Antimicrobial Resistance Solutions

Management. Education. Innovation.

Antibiograms

Regulatory Standard - Impacting Patient Lives

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July 25, 2023

What is an Antibiogram

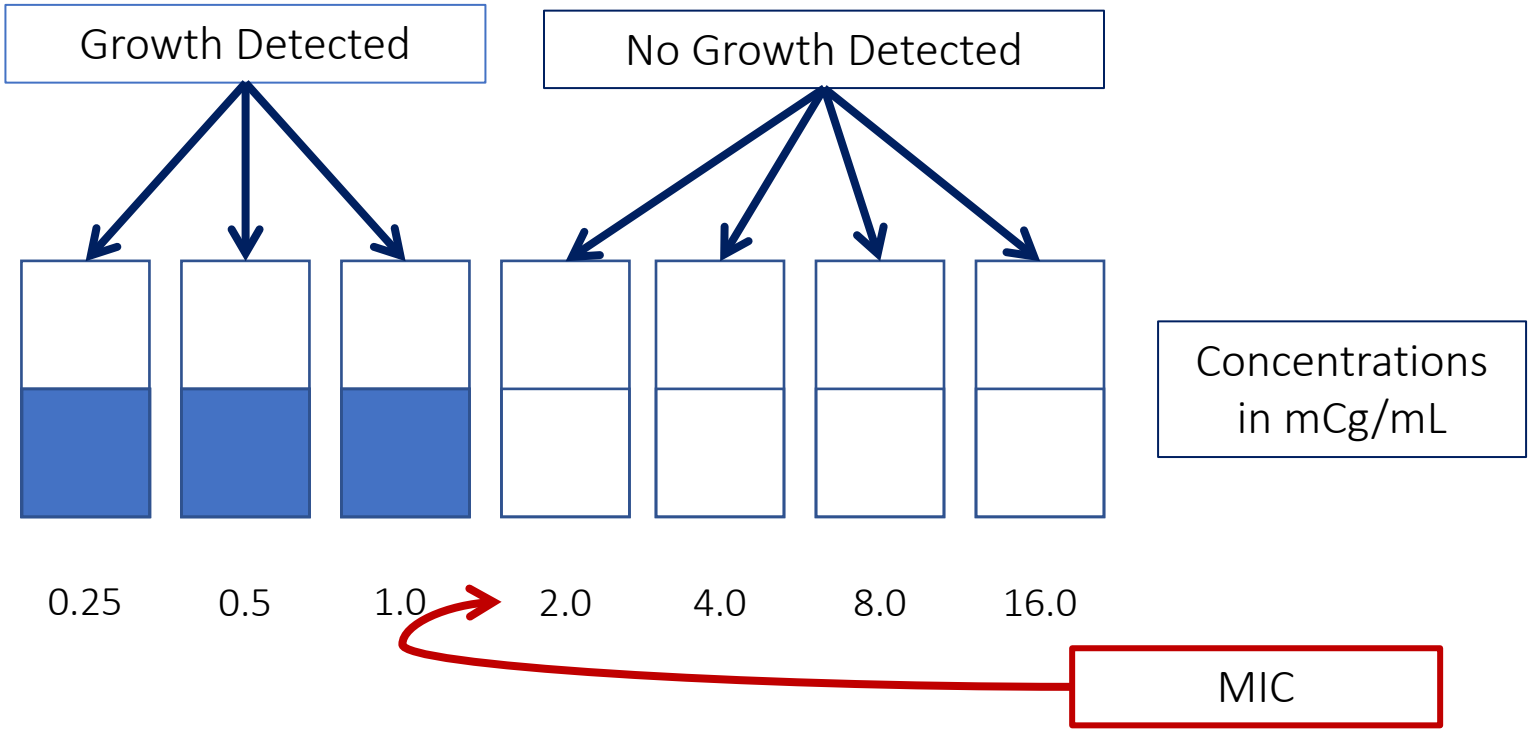
- A summary of antimicrobial susceptibility testing for a specific/unique care setting or population of patients.
- Clinically isolate micro-organisms are listed against and a panel of anti-infectives in table form summarizing the percentage of susceptible organisms to anti-infective drugs.
- Data summary period is typically one year but may vary.

