Analysis and Presentation of Cumulative Antibiograms: A New Consensus Guideline from the Clinical and Laboratory Standards Institute

Janet F. Hindler[1] and John Stelling[2]

[1]University of California Los Angeles Medical Center, Los Angeles; and [2]Brigham and Women's Hospital, Boston, Massachusetts

It is crucial to monitor emerging trends in resistance at the local level to support clinical decision making, infection-control interventions, and antimicrobial-resistance containment strategies. Monitoring of antimicrobial resistance trends is commonly performed in health care facilities using an annual summary of susceptibility rates, known as a cumulative antibiogram report. The Clinical and Laboratory Standards Institute M39-A2 consensus document, entitled "Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data," provides guidance to clinical laboratories in the preparation of a cumulative antibiogram. The purpose of this review is to describe this document, explain the rationale for some of the recommendations, discuss limitations of its use, and propose new directions for future revisions. The document contains specific recommendations for the collection, storage, analysis, and presentation of data and includes sample templates highlighting the recommendations. Critical issues include the recommended frequency of reporting, the number of isolates to include in a statistic, and a mechanism for eliminating multiple isolates of a given bacterial species obtained from an individual patient.

With increasing antimicrobial resistance worldwide, it is crucial to monitor emerging trends in drug resistance at the local level to support clinical decision making, infection-control interventions, and antimicrobial-resistance containment strategies [1, 2]. Monitoring of antimicrobial resistance trends is commonly performed in health care facilities using an annual summary of susceptibility rates, known as a cumulative antibiogram report.

Several distinct approaches can be used in summarizing results from a database of clinical isolates, but, unfortunately, results obtained using different calculation algorithms may not necessarily be comparable. In the year 2000, a survey coordinated by the Clinical and Laboratory Standards Institute (CLSI; formerly NCCLS) highlighted a diversity of calculation algorithms used in clinical laboratories in the United States (data not published). Two observations from this survey were as follows: (1) there may be poor comparability of antimicrobial susceptibility statistics between institutions because of the diversity of calculation methods, and (2) many laboratories use a simplistic calculation approach, with a strong tendency to overestimate drug-resistance rates. To address these limitations, CLSI recognized the need to develop practical but clinically and epidemiologically useful recommendations for the analysis and presentation of data on antimicrobial susceptibility trends.

To this end, the CLSI established a working group to develop consensus guidelines for implementation by health care facilities. The current guideline is CLSI M39-A2, entitled "Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data" [3]. This miniature review will describe CLSI M39-A2 [3], explain the rationale for some of the recommendations made in this document, discuss limitations of its use, and propose directions for expanding this guideline in future revisions. Data presented are from a large teaching hospital and were analyzed with WHONET software, version 5.3, a software program for the management of microbiology laboratory data that is available free of charge from the World Health Organization [4].

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Reprints or correspondence: Janet Hindler, UCLA Medical Center 171315, Dept. of Pathology and Laboratory Medicine, 10833 LeConte Ave., Los Angeles, CA 90095-1713 (jhindler@ucla.edu).

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Table 1. Clinical and Laboratory Standards Institute M39-A2 [3] recommendations for cumulative antibiogram preparation.

Analyze and present data at least annually
Include only species with at least 30 isolates tested
Include diagnostic, not surveillance, isolates
Include results only for drugs that are routinely tested
Include the first isolate per patient in the period analyzed, irrespective of the body site from which the specimen was obtained or the antimicrobial susceptibility pattern
Calculate the percentage susceptible. Do not include the percentage of isolates with intermediate susceptibility.
For *Streptococcus pneumoniae,* calculate and list both the percentage susceptible and the percentage of isolates with intermediate susceptibility for penicillin; calculate and list the percentage susceptible for cefotaxime or ceftriaxone using both the meningitis and nonmeningitis breakpoints
For viridans streptococci, calculate and list both the percentage susceptible and the percentage of isolates with intermediate susceptibility for penicillin
For *Staphylococcus aureus,* calculate and list the percentage susceptible for all isolates, as well as for the subset of methicillin-resistant *S. aureus*

