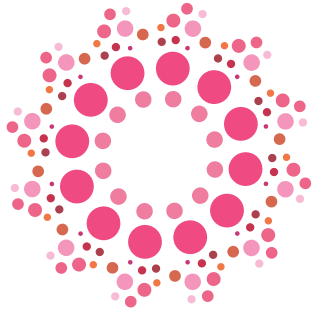# Guide on How to Prepare a Hospital Antibiogram

AMR&S
WORKING GROUP

Guide on How to Prepare a Hospital Antibiogram

What is an antibiogram?

An antibiogram is a report that displays the overall susceptibility profile of isolated pathogens to different antimicrobial agents. A hospital antibiogram shows the antimicrobial susceptibility pattern across the hospital over a defined period of time and gives a clear picture of the most common disease-causing pathogens in various units of the hospital.[1-3] A hospital antibiogram is considered a core component of antimicrobial stewardship (AMS).[2-4]

Antibiogram uses

Antibiograms can be used to[3,5,6]:

- Guide clinicians in the selection of the most appropriate empiric antimicrobial therapy to treat suspected pathogens and avoid the use of ineffective agents when definitive antimicrobial susceptibility test results are not available
- Develop hospital **prescribing guidelines**
- Monitor antimicrobial resistance trends over time
- Compare antimicrobial resistance rates across institutions
- Provide rationale for formulary decisions and policies for antimicrobial use
- Plan and evaluate **AMS interventions**

The usefulness of antibiograms largely depends on standardized antimicrobial susceptibility testing and reporting.[3,5] Performance standards for antimicrobial susceptibility testing are available from the Clinical and Laboratory Standards Institute (CLSI) (**www.clsi.org/standards/products/microbiology/documents/m100**) and the European Committee on Antimicrobial Susceptibility Testing (EUCAST) (**www.eucast.org/eucastguidancedocuments/**).

How to prepare a traditional hospital antibiogram

Antibiograms should be created in accordance with quality standards as established by the CLSI (**www.clsi.org/standards/products/microbiology/documents/m39/**).[3,7] Key recommendations for routine antibiogram development are outlined in Box 1 and guidance for specific pathogens is outlined in Table 1.

Box 1: CLSI recommendations for antibiogram preparation[7]

- Analyze and present antibiogram reports at least annually
- Include only final, verified organism identification and antimicrobial susceptibility test results
- Include only species with testing data for at least 30 isolates tested*
- Include diagnostic isolates, not surveillance isolates
- Include results only for antimicrobial agents that are routinely tested against the population of isolates to be analyzed
- Do not include results for supplemental antimicrobial agents selectively tested on resistant isolates only
- Eliminate duplicates by including only the first isolate of a species, patient, and/or analysis period, irrespective of the specimen source or the antimicrobial susceptibility profile
- Report only the percent susceptible (%S), do not include the percent intermediate (%I) in the %S statistic

*When fewer than 30 isolates are obtained in the course of the year, it is permissible to include isolates collected over a longer period and indicate this clearly in an explanatory footnote

Table 1

Pathogen-specific recommendations for antibiogram preparation[7]

Streptococcus pneumoniae	**Penicillin:** Calculate and list %S using meningitis and non-meningitis breakpoints; also consider listing oral penicillin breakpoints **Ceftriaxone, cefotaxime, cefepime:** Calculate and list %S using meningitis and non-meningitis breakpoints
Staphylococcus aureus	List %S for all *S. aureus*, and for MRSA and MSSA subsets
Enterococcus spp.	Separate analysis each for *E. faecalis* and *E. faecium,* as well as for all enterococci as a group
Klebsiella pneumoniae	In facilities where *K. pneumoniae* that produce ESBLs and/or KPCs are frequently isolated, consider reporting data by resistance mechanism or resistance pattern, and/or hospital unit to illustrate potentially useful antibiotics for empiric therapy

%S, percent susceptible; ESBL, extended-spectrum beta lactamase; KPC, *Klebsiella pneumoniae* carbapenemase; MRSA, methicillin-resistant *S. aureus*; MSSA, methicillin-susceptible *S. aureus*

Step 1: Data collection

Data for antibiograms are collated from laboratory reports of antimicrobial susceptibility testing for collected isolates. Ideally these data can be compiled using existing laboratory information systems and data management software; alternatively, they can be entered manually using a **spreadsheet**.[7] Table 2 summarizes the key information used for the generation of an antibiogram.

