizing standard methodology of aggregating proportion resistant, better local and regional assessments of the magnitude of a particular resistance phenotype will be more valid.

Objectives:

1. Facilitate evaluation of antimicrobial resistance data using a standardized approach to
    a. Provide local practitioners with an improved awareness of a variety of antimicrobial-resistance problems to both aid in clinical decision making and prioritize transmission prevention efforts
    b. Provide facility-specific measures in context of a regional and national perspective (i.e., benchmarking) which can inform decisions to accelerate transmission prevention efforts and reverse propagation of emerging or established problematic resistant pathogens.
2. Regional and national assessment of resistance of antimicrobial resistant pathogens of public health importance including ecologic assessments and infection burden

Methodology:

Antimicrobial resistance data are reported as a proportion and rate in this module.[8] The proportion resistant is defined as the number of resistant isolates divided by the number of isolates tested for the specific antimicrobial agent being evaluated. In comparison, the antimicrobial resistance rate is defined as the number of resistant isolates per 1000 patient days. For each facility, the numerator (i.e., number of resistant isolates) is derived from isolate-level reports submitted. The denominator is reported directly (i.e., not derived from other reports). The numerator and denominator are further defined below and must adhere to the data format prescribed by the HL7 CDA Implementation Guide developed by the CDC and HL7.[7]

Settings:

NHSN requires reports to cover all NHSN-defined inpatient locations and select outpatient acute-care settings (i.e., outpatient emergency department, pediatric emergency department, 24-hour observation area) at each facility. Eligible facilities include acute care facilities including long-term acute care and inpatient rehabilitation facilities.

Requirements:

Each month,

1. The facility must choose to monitor antimicrobial resistance data on the *Patient Safety Monthly Reporting Plan* (CDC 57.106)
2. Two record types must be reported for each month of surveillance.
   - One for the isolate-based reports
   - One for the denominator data report (facility-wide).

Isolate-based report

Report all required data each month for each eligible Isolate-based report. Eligible Isolate-based reports must have had susceptibility testing performed. Two distinct events should be reported. (See Appendix A)

1. **First** eligible pathogen isolated from blood culture per patient, per 14 day period even across calendar months (i.e., report all *unique blood* specimens).
2. **First** eligible pathogen isolated from any eligible non-blood culture source, per patient, per month. This should be consistent with CLSI M39 Guidance on reporting cumulative susceptibility test results.

A. Eligible pathogens include:

- *Acinetobacter baumannii* (ACBA)
- *Candida albicans* (CA)
- *Candida glabrata* (CG)
- *Citrobacter freundii* (CF)
- *Enterobacter spp.*(ESP)
- *Enterococcus faecalis* (ENTFS)
- *Enterococcus faecium,* (ENTFM)
- *Enterococcus spp. NOS (not otherwise specified to the species level)* (ENTSP)
- *Escherichia coli* (EC)
- *Group B Streptococcus* (GBS)
- *Klebsiella oxytoca* (KO)
- *Klebsiella pneumoniae* (KP)
- *Morganella morganii* (MM)
- *Proteus mirabilis* (PM)
- *Pseudomonas aeruginosa* (PA)
- *Serratia marcescens* (SM)
- *Staphylococcus aureus* (SA)
- *Stenotrophomonas maltophilia* (STEMA)
- *Streptococcus pneumoniae* (SP)

B. Specimen Sources

- Eligible non-blood culture source (one per patient, per month) include:
  - Lower respiratory (e.g., sputum, endotracheal, bronchoalveolar lavage)
  - Urine
  - Cerebral spinal fluid

- Unique Blood Specimen:
  - Report blood cultures growing same eligible pathogen with no intervening positive blood culture (with same eligible pathogen) within 14 days.
    - In a patient who already has a blood culture isolate-based report for a specific organism, report an additional Isolate-based report from an additional blood culture only if there is no prior positive blood culture for the same genus/species within 14 days, even across calendar months.
    - There should be a full 14 days with no positive blood culture result with the same genus/species from the same patient before another Unique Blood Specimen is reported. (e.g., there should be >14 days since previous isolation)

Use SNOMED codes to identify eligible specimen types to be included in identification of Isolate-based report. (Appendix B)

C. Required data includes mostly data available from the laboratory information system and some from administrative data systems. The set of variables for each isolate consists of a technical variable, healthcare facility identifier and epidemiological variables which are further classified into variables at isolate level and variables at antimicrobial test level. The first level includes data referring to the isolate which are repeated in all records reporting the antimicrobial susceptibility tests performed for that isolate (See Appendix C).