THE CLSI M39-A2 GUIDELINE

CLSI M39-A2 [3] is intended for those involved in the preparation and use of cumulative antibiogram reports, as well as for information technology managers who are responsible for designing and supporting the clinical laboratory's data management needs. The document contains specific recommendations for the collection, storage, analysis, and presentation of data and includes sample templates that highlight the recommendations. Critical issues addressed include the recommended frequency of reporting, the number of isolates to include in a statistic, and a mechanism for eliminating multiple isolates of a given bacterial species obtained from an individual patient (repeat isolates).

The most frequent use of a cumulative antibiogram report is in guiding initial empirical antimicrobial therapy decisions for the management of infections in patients for whom microbiological test data to target treatment do not yet exist, and this is the focus of CLSI M39-A2 [3]. For the ongoing management of prolonged infections, clinicians should rely on culture and antimicrobial susceptibility test results previously available for the patient and an understanding of the likelihood of the emergence of an antimicrobial-resistant strain during therapy. There are other applications for the analysis of susceptibility test data (e.g., monitoring the emergence of antimicrobial resistance during therapy, guiding therapy choices for subsequent infections, and identifying isolates with specific antimicrobial resistance phenotypes) for which it may be preferable to analyze data in manners different from those described in CLSI M39-A2 [3]. However, discussion of this is beyond the scope of the current document and this review. A summary of specific recommendations in CLSI M39-A2 [3] is shown in table 1.

Frequency of data analysis and reports. Most facilities use data collected during 1 calendar year in their analyses. If there are substantial numbers of isolates, it would be reasonable to consider more-frequent analyses if there is a perceived change in the percentage of isolates that are susceptible during the course of the year.

Number of isolates. Having a sufficient number of isolates of a given species available for analysis is a concern in smaller facilities and for infrequently isolated species. Although CLSI M39-A2 [3] suggests annual analysis, if <30 isolates of a species are encountered during a 1-year period, it is acceptable to include isolates collected over a longer period and to include a footnote in the report indicating that this is the case. Combining data from several facilities located in the same geographic area is another way to circumvent the concern about having a small number of isolates available for analysis.

Screening isolates. Isolates that are collected from surveillance or screening cultures, such as cultures for methicillin-resistant *Staphylococcus aureus* or vancomycin-resistant *Enterococcus* species, should be excluded from routine analyses, because they may misrepresent the types of isolates encountered from patients with suspected infection.

Antimicrobial agents to analyze. Only results for antimicrobial agents that are routinely tested and clinically useful should be presented to clinicians. To avoid biases introduced by selective reporting practices (e.g., reporting broad-spectrum agents only for bacteria with resistance to primary agents), the analysis database should include the results for all antimicrobials tested, including those agents that may not be routinely reported to clinicians. Results for antimicrobials tested only against drug-resistant strains as part of reserve or second-line testing panels are generally biased towards higher rates of antimicrobial resistance and should not be considered to be representative.

Susceptibility test results. CLSI M39-A2 [3] recommends recording, in separate fields, both the quantitative test measurement (inhibition zone diameters for the disk diffusion and MIC values for dilution testing) and the qualitative test interpretation (i.e., whether the isolate is classified as resistant, intermediate, or susceptible). The test measurements are important in the event of changes in CLSI breakpoints, in evaluating the quality of susceptibility test results, and in understanding the epidemiology of antimicrobial-resistant bacterial subpopulations.

Percentage susceptible. The cumulative antibiogram report should present data as the percentage of isolates that are susceptible. Pharmacologists and clinicians are more accustomed

Table 2. *Staphylococcus aureus* susceptibility test results for a sample patient.