To guarantee statistical validity of susceptibility estimates, only species with testing data for ≥30 isolates per reporting period should be included in the antibiogram.[5,7] If it is essential to include a pathogen with fewer than 30 isolates,

include a footnote advising discretion when interpreting the susceptibility rates for this pathogen. When the number of tested isolates is small, consider combining data for more than one species within a genus, combining data for a pathogen collected >12 consecutive months, combining with data from comparable local institutions, or providing data from published summaries and guides.[7]

Be sure to note any modifications in antimicrobial susceptibility testing methodology and interpretation rules so that these can be considered when assessing trends across different periods.[5]

Table 2

Information used to generate an antibiogram[7]

Patient demographics	Specimen	Pathogen	Antimicrobial susceptibility*
• Unique patient identifier • Healthcare facility identifier • Date of birth/age • Gender • Patient location • Admission date for hospitalized patients	• Specimen identifier • Specimen type • Collection date • Body site	• Pathogen identification • Isolate number	• Quantitative test measurements (MIC or disk diffusion zone diameters) and/or final test interpretations (eg, susceptible, intermediate, resistant)

MIC, minimum inhibitory concentration
*Note: Antimicrobials should be recorded using their generic name

Step 2: Data analysis

Data for antibiograms should be analyzed and reported at least annually. More frequent analysis may be needed when large numbers of isolates or new antimicrobial agents have been tested, or if clinically relevant changes occur.[5]

Various analytic software tools are available for the analysis of microbiology susceptibility test results. WHONET **(https://whonet.org)** is a freely available Windows-based software that can be used on stand-alone computers or linked to existing laboratory information systems for analysis of antimicrobial susceptibility test results. Data files such as spreadsheets of antibiogram data can be exported to WHONET using the free BacLink data conversion utility.

Data analysis software should be able to select first isolates when calculating susceptibility rates.[7] Inclusion of multiple isolates from the same patient can bias susceptibility data and overestimate resistance.[5,7]

In some circumstances, hospital-wide antibiogram data may not be generalizable to specific patient populations or units. Consider supplemental analyses to stratify microbiology susceptibility test results by[5]:

- Acquisition of infection (community- vs hospital-acquired infection)
- Patient location (specific hospital wards, eg, intensive care unit)
- Patient population (pediatric patients, oncology patients, etc.)
- Specimen type or infection site (blood, urine, stool, sputum, skin, etc.)
- Pathogen resistance characteristics (eg, methicillin-resistant vs methicillin-sensitive *Staphylococcus aureus*)

- **WHONET** is a free Windows-based database software developed by the WHO Collaborating Centre for Surveillance of Antimicrobial Resistance for use in the management and analysis of microbiology laboratory data with a special focus on the analysis of antimicrobial susceptibility test results

- WHONET is used in over 130 countries and 2,300 laboratories around the world to support local and national surveillance programs

- WHONET is a multilingual desktop application with support for 44 languages and 2022 CLSI and EUCAST breakpoints

Step 3: Data review

It is important to assess all antimicrobial susceptibility test results on every patient's isolate before reporting the results as final and including these data in the dataset to be analyzed for the antibiogram report.[7] Once analysis of the data is complete, multidisciplinary review of the output is important to identify misleading or unusual susceptibility information and assess the clinical appropriateness of the information provided.[6]

1. Has the minimum number of isolates been achieved? If data are listed for pathogens with <30 isolates, determine if it is essential to include the species and include a footnote to indicate reduced statistical validity of the susceptibility estimate.[7,8]

2. Are the antimicrobials reported for each species appropriate for clinical use? For example, trimethoprim-sulfamethoxazole may be included on the Gram-negative test panel but is not appropriate for *Pseudomonas aeruginosa*.[7]

3. Are there antimicrobial-pathogen combination results suggestive of an error in organism identification or in susceptibility test results? Examples of unusual results include meropenem resistance in *Escherichia coli*, vancomycin resistance in *Streptococcus pneumoniae*, and amikacin resistance coexisting with gentamicin and tobramycin susceptibility in *E. coli*.[7]