- Isolate / Patient related data
  - Patient identifier
  - Date of Birth
  - Gender
  - Date admitted to hospital
  - Specimen Collection Date
  - Specimen source (SNOMED)
  - Location code – (mapped to CDC location codes)
  - Isolate identifier (unique isolate ID)
  - Pathogen (Appendix A)

- Antimicrobial susceptibility data
  - Antibiotic (Appendix A)
  - PBP2a-agglutination (only if STAAUR)

- PCR mec-gene (only if STAAUR)
- E-test sign
- E-test value
- Interpretation of E-test
- MIC sign
- MIC value
- Interpretation of MIC test
- Zone sign
- Zone value
- Interpretation of zone test (disk diffusion)
- Final interpretation result

- Technical variable
  - Facility ID (facility identifier, unique to NHSN)

D. Remove Duplicates

The goal of this option to capture the first isolate per patient per month from non-blood culture source and in addition, every unique blood isolate per patient per month (maximum of 3 per month per patient). However, often multiple isolates of the same species are processed on the same day, often with conflicting results. Only one isolate should be chosen, retaining the unique nature of the test results. Rules must be in place to ensure duplicate isolate reports are removed. Duplicates are defined as same species or same genus when identification to species level is not provided from same patient on same day. Identify observations reflecting multiple isolates within the same day (i.e., using the field Isolate ID when available) and select the isolate to report to NHSN based on these rules:

- Eliminate isolates on same day without susceptibility test results
- On a single isolate if no final interpretation, prioritize test results for "E-test interpretation> MIC interpretation > Zone Interpretation"
- On a single isolate, when multiple results per antimicrobial (for a single test method), choose the most resistant result for each antimicrobial
- Do not merge test results across multiple isolates (i.e., don't summarize results across different isolates tested on same day)
- If testing results are indistinguishable, choose isolate test with more complete fields for other variables
- Interpretation of test results (E-test, MIC test, Zone test) includes the following results S=Susceptible, S-DD – Susceptible-Dose Dependent, I =Intermediate, R=Resistant NS = Non-Susceptible, N = Not Tested

Examples should reflect the above rules:

- Example 1: two different tests on same date are performed, producing conflicting SIR interpretations. Results should be merged into a single observation, with the "Final interpretation" variable being populated by the final determination of the laboratory.
- Example 2: Same test but conflicting results. Report most resistant (i.e., R > I > S).

- Example 3: Same test and same results. Report result with most complete fields for other variables.

Denominator data report

For each month, report facility-wide denominator data (See Appendix D)

1. Patient Days: Number of patients present in the hospital at the same time period on each day of the month, summed across all days in the month
2. Admissions: Number of patients admitted to the hospital each month
3. Number of blood cultures performed, each month (for all locations included in the reporting plan).

   For further information on counting patient days and admissions http://www.cdc.gov/nhsn/PDFs/PatientDay_SumData_Guide.pdf.

Minimizing Bias
Source of test results should be from the hospital laboratory-information system (LIS). However, efforts should be made to reduce selection bias inherent in systems that have suppression rules in place preventing testing results from being placed into the LIS. Efforts should be made to optimize suppression rules so resistant results are not suppressed (i.e. only suppress susceptible results of candidates to be suppressed). Alternatively, allow transmission of suppressed results to LIS but construct LIS-based selective suppression of reports to clinicians (but not laboratorians).