Isolate	Hospitalization day	Specimen source	Antimicrobial tested					
			Clin	Ery	Gen	Pen	Ox	Van
1	1	Wound (toe)	S	S	S	R	S	S
2	7	Blood	R	R	R	R	R	S
3	20	Wound (foot)	R	R	S	R	R	S
4	32	Wound (foot)	R	R	R	R	R	S

NOTE. Clin, clindamycin; Ery, erythromycin; Gen, gentamicin; Ox, Oxacillin; Pen, penicillin; R, resistant; S, susceptible; Van, vancomycin.

to working with results presented as the percentage of isolates that are susceptible, because they focus on the likelihood of a successful therapeutic response. Because clinicians generally avoid prescribing antimicrobials if a test result indicates intermediate susceptibility, isolates with intermediate susceptibility should not be included in the calculation of the percentage of isolates that are susceptible. Among microbiologists and epidemiologists, the percentage of isolates that are resistant or the percentage of isolates that are nonsusceptible may be of greater interest, because the focus of these groups is on changing trends in antimicrobial resistance, and these percentages could be used to emphasize certain findings regarding emerging drug resistance.

Data stratification. To encourage optimal antimicrobial therapy, it is often useful to stratify results for select patient populations, medical services, or specimen types. For example, in one study [5], 70% of *S. aureus* isolates from patients not hospitalized in intensive care units were susceptible to oxacillin, whereas only 52% of isolates from patients hospitalized in intensive care units were susceptible. In another study, isolates of *Pseudomonas aeruginosa* from patients with cystic fibrosis were found to be significantly less susceptible than isolates from patients without cystic fibrosis [6]. In one of our facilities (University of California Los Angeles Medical Center, Los Angeles), 84% of all *Escherichia coli* isolates obtained from outpatient urine specimens were ciprofloxacin susceptible, whereas a susceptibility rate of 62% was noted among the subset of patients >65 years old. This observation led to a reevaluation of the use of ciprofloxacin as empirical therapy for urinary tract infections in outpatients >65 years old.

Distribution and review of cumulative antibiograms. There are several suggestions in CLSI M39-A2 [3] for the distribution of cumulative antibiogram reports, such as "pocket guides" and Web site postings. CLSI M39-A2 [3] also lists stepwise suggestions for presenting the data to other health care professionals, including pharmacists, infectious diseases physicians, and infection-control personnel. Group review of the cumulative antibiogram presents an opportune time for stakeholders to examine antimicrobial-resistance trends, assess current therapy guidelines and formulary decisions, and more.

HANDLING REPEAT ISOLATES

Algorithms for Handling Repeat Isolates

Perhaps the most controversial aspect of cumulative antibiogram preparation is the way in which multiple isolates of a given bacterial species from an individual patient (so-called "repeat isolates") are handled. The simplest calculation would involve an isolate-based approach in which all isolates are considered equally. However, patients with complicated clinical courses, long hospital stays, and infections with multidrug-resistant organisms frequently have specimens cultured on multiple occasions. As a consequence, estimates determined using this simplistic "all isolates" approach are often biased towards the results of this exceptional patient subpopulation, who typically have a greater percentage of antimicrobial-resistant strains.

Therefore, it is recommended that repeat isolates be eliminated, and there are several options for accomplishing this. Table 2 displays results for 4 isolates of *S. aureus* obtained from the same sample patient, and table 3 illustrates how the following algorithms would handle the isolates.

Patient-based algorithms. Each patient contributes equally to the estimate of the percentage of isolates that are susceptible. Patient-based approaches are directly clinically and epidemiologically relevant, and they have practical benefits, including involving fewer assumptions and simpler calculations than episode-based or phenotype-based approaches.

Episode-based algorithms. In these approaches, the focus is on "episodes" of infection. Unfortunately, for most clinical

Table 3. Isolates obtained from the sample patient that would be included in the analysis according to various algorithms for handling repeat isolates.

Algorithm	Isolates included in the analysis[a]
Isolate based (all isolates)	1, 2, 3, 4
Patient based (first isolate per patient)	1
Episode based (first isolate per episode)	
7-Day interval from initial isolate	1, 3, 4
7-Day interval from previous isolate	1, 3, 4
30-Day interval from initial isolate	1, 4
30-Day interval from previous isolate	1
Resistance phenotype based (first isolate per phenotype)	
Major difference in any antimicrobial result	
Consecutive isolates	1, 2, 3, 4
Nonconsecutive isolates	1, 2, 3
Major difference in oxacillin result	
Consecutive isolates	1, 2
Nonconsecutive isolates	1, 2

[a] Isolates are numbered as in table 2.