What is the Intended Use

- Optimizing empiric antimicrobial therapy, thereby influencing outcomes.
- Tracking the development of resistance within and institution, patient population, clinical setting or geographic area over time, allowing for adaptations in anti-infective use to prevent or reverse antimicrobial resistance.
- Tracking resistance is limited by breakpoints, antibiogram does not track specific changes in MIC over time unless threshold for resistance is surpassed.
- Summarizing year-over-year susceptibility patterns for sentinel organisms (*Strep pneumoniae*).

Defining MIC

- MIC – minimum inhibitory concentration



What are Breakpoints?

- Breakpoints are determined by laboratory standard organizations utilizing MIC values
- Organisms can be defined as susceptible or resistant
- Susceptible organisms should respond to standard dosing regimens of antimicrobials
- Methods used to determine susceptibility breakpoints can differ
- Historically many different entities recommended breakpoints
  - Pharmaceutical companies
  - FDA
  - Laboratory oversight bodies
- Breakpoint questions
  - How are breakpoints determined?
  - Who defines susceptible?
  - Are definitions consistent in all countries?
  - Do breakpoints change over time?

Standards Organizations

- FDA
- CLSI
- EUCAST (formed 1997, harmonized breakpoints in Europe, ongoing)
- USCAST (formed 2014, liaison to CLSI and EUCAST)

Breakpoint Questions

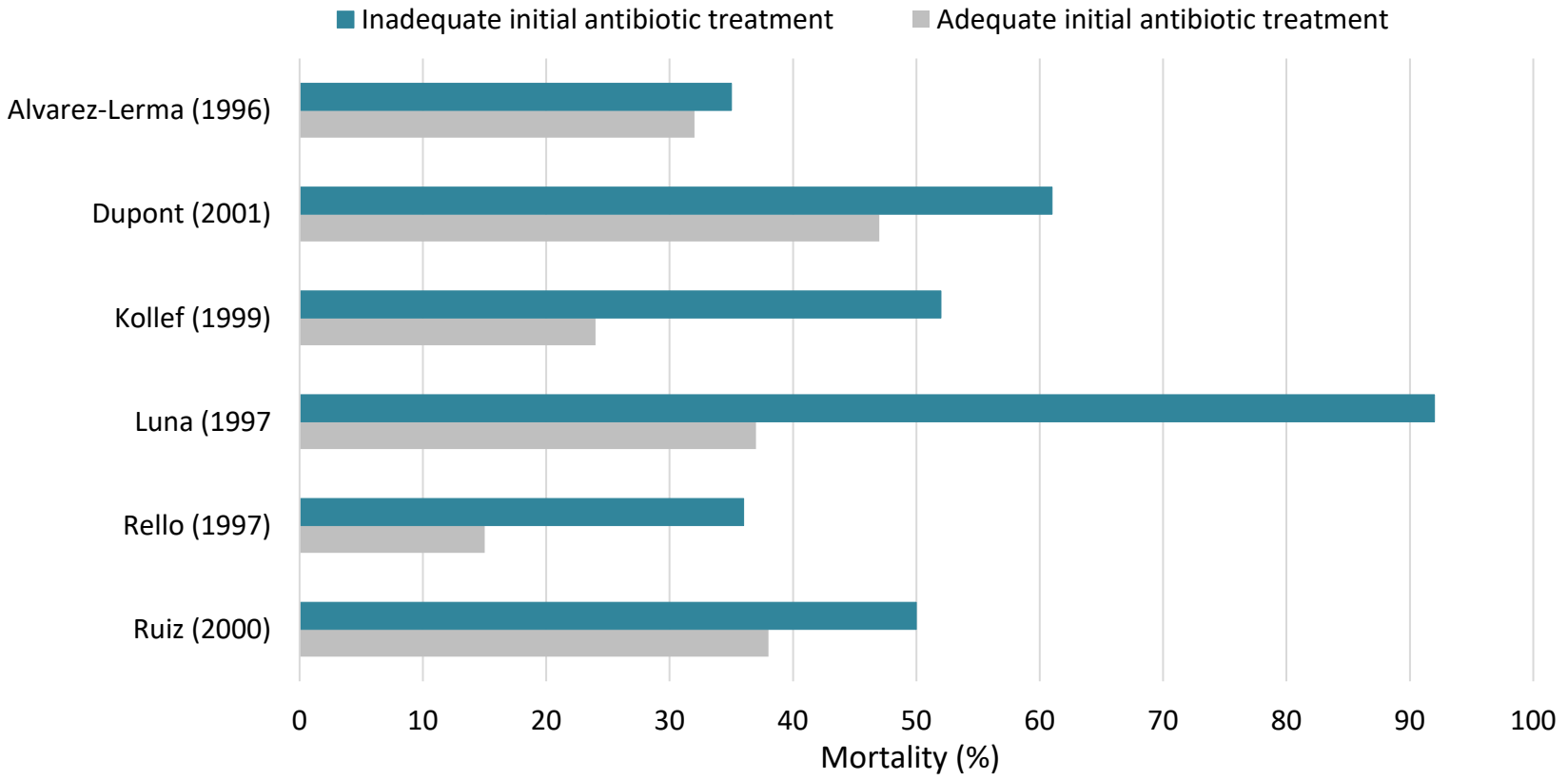
How are breakpoints determined?

