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Antimicrobial Stewardship in Long-Term Care Facilities: Approaches to Creating an Antibiogram when Few Bacterial Isolates Are Cultured Annually

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A B S T R A C T

Antibiograms are important clinical tools to report and track antibiotic susceptibility and help guide empiric antimicrobial therapy. Antibiograms support compliance with antimicrobial stewardship (AMS) requirements from the Centers for Medicare and Medicaid Services and are in line with recommendations from the Centers for Disease Control and Prevention Core Elements of AMS for nursing homes/long-term care facilities (LTCFs). Unlike most acute-care settings, LTCFs are challenged in creating antibiograms because of the low number of bacterial isolates collected annually. Determining the best methodology for creating clinically useful antibiograms for LTCFs needs to be explored. Possible approaches include (1) extending the isolate data beyond 1 year, (2) combining isolate data from the same geographic region, (3) using a nearby acute-care facility's antibiogram as a proxy, or (4) collapsing isolate data. This article discusses the benefits and limitations of each approach.
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Antimicrobial stewardship (AMS) initiatives consist of multidisciplinary approaches to coordinate appropriate antimicrobial use in an effort to decrease selective pressures that drive the emergence of multidrug resistant organisms (MDROs).[1,2] AMS initiatives have been effectively implemented across many acute-care settings but are less well established in long-term care facilities (LTCFs).[3,4] The Centers for Medicare and Medicaid Services "proposed that the facility's infection prevention and control program must also include an antibiotic stewardship program that includes antibiotic use protocols and systems for monitoring antibiotic use and recording incidents" under Reform of Requirements for Long-Term Care facilities.[5] The Centers for Disease Control and Prevention Core Elements for AMS encourages nursing homes to start implementing at least 1 AMS activity and then gradually incorporate additional strategies.[6] A facility-specific antibiogram supports AMS activity for tracking and reporting antibiotic resistance and represents a tangible contribution to meet the recommendations of the Centers for Medicare and Medicaid Services and the Centers for Disease Control and Prevention.

An antibiogram summarizes a healthcare facility's bacteria susceptibilities to antibiotics, typically over a 1-year time period.[7] By displaying which bacteria have the highest rates of susceptibility to specific antibiotics in a given facility, antibiograms may help guide the establishment of antibiotic-use protocols.[1,6–8] Prudent use of such protocols supports AMS efforts to reduce the prevalence of MDROs and the risks of adverse drug events in the long-term care population.[9–14]

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Unfortunately, LTCFs may run into challenges when creating antibiograms because of the relative low number of residents in some facilities and the paucity of bacterial isolates collected for diagnostic purposes.[15] To address this, we reviewed the literature to evaluate proposed methods for developing an antibiogram with low isolate counts and to address some of the common pitfalls pertaining to the long-term care environment. Articles were identified by PubMed searches with the following keywords in various combinations: acute-care antibiograms, antibiograms, development of antibiograms, long-term care facility antibiograms, nursing home antibiograms, regional antibiograms, and stratified antibiograms. Manual searches of reference lists found from initial searches were also conducted. Studies were included based on the authors' judgment of relevance to the topic.

Guidelines for Creating an Antibiogram

The Clinical and Laboratory of Standards Institute (CLSI) publishes the M39 Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data; Approved Guideline, which is a commonly referenced guideline on how to create antibiograms.[1,2,7] It provides comprehensive recommendations geared toward microbiologists, physicians, pharmacists, epidemiologists, and other healthcare personnel on how to collect, analyze, and present cumulative antimicrobial susceptibility data. When completed, the antibiogram is often displayed as a table with columns and rows dedicated to listing all individual bacterial species with all individual antibiotics to match each "drug-bug" pair's cumulative susceptibility as a percent.