Step 4: Data presentation

Present the antibiogram in a **tabular** form with clear titles showing the inclusive dates of the report and unit- or site-specific information (visit **www.antimicrobialstewardship.com/antibiograms** for examples).[7,9] Antimicrobial agents can be listed alphabetically or by class.[7] Percentage susceptibilities should be depicted separately for Gram-positive and Gram-negative isolates, and if applicable for anaerobic bacteria and yeasts.[7,9] Table 3 lists the species recommended for inclusion when sufficient numbers of isolates are tested. The antibiogram shows the percent susceptible for each pathogen-antimicrobial combination. Intrinsic resistance is indicated by an 'R' and a dash (–) indicates an agent was not tested or is known to be clinically ineffective (eg, narrow-spectrum cephalosporins for *Salmonella* spp.).[7] Include contact information for key AMS personnel and footnotes for explanation of data, abbreviations and therapeutic guidance. Inclusion of information on formulary restrictions and recommended empiric regimens are optional.[7]

Species recommended for inclusion when sufficient numbers of isolates are tested[7]

Gram-negative	Gram-positive
Acinetobacter baumannii	*Enterococcus* spp.
Citrobacter freundii	*Staphylococcus aureus*
Enterobacter cloacae	Coagulase-negative staphylococci**
Escherichia coli	*Streptococcus agalactiae*
Klebsiella aerogenes	*Streptococcus pneumoniae*
Klebsiella oxytoca	Viridians group streptococci
Klebsiella pneumoniae	
Morganella morganii	**Anaerobes**
Proteus mirabilis	*Bacteroides fragilis*
Providencia spp.	*B. fragilis* group (other than *B. fragilis*)
Pseudomonas aeruginosa	*Clostridium perfringens*
Salmonella spp.	
Serratia marcescens	
Shigella spp.	
Stenotrophomonas maltophilia	
*Haemophilius influenzae**	

*May be included as a line entry or footnote. The latter is preferred if only β-lactamase testing is performed (eg, the percent β-lactamase positive should be calculated and reported)

**Consider separate listings for those species with unique breakpoints if sufficient numbers of isolates have been tested (eg, *S. epidermidis, S. lugdunensis*)

Step 5: Distribution

The antibiogram should be made easily available to all prescribers, clinicians, nurses, pharmacists, microbiology teams and infection-control personnel.[8,9] Distribute printed copies and publish on the hospital intranet, if available, for easy access.[9] Distribution of the antibiogram should be accompanied with instructions for use and an interpretation of the data. It is advisable to provide an annual summary that highlights current susceptibility information and shifts in susceptibility from one reporting period to another.[6] Explain the source of the isolates for any supplementary analyses, consider the number of isolates for each pathogen, and distinguish between susceptibilities to individual antimicrobials and antimicrobial combinations. Review of the antibiogram presents an opportunity to assess antimicrobial resistance trends and evaluate current therapy guidelines and formulary decisions.[8]

Considerations

While the antibiogram is a very useful tool, it should not be solely relied upon for guiding antimicrobial therapy. Data do not take into account patient factors such as history of infection, past antimicrobial use, or underlying medical conditions, nor do they account for the synergistic properties of antimicrobials used in combination.[10] Combination antibiograms can be developed to evaluate pathogen cross-resistance among multiple antimicrobials.[2,11]

Online resources

Additional information on the preparation and use of antibiograms can be found online:

- The Arizona Department of Health Services Antibiogram Toolkit provides guidance on optimizing accuracy of the antibiogram and its application in AMS programs: **www.azdhs.gov/documents/preparedness/epidemiology-disease-control/healthcare-associated-infection/advisory-committee/antimicrobial-stewardship/antibiogram-toolkit.pdf**
- The Agency for Healthcare Research and Quality provides toolkits for establishing and using antibiograms in nursing homes; the general information here is also relevant for acute-care hospitals: **www.ahrq.gov/nhguide/toolkits/help-clinicians-choose-the-right-antibiotic/index.html**
- Examples of hospital antibiograms are provided by the Sinai Health System - University Health Network Antimicrobial Stewardship Program: **www.antimicrobialstewardship.com/antibiograms**

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