- Cumulative MIC distributions

- Historically breakpoints viewed as static and necessary for less industry and clinical disruption
  - Pharma wants favorable susceptibilities to drugs to drive use
  - Microbiology testing companies do not want to change assays frequently
  - Desire for concrete answers

- May not reflect ability
  - achieve antimicrobial concentrations necessary for adequate microbiological or clinical response
  - Prevent emergence of resistance

Importance of Initial Empiric Antibiotic Selection



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Dupont H, et al. *Intensive Care Med.* 2001;27:355-362.
Kollef MH, et al. *Chest.* 1999;115:462-474.
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Rello J, et al. *Am J Respir Crit Care Med.* 1997;156:196-200.
Ruiz M, et al. *Am J Respir Crit Care Med.* 2000;162:119-125.

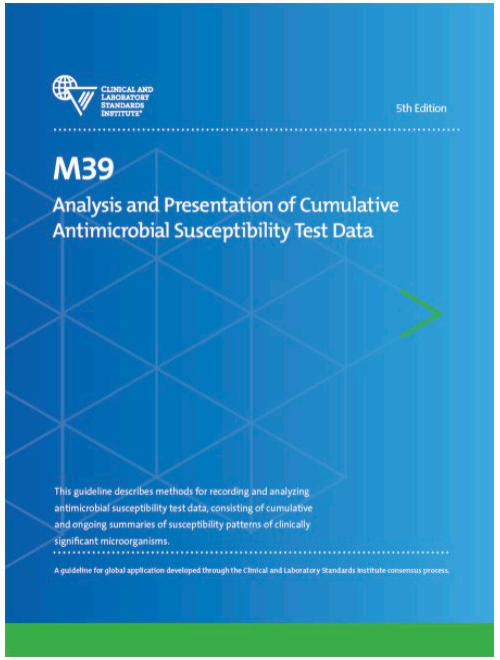
Example Antibiogram

Example Annual Antibiogram

Gram Negatives	Total Isolates	Amikacin	Amox/K Clav	Ampicillin	Ampicillin/sulbactam	Aztreonam	Cefazolin	Cefepime	Ceftazidime	Cefuroxime	Ceftriaxone	Ciprofloxacin	Ertapenem	Gentamicin	Imipenem	Levofloxicin	Linezolid	Nitrofurantoin	Oxacillin	Penicillin	Piperacillin-Tazobactam	Tetracycline	Tobramycin	Trimethoprim/Sulfa	Vancomycin
Acinetobacter baumannii	*0																								
Citrobacter freundii	*3	100	0	0	0		0	100		0	33	100	100	100		100		100			67	67	100	67	
Enterobacter aerogenes	*2	100	0	0	0		0	100		0	100	100	100	100		100		0			100	100	100	100	
Enterobacter cloacae	*3	100	0	0	0		0	100		0	67	100	100	100		100		67			100	100	100	100	
Escherichia coli	46	100	78	0	52		84	100		89	100	59	100	98		75		91			100	76	91	78	
Escherichia coli ESBL	*9	100	67	0	44		0	0		0	0	0	100	100	100	0		100			100	11	78	67	
Klebsiella pneumoniae	*9	100	78	0	56		67	89		78	89	78	100	89		78		33			78	89	78	67	
Klebsiella pneumoniae ESBL	*6	100	17	0	0		0	0		0	0	0	100	17	100	80		17			83	50	17	0	
Morganella morganii	*5	100	0	0	20		0	100		0	60	80	100	80		80		0			100	60	100	80	
Pseudomonas aeruginosa	*14	100				100		100	100			77		79	100	77					100		100		
Proteus mirabilis	31	100	97	0	97		87	100		100	100	35	100	94		38		0			100	0	97	48	
Proteus mirabilis ESBL	*5	100	80	0	60		0	0		0	0	0	100	40		0		0			100	0	60	40	
Providencia stuartii	*8	100	0	0	25		0	100		38	88	25	100	0		25		0			100	0	0	100	
Serratia marcescens	*2	100	0	0	0		0	0		0	0	0	0	100		0		0			0	0	100	0	
Gram Positives																									
Coagulase Negative Staph	*0																								
Enterococcus faecalis	*18			0								67					100	100		100		11			100
Enterococcus faecalis VRE	*4			0								0					100	100		100		0			0
Enterococcus faecium	*0																								
Enterococcus faecium VRE	*7			0								0					100	57		0		14			0
Methicillin Resistant S aureus MRSA	*0																								
Staphylococcus aureus	*1		0									100		100			100	0	100	0		100		100	100