Table 4. Estimates of the percentage susceptible for *Staphylococcus aureus* (oxacillin) and *Pseudomonas aeruginosa* (ciprofloxacin) using 5 different calculation algorithms to analyze data in a single dataset.

Pathogen, algorithm	No. of isolates	Susceptible isolates, %
S. aureus		
Patient based (first isolate per patient)	1439	55
Episode based (30-day interval)	1615	53
Phenotype based		
Major difference in oxacillin result	1467	55
Major difference in any antimicrobial result	1536	54
Isolate-based (all isolates)	2192	49
P. aeruginosa		
Patient based (first isolate per patient)	742	70
Episode based (30-day interval)	864	69
Phenotype based		
Major difference in ciprofloxacin result	767	69
Major difference in any antimicrobial result	919	66
Isolate based (all isolates)	1445	62

NOTE. The 5 different calculation algorithms are (1) first isolate per patient; (2) first isolate per episode with an interval of up to 30 days between consecutive isolates; (3) first isolate per resistance phenotype, defined by major resistance-susceptibility differences in the oxacillin result (for *S. aureus*) or ciprofloxacin result (for *P. aeruginosa*) between consecutive isolates; (4) first isolate per resistance phenotype, defined by major resistance-susceptibility differences in the results for any antimicrobial tested; and (5) an isolate-based algorithm in which all isolates contribute equally to the overall estimate of percentage susceptible.

scenarios, there is no agreed consensus on the definition of an episode. Definitions could include features such as the interval of time between obtaining isolates, the phenotypic characteristics of the isolates, or the site of infection.

Resistance phenotype–based algorithms. In a phenotype-based approach, the data analyst focuses on particular bacterial strains, as defined by phenotypic characteristics such as the antimicrobial susceptibility pattern. A challenge in these approaches is defining the features to be used to discriminate between isolates. Specific issues to address include the following: (1) whether to consider results for all antimicrobials tested or only the results for a few key agents and, in the latter case, how discordant results for non-key antimicrobials should be handled; (2) whether to distinguish between "major" (resistant vs. susceptible) or "minor" (resistant vs. intermediate vs. susceptible) differences in test interpretation; and (3) whether to compare results for sequential isolates only or for the entire set of a patient's isolates. Calculations are further complicated if different antimicrobial panels are tested against different isolates, which may be the case if urine or second-line testing panels are used frequently.

If a patient, episode, or phenotype is associated with multiple isolates of a given bacterial species, then the data analyst must decide which of the isolates to use in the calculations. The simplest approach would be to select the first isolate per patient, episode, or phenotype during the time period of analysis of the bacterial species in question. Alternatives to this approach are to select only the last isolate, only the most resistant result per antimicrobial, only the most susceptible result per antimicrobial, and a weighted average of individual patient susceptibility test results for a given antimicrobial.

Examples of Methods for Handling Repeat Isolates

To better understand the impact of the various approaches on estimates of susceptibility rates, we applied 5 calculation algorithms to the analysis of 1 year of data for *S. aureus* and *P. aeruginosa.* Results are presented in table 4.

A number of conclusions are suggested from the data presented. First, isolate-based approaches that include all isolates generally have lower estimated percentage susceptible rates than other approaches. This is especially true for hospital pathogens (e.g., *S. aureus* and *P. aeruginosa*), which are commonly associated with prolonged infections and repeated cultures. In the management of acute infections in outpatients (e.g., pneumonia due to *Streptococcus pneumoniae*) or in low-resource regions, repeat isolates are relatively infrequent; therefore, isolate-based estimates will generally be similar to other estimates.