Data Analyses:
Antimicrobial resistance data will be expressed using several metrics, likely at quarterly, semi-annual, or annual time frame depending on how rare the isolates occurred. (See Table 1)

Table 1. ***Proposed Resistance Metrics***

Metric	Definition	Comments
Facility-wide-inpatient: standard output for facility and group user.		
% non-susceptible	(# Resistant + # Intermediate/ # tested) Drug-specific antimicrobial resistance for a facility /Number of isolates tested per facility for specific microorganism-antimicrobial pairing	Custom output can include stratification by specimen source; blood, urine, other; helpful for empiric prescribing for suspected pathogen. Report non-susceptible since many organisms lack resistant breakpoint to specific drugs, reporting would be similar to, EARS-Net and more closely represents clinical care setting.
BSI % non-susceptible	(# Resistant BSI + # Intermediate BSI/# tested) Drug-specific antimicrobial resistance among positive blood cultures for a facility/Number of isolates from blood cultures tested per facility for specific microorganism-antimicrobial pairing	Most comparable to EARS-net. If patient identifiers are retained, this can be de-duplicated to be fully comparable with EARS-Net with a 1 patient/year measure.
Hospital- onset antimicrobial resistance rate	Drug-specific antimicrobial resistance (i.e., # non-susceptible) among isolates collected >3 days after admission, for a facility/1000 patient-days	Focuses on incident cultures, proxy for transmission within a hospital or exogenous acquisition. May be good outcome for stewardship
BSI resistance incidence (stratified by timing of onset)	Drug-specific antimicrobial resistance (i.e., # non-susceptible) unique blood culture positive tests /100 admissions. Evaluate by timing of blood culture (hospital onset vs. present on admission)	Overall good measure of community and hospital-based occurrence, estimates crude burden, can be split by crude hospital onset and crude community onset

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Appendix A. List of Microorganisms for Antimicrobial Resistance[9]

Please note that mapping of standardized terminology (SNOMED) are provided via the hai-voc spreadsheet.

Micro-organism	Specimen Type	Antimicrobial Agents
Acinetobacter baumannii	Blood, Urine, Lower Respiratory, CSF	Ampicillin-sulbactam Ceftazidime Ciprofloxacin Levofloxacin Imipenem Meropenem Gentamicin Tobramycin Amikacin Piperacillin-tazobactam Ticarcillin-clavulanate Cefepime Cefotaxime Ceftriaxone Doxcycline Minocycline Tetracycline Piperacillin Trimethoprim-sulfamethoxazole
	Additional Agents for Urine	None
Candida albicans *Candida glabrata*	Blood, Urine, CSF [Lower respiratory will not be collected for Candida spp.],	Anidulafungin Caspofungin Fluconazole Flucytosine Itraconazole Micafungin Posaconazole Voriconazole
	Additional Agents for Urine	None
Citrobacter freundii *Enterobacter* spp. *Escherichia coli* *Klebsiella oxytoca* *Klebsiella pneumoniae* *Morganella morganii*	Blood, Urine, Lower Respiratory, CSF	Ampicillin Cefazolin Gentamicin Tobramycin Amikacin Amoxicillin-clavulanic acid

Micro-organism	Specimen Type	Antimicrobial Agents
Proteus mirabilis *Serratia marcescens*		Ampicillin-sulbactam Piperacillin-tazobactam Ticarcillin-clavulanic acid Cefuroxime Cefepime Cefoxitin Cefotaxime Ceftriaxone Ciprofloxacin Levofloxacin Doripenem Ertapenem Imipenem Meropenem Piperacillin Trimethoprim-sulfamethoxazole Aztreonam Ceftazidime Chloramphenicol Tetracycline
	Additional Agents for Urine	Cephalothin Lomefloxacin Ofloxacin Norfloxacin Nitrofurantoin Sulfisoxazole Trimethoprim
Enterococcus faecalis *Enterococcus faecium* *Enterococcus* spp. NOS (not otherwise specified) (excluding *E. faecalis* and *E. faecium, and excluding other identified species)*	Blood, Urine, Lower Respiratory, CSF	Ampicillin Penicillin Daptomycin Linezolid Quinupristin/dalfopristin Vancomycin High-level Resistance Screen for Gentamicin and Streptomycin (non-urine isolates only); synergistic test result will be reported as susceptible; non-synergistic test result will be reported as resistant.