Figure 1 shows an example of an antibiogram prepared for a healthcare facility and guidance on how to use it. In that example, 29 out of 39 clinical *Escherichia coli* isolates collected from patients at that facility were resistant to ciprofloxacin. Accordingly, the percent susceptible listed in the antibiogram is 26% [$(10/39) \times 100 = 26\%$]. The same procedure was performed for all other antibiotics used to treat *E coli* infections as well as for antibiotics used to treat infections caused by other bacteria isolated.

Some of the recommendations from the CLSI M39 document on how to collect the data for these reports include the following: report at least annually, include only verified final results, include only species with data for ≥30 isolates, include only diagnostic (not surveillance) isolates, and only include the first isolate of a species obtained from a patient for each analysis period.[7] Only including diagnostic isolates and the first isolate of a species obtained from a patient are recommended to prevent overestimation of bacterial resistances. The cut-off of 30 isolates is recommended to improve the accuracy of the calculated susceptibility rates. As the number of isolates decreases, the 95% confidence intervals (CIs) become wider. For example, if considering a 90% susceptibly rate for n = 30 the 95% CI is 74%–97% compared with n = 20 and n = 10, for which the 95% CIs are 69%–98% and 57%–100%, respectively. A descriptive study found that out of 32 community hospitals, only 8 followed this 30-isolate recommendation whereas the rest included footnotes of "impaired statistical validity."[15] LTCFs, often smaller than community hospitals and with a lower rate of admissions, are even less likely to satisfy this recommendation. Thus, the question becomes how do we create antibiograms for LTCFs that will best estimate bacteria susceptibility rates to empiric guide antibiotic selection and support AMS practices?

Significance of the Problem

When clinicians start antibiotics without having culture results complete with susceptibilities to inform their antibiotic choices, antibiograms can help guide selection of an antibiotic likely to be effective against the

Hypothetical Healthcare Facility
1 January-31 December 2017 Cumulative Antimicrobial Susceptibility Report+
Percent Susceptible

Gram (-) Organisms	# of Isolates	Amoxicillin/ Clavulanate	Cefazolin	Ceftriaxone	Cefepime	Nitrofurantoin	Piperacillin/ Tazobactam	Ciprofloxacin	Gentamicin	TMP/SMX
Escherichia coli	39	84	64	74	89	100	87	26	82	85
Klebsiella pneumoniae	17*	76	76	82	100	65	88	94	88	76
Proteus mirabilis	32	95	53	88	100	R	97	16	100	81
Pseudomonas aeruginosa	11*	--	R	--	73	--	57	64	64	--
Gram (+) Organisms	**# of Isolates**	**Ampicillin**	**Clindamycin**	**Oxacillin**	**Gentamicin**	**Linezolid**	**Nitrofurantoin**	**Tetracycline**	**TMP/SMX**	**Vancomycin**
Staphylococcus aureus	19*	--	50	36	79	100	100	79	100	93
Enterococcus	35	83	--	--	52	100	81	17	--	83

Fig. 1. Example of hypothetical facility antibiogram with instructions for use.[7] Hypothetical healthcare facility 1 January-31 December 2017 cumulative antimicrobial susceptibility report+ percent susceptible; +The percent susceptible for each organism/antimicrobial combination was generated by including the first isolate of that organism encountered on a given patient; *Indicates <30 isolates tested and potentially low accuracy of susceptibility rates; −Indicates the antimicrobial agent is not tested, or is known to be clinically ineffective. R, intrinsic resistance; TMP/SMX, Sulfamethoxazole/Trimethoprim. Instructions for Use: (1) Locate the rows that list pathogens that are most likely to cause the infection: (ie, *Escherichia coli*, *Klebsiella pneumoniae*, and *Proteus mirabilis* for a urinary tract infection); (2) Locate columns of antibiotics within the same pathogen rows that have the highest percent susceptible (closest to 100); (3) Identify which antibiotics have the highest percent susceptibility rates, >80%–85% preferred,[15,16] and consider these as potential empiric therapeutic options; (4) To support antimicrobial stewardship, choose narrow spectrum agents when possible (eg, TMP/SMX rather than piperacillin/tazobactam).