Second, in many instances, patient-, episode-, and phenotype-based algorithms will yield comparable estimates. However, episode- and phenotype-based approaches reflect results for patients with multiple episodes and/or phenotypically different strains to a greater degree than patient-based approaches. Because this group of patients tends to have a higher percentage of resistant bacteria, the percentage susceptible is usually lower when using episode- or phenotype-based approaches than when using patient-based approaches. This tendency will be particularly pronounced for organisms such as *P. aeruginosa,* which can exhibit significant heterogeneity in resistance phenotypes as a result of mutation, coinfection or colonization with multiple clones, or biological variability in susceptibility test results.

Third, differences in the definitions used to define episodes and phenotypes can significantly impact the percentage sus-

Table 5. Sample format for results of *Streptococcus pneumoniae* isolate testing in a laboratory that routinely performs only oxacillin disk tests for penicillin (Pen) susceptibility and performs susceptibility tests for 3 additional antimicrobials for isolates that are suspected of being nonsusceptible to Pen.

Organism	No. of isolates	Percentage susceptible			
		Pen	Cro	Ery	Lvx
S. pneumoniae	78	75	90[a]	25[a]	90[a]

NOTE. Cro, ceftriaxone; Ery, erythromycin; Lvx, levofloxacin.

[a] Cro, Ery, and Lvx were tested only against those isolates that were not susceptible to Pen ($n = 20$), based on oxacillin disk diffusion screen results of $\leqslant$19 mm.

Table 6. Alternative format for results of *Streptococcus pneumoniae* isolate testing in a laboratory that routinely performs only oxacillin disk tests for penicillin (Pen) susceptibility and performs susceptibility tests for 3 additional antimicrobials for isolates that are suspected of being nonsusceptible to Pen.

Organism	No. of isolates	Percentage susceptible			
		Pen	Cro[a]	Ery[a]	Lvx[a]
S. pneumoniae	78	75	…	…	…
PNSSP	20	0	90	25	90

NOTE. Cro, ceftriaxone; Ery, erythromycin; Lvx, levofloxacin.; PNSSP, Pen-nonsusceptible *S. pneumoniae.*

[a] Cro, Ery, and Lvx were tested only against those isolates that were not susceptible to Pen ($n = 20$), based on oxacillin disk diffusion screen results of ⩽19 mm.

ceptible estimate obtained. This is especially true for organisms associated with hospital-acquired infections.

The Rationale behind Recommending the First Isolate per Patient Approach

For the reasons presented above, it is wise to use some mechanism to eliminate the bias inherent in an "all isolates" approach. The first isolate per patient estimate is an approach with direct relevance to guiding recommendations for initial empirical therapy (for that group of patients for whom microbiological test results are not yet available). Calculations are straightforward, and results are easily communicated to clinical staff. This recommendation has also been supported by the results of a number of investigators who have examined this issue [5, 7–11].

There are several problems, often unrecognized, that are inherent in episode- and phenotype-based approaches that make them less suitable as a general recommendation. From an epidemiological perspective, such approaches are automatically biased towards the results of those patients with higher rates of antimicrobial-resistant isolates. They are also particularly sensitive to changes in local specimen-collection practices (e.g., the frequency of repeat cultures) and susceptibility test protocols (e.g., the number and types of antimicrobials tested). With regard to practical considerations, without a clear consensus on the definitions to be used for episodes and phenotype, such approaches compromise the comparability of statistics over time and between institutions. Furthermore, programming and calculations are more involved and may be beyond the technical capabilities of many laboratories.

AVOIDING THE PRESENTATION OF POTENTIALLY MISLEADING DATA

The laboratory has a responsibility to avoid presenting results that are confusing or potentially misleading. Such problems can often be attributed to a lack of understanding by clinicians and pharmacists of laboratory practices for organism identification and susceptibility test practices or of biases in specimen collection practices.