Micro-organism	Specimen Type	Antimicrobial Agents
	Additional Agents for Urine	Ciprofloxacin Levofloxacin Norfloxacin Nitrofurantoin Tetracycline
Pseudomonas aeruginosa	Blood, Urine, Lower Respiratory, CSF	Ceftazidime Gentamicin Tobramycin Piperacillin Amikacin Aztreonam Cefepime Ciprofloxacin Levofloxacin Imipenem Meropenem Piperacillin-tazobactam Ticarcillin
	Additional Agents for Urine	Lomefloxacin Ofloxacin Norfloxacin
Staphylococcus aureus	Blood, Urine, Lower Respiratory, CSF	Azithromycin Clarithromycin Erythromycin Clindamycin Oxacillin Cefoxitin Penicillin Trimethoprim-sulfamethoxazole Daptomycin Linezolid Telithromycin Doxycycline Minocycline Tetracycline Vancomycin Rifampin Chloramphenicol Ciprofloxacin Levofloxacin Ofloxacin Moxifloxacin

Micro-organism	Specimen Type	Antimicrobial Agents
		Gentamicin Quinupristin-dalfoprisin
	Additional Agents for Urine	Lomefloxacin Norfloxacin Nitrofurantoin Sulfisoxazole Trimethoprim
Stenotrophomonas maltophilia	Blood, Urine, Lower Respiratory, CSF	Trimethoprim-sulfamethoxazole Ceftazidime Chloramphenicol Levofloxacin Minocycline Ticarcillin-clavulanate
	Additional Agents for Urine	None
Streptococcus pneumoniae	Blood, Urine, Lower Respiratory, CSF	Erythromycin azithromycin Penicillin (meningitis breakpoint) Penicllin (non-meningitis breakpoint) Penicillin V (oral breakpoint) Trimethoprim-sulfamethoxazole Cefepime, Cefotaxime (meningitis breakpoint) Cefotaxime (non-meningitis breakpoint) Ceftriaxone(meningitis breakpoint) Ceftriaxone (non-meningitis breakpoint) Clindamycin Gemifloxacin Levofloxacin Moxifloxacin Ofloxacin Meropenem Telithromycin Tetracycline Vancomycin Amoxicillin

Micro-organism	Specimen Type	Antimicrobial Agents
		Amoxicillin-clavulanic acid Cefuroxime Chloramphenicol Ertapenem Imipenem Linezolid Rifampin
	Additional Agents for Urine	None
Group B Streptococcus	Blood, Urine, Lower Respiratory, CSF	Clindamycin Erythromycin Cefotaxime Cefazolin Cefoxitin Ampicillin Penicillin Levofloxacin Ciprofloxacin Tetracycline Vancomycin Daptomycin Linezolid

Appendix B. SNOMED Codes to Identify Eligible Specimen Types

[a]Mapping of standardized terminology for specimen type are provided via the hai-voc spreadsheet

Specimen Type	Description[a]	SNOMED CT Code
Blood	Blood specimen (specimen)	119297000
Urine	Urinary specimen (specimen)	122575003
Cerebral Spinal Fluid	Cerebrospinal fluid sample (specimen)	258450006
Lower Respiratory Specimens	coughed sputum specimen (specimen)	119335007
	specimen from trachea (specimen)	119390000
	specimen from lung obtained by bronchial washing procedure (specimen)	122609004
	specimen from lung obtained by biopsy (specimen)	122610009
	specimen from lung obtained by fiberoptic bronchoscopic biopsy (specimen)	122611008
	upper respiratory fluid specimen obtained by tracheal aspiration (specimen)	122877000
	tissue specimen from bronchus (specimen)	128158009
	tissue specimen from trachea (specimen)	128173005
	bronchial fluid sample (specimen)	258446004
	sputum specimen obtained by aspiration (specimen)	258608003
	sputum specimen obtained by aspiration from trachea (specimen)	258609006
	sputum specimen obtained by sputum induction (specimen)	258610001
	sputum specimen obtained from sputum suction trap (specimen)	258611002
	lower respiratory tissue sample (specimen)	309170008
	lower respiratory fluid sample (specimen)	309171007
	transbronchial lung biopsy sample (specimen)	309173005
	bronchial biopsy sample (specimen)	309174004
	bronchial brushings sample (specimen)	309176002
	tissue specimen from lung (specimen)	399492000
	specimen obtained by bronchial aspiration (specimen)	441903006
	specimen obtained by bronchioloalveolar lavage procedure (specimen)	441917002
	specimen from trachea obtained by aspiration (specimen)	445447003
	specimen obtained by bronchial trap (specimen)	446838005
	bronchial fluid specimen obtained from bronchial trap (specimen)	447345009