Example 1. In a certain laboratory, penicillin susceptibility is predicted with the oxacillin disk diffusion test for all isolates of *S. pneumoniae.* For nonsusceptible strains (oxacillin inhibition zone diameter ⩽19mm), the isolate is subsequently tested against ceftriaxone, erythromycin, and levofloxacin as a second-line panel. In table 5, all of the results are presented in a single row with an appropriate footnote. There is a risk, however, that if footnotes are not prominently displayed, one may incorrectly conclude that only 25% of all *S. pneumoniae* isolates are susceptible to erythromycin. In table 6, the same data are presented but in a way that would, perhaps, decrease the possibility of misinterpretation.

Example 2. Table 7 shows results from the testing of *Enterococcus faecium* isolates against vancomycin. The percentage susceptible increased from 14% in 2003 to 29% in 2004, a surprising 15% increase. Upon further investigation, it was noted that laboratory practices had changed between the 2 years. Until the end of 2003, all isolates of enterococci found to be vancomycin resistant were identified to the species level. In 2004, this practice was discontinued, and species identification was only performed for isolates of vancomycin-resistant *Enterococcus* species obtained from normally sterile body sites. A more useful way of presenting the data would be to tabulate results from comparable isolate subsets—for example, to compare isolates obtained from sterile sites between the 2 years, as in table 8.

CONFIDENCE INTERVALS AND STATISTICAL SIGNIFICANCE OF CHANGES IN THE PERCENTAGE OF SUSCEPTIBLE ISOLATES

CLSI M39-A2 [3] includes tables to help users assess the statistical confidence that they should have in observed estimates of the percentage susceptible for different sample sizes. For example, if a laboratory tests 10 isolates of *Enterobacter cloacae,* and 9 isolates are susceptible to gentamicin, then the observed percentage susceptible is 90%. If the isolates tested are representative of the broader population of *E. cloacae,* a table in CLSI M39-A2 [3] indicates that one can be 95% certain that the true percentage susceptible lies somewhere in the rather

Table 7. Percentages of *Enterococcus faecium* isolates susceptible to vancomycin in a laboratory in which the criteria for species determination of vancomycin-resistant enterococci changed between 2003 and 2004.

Year	No. of isolates	Percentage susceptible
2003	174	14
2004	77	32

Table 8. Percentages of *Enterococcus faecium* isolates susceptible to vancomycin obtained from sterile sites in a laboratory in which the criteria for species determination of vancomycin-resistant enterococci changed between 2003 and 2004.

Year	No. of isolates from sterile sites	Percentage susceptible
2003	56	46
2004	77	32

wide range of 55%–100%. However, if 1000 isolates were tested and 900 were found to be susceptible, the observed percentage susceptible would still be 90%, but one would be 95% certain that the true percentage susceptible was between 88% and 92%.

CLSI M39-A2 [3] includes additional tables for determining whether differences in the observed percentage susceptible in 2 populations are statistically significant (for example, when comparing results from 2 different years or 2 different institutions). The table provided in CLSI M39-A2 [3] can only be used if the 2 populations are of similar size. Table 9 illustrates the use of this table to compare susceptibility percentage results for *S. aureus* and oxacillin between 2003 and 2004 from all isolates, from outpatient isolates, and from inpatient isolates. Comparable numbers of isolates were tested in the 2 years.

ENSURING THE QUALITY OF THE CUMULATIVE ANTIBIOGRAM

It is assumed that the microbiological test results in the database that will be analyzed for the cumulative antibiogram are accurate. Nevertheless, once the report is complete, it is important to review for potential errors, unlikely or important results, and the clinical appropriateness of the information provided. Are the antimicrobials reported for each species appropriate for clinical use? Is the minimum number of isolates achieved? Are there inconsistent drug-pathogen combination results that could be suggestive of an error in organism identification or in susceptibility test results? CLSI M39-A2 provides a useful reference for results that should not be reported without confirmation [3].