Specimen Type	Description[a]	SNOMED CT Code
	sputum specimen (specimen)	119334006
	specimen from bronchus (specimen)	119391001
	specimen from lung (specimen)	127458004
	lower respiratory sample (specimen)	258606004
	bronchoalveolar lavage fluid sample (specimen)	258607008
	tracheal biopsy sample (specimen)	309169007

Appendix C. Technical and Isolate Based Report Variables

NAME	DESCRIPTION OF FIELD	CODE VALUE LIST	LEVEL OF REQUIREMENT
Facility ID	NHSN-assigned facility ID number	NHSN	Required
Patient ID	Alphanumeric patient ID assigned by the hospital and may consist of any combination of numbers and/or letters. This should be an ID that remains the same for the patient across all visits and admissions.		Required
Date of Birth	The date of the patient's birth including month, day , year		Required
Gender	M (Male), F (Female), O (Other) to indicate the gender of the patient		Required
Date admitted to facility	Date patient was admitted to an inpatient acute care facility Including month, day ,year If the laboratory specimen is reported from an outpatient location enter a null value		Required
Specimen collection date	Date the specimen was collected including month, day, year		Required
Specimen source	Specimen source from which the isolate was recovered (e.g. urine, lower respiratory, blood, CSF)	(SNO MED)	Required
Location	Patient care area where patient was when the laboratory specimen was collected	CDC Location Codes	Required
Isolate identifier	Isolate identifier unique for each isolate within laboratory and year.		Required
Pathogen	Pathogen identified from specimen collected (Appendix A)	Pathogen NHSN	Required
Antibiotic	Antibiotic(s) tested for susceptibility (Appendix A will define agents by pathogen and specimen source)		Required
PBP2a-agglutination	Result for PBP2a-agglutination (only if SA) Pos/Neg/Unk		Conditional (for Staph aureus)
PCR mec-gene	Result for PCR mec-gene (only if SA) Pos/Neg/Unk		Conditional (for Staph aureus)
E-test sign	E-test sign (> < =).		Conditional
E-test value	E-test (Value in micrograms/liter). Use '.' as decimal delimiter, e.g. 0.25		Conditional

NAME	DESCRIPTION OF FIELD	CODE VALUE LIST	LEVEL OF REQUIREMENT
Interpretation of E-test	Interpretation result of the E-test susceptibility test performed		Conditional
MIC sign	MIC sign (> < =).		Conditional
MIC value	MIC (Value in micrograms/liter). Use '.' as decimal delimiter, e.g. 0.25		Conditional
Interpretation of MIC test	Interpretation result of the MIC susceptibility test performed		Conditional
Zone sign	Zone sign (> < =).		Conditional
Zone value	Zone value in millimeters		Conditional
Interpretation of Zone test	Interpretation result of the zone susceptibility test performed		Conditional
Final Interpretation result	Final interpretation result of all different susceptibility tests performed		Required

Appendix D. Denominator Data Variables

	DESCRIPTION OF FIELD	CODE VALUE LIST	LEVEL OF REQUIREMENT
Facility Wide Denominator			
Facility ID	NHSN –assigned facility ID number	NHSN	Required
Location	FacWideIN		Required
Month	2-Digit month		Required
Year	4-Digit year		Required
Patient Days	For facility wide inpatient locations enter the total number of patient days collected at the same time each day combined for the month. All of the facility's inpatient locations with an overnight stay should be included where denominators can be accurately collected.		Required
Admission Count	For facility wide inpatients, enter the total number of admissions for all facility inpatient locations combined for the month. All the facility's inpatient locations with an overnight stay should be included where denominators can be accurately collected.		Required
Blood cultures performed	Number of blood cultures performed, each month (for all inpatient locations included in the reporting plan).		Required