REQUIREMENTS FOR PREPARATION OF CUMULATIVE ANTIBIOGRAMS

At present, there are no federal regulations requiring public health departments or health care institutions to monitor antimicrobial-resistance trends. The Joint Commission for Healthcare Organizations suggests, but does not require, that cumulative antibiograms be prepared and distributed to clinical staff, and The College of American Pathologists Checklist Item MIC.21946 asks "For hospital-based microbiology laboratories, are cumulative antimicrobial susceptibility test data maintained and reported to the medical staff at least yearly?" [12, p. 51]. The Centers for Disease Control and Prevention initiated a campaign to prevent antimicrobial resistance. One suggestion in this campaign is to "use antimicrobials wisely," and step 6 of this campaign reminds health care providers to "Use local data; know your antibiogram" [13]. At the state level, Missouri recently passed legislation that suggests that clinical laboratories report antimicrobial susceptibility statistics to the state annually [14].

SUMMARY AND FUTURE DIRECTIONS

Table 10 provides a summary of some of the key points and pitfalls described in this review. The authors of CLSI M39-A2 [3] and the CLSI Subcommittee on Antimicrobial Susceptibility Testing intend to address additional issues in subsequent revisions of the guideline. Priority issues include graphical displays to highlight specific trends in drug resistance, bias in susceptibility estimates introduced by specimen-collection practices (particularly in treating outpatients), and suggestions for the presentation and interpretation of noninitial isolates (for example, in assessing the frequency of the emergence of

Table 9. Percentage of *Staphylococcus aureus* isolates susceptible to oxacillin in 2003 and 2004 and thresholds for statistical significance.

	2003		2004		CLSI M39-A2 [3] thresholds[a]	
Isolate group	Percentage susceptible	No. of isolates	Percentage susceptible	No. of isolates	Percentage susceptible	No. of isolates
All isolates	60	1384	55	1426	57	1400
Outpatient isolates	66	843	57	907	61	850
Inpatient isolates	47	427	45	393	40	400

NOTE. In 2004, estimates of the percentage susceptible to oxacillin for the all isolates group and the outpatient isolates group decreased below the indicated thresholds, so that one can conclude that there was a statistically significant decrease in susceptibility to oxacillin from 2003 to 2004 for these 2 isolate subsets. The decrease from 47% to 45% in the percentage of inpatient isolates was not statistically significant.

[a] A decrease in susceptibility percentage below these thresholds would be considered to be statistically significant for the specified sample sizes ($P = .05$). Data given are approximations.

Table 10. Summary of conclusions.

When using cumulative antibiogram data, you should know that:
Cumulative antibiograms compiled following Clinical Laboratory Standards Institute M39-A2 [3] recommendations are to be used to guide empirical therapy of initial infections
The percentage susceptible for a specific drug-pathogen combination will be impacted by culturing practices, patient population, specimen collection practices, and laboratory antimicrobial-susceptibility testing policies
If some drugs included in the cumulative antibiogram are only tested on selected isolates, the data will be skewed
If repeat isolates are not eliminated from analysis, the percentage susceptible will in most cases be lower than if repeat isolates are eliminated
Depending on the method used to eliminate repeat isolates, the percentage susceptible may vary
The first isolate per patient algorithm is a practical guideline with immediate relevance to guiding empirical therapy decisions
Episode-based and resistance-phenotype based approaches are highly dependent on local culturing and susceptibility testing practices, and they tend to reflect the results of patients with a higher percentage of resistant bacteria
If the sample number is small, the 95% CI will be large; for example, for a sample of 50 isolates, increases or decreases in the percentage susceptible as great as 20% may not be statistically significant
Not all clinical laboratories currently comply with Clinical Laboratory Standards Institute M39-A2 [3], primarily because of software limitations

resistance during therapy). As with all CLSI documents, input from those who use them is welcomed and can be submitted through the CLSI Web site [15].

CLSI M39-A2 [3] provides suggestions for the analysis and presentation of cumulative antimicrobial susceptibility test data. However, few publications have addressed practical recommendations for how to use these data in making therapy decisions and prescribing policies [16–19]. It is hoped that, in the near future, the CLSI, the Infectious Diseases Society of America, and others will look more critically at this aspect of the cumulative antibiogram to optimize the way in which the data are used to encourage prudent prescribing.

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