Antibiogram Requirements

- Accreditation/regulatory requirements
- Specific recommendations guidance: CLSI M-39
  - Current 5th edition, published Jan 24, 2022
- EMR Pitfalls
  - Screening for quality assurance if utilizing data from surveillance software (WHONET, TheraDoc) or EMR (EPIC)



Creating an Antibiogram

- Who makes an antibiogram
  - Laboratory
  - Microbiologist
  - Pharmacist
  - Physician
  - Infection prevention practitioner

- Optimal collaboration
  - **Microbiologist**
  - **Pharmacist / ID Pharmacist**
  - **ID Physician**

Antibiogram Distribution and Education

- Individuals
  - Clinician
  - Microbiologist
  - Pharmacist
  - Infection prevention practitioner

- Care Environments
  - Acute Care (Inpatient, Units, ED, etc)
  - Post-acute (LTAC, LTC, etc)
  - Outpatient Practices (Dialysis, Physician offices, immediate care)
    - Patient type vs community specific
  - Community or region

Influences on Antibiogram Validity

Internal	External
Formulary	**CLSI (M-39 or version of M-100)** **EUCAST, USCAST, AGAR**
Electronic Medical Record	AST Panels Available/Utilized
Micro Reporting (e.g. cascade, suppression)	Third Party Lab – reporting of data
Antimicrobial Dosing Protocols	
Facility Size/Numbers	

Example Antibiogram

Example Annual Antibiogram **Gram Negatives**	**Total Isolates**	Amikacin	Amox/K Clav	Ampicillin	Ampicillin/sulbactam	Aztreonam	Cefazolin	Cefepime	Ceftazidime	Cefuroxime	Ceftriaxone	Ciprofloxacin	Ertapenem	Gentamicin	Imipenem	Levofloxicin	Linezolid	Nitrofurantoin	Oxacillin	Penicillin	Piperacillin-Tazobactam	Tetracycline	Tobramycin	Trimethoprim/Sulfa	Vancomycin
Acinetobacter baumannii	*0																								
Citrobacter freundii	*3	100	0	0	0		0	100		0	33	100	100	100		100		100			67	67	100	67	
Enterobacter aerogenes	*2	100	0	0	0		0	100		0	100	100	100	100		100		0			100	100	100	100	
Enterobacter cloacae	*3	100	0	0	0		0	100		0	67	100	100	100		100		67			100	100	100	100	
Escherichia coli	46	100	78	0	52		84	100		89	100	59	100	98		75		91			100	76	91	78	
Escherichia coli ESBL	*9	100	67	0	44		0	0		0	0	0	100	100	100	0		100			100	11	78	67	
Klebsiella pneumoniae	*9	100	78	0	56		67	89		78	89	78	100	89		78		33			78	89	78	67	
Klebsiella pneumoniae ESBL	*6	100	17	0	0		0	0		0	0	0	100	17	100	80		17			83	50	17	0	
Morganella morganii	*5	100	0	0	20		0	100		0	60	80	100	80		80		0			100	60	100	80	
Pseudomonas aeruginosa	*14	100				100		100	100			77		79	100	77					100		100		
Proteus mirabilis	31	100	97	0	97		87	100		100	100	35	100	94		38		0			100	0	97	48	
Proteus mirabilis ESBL	*5	100	80	0	60		0	0		0	0	0	100	40		0		0			100	0	60	40	
Providencia stuartii	*8	100	0	0	25		0	100		38	88	25	100	0		25		0			100	0	0	100	
Serratia marcescens	*2	100	0	0	0		0	0		0	0	0	0	100		0		0			0	0	100	0	
Gram Positives																									
Coagulase Negative Staph	*0																								
Enterococcus faecalis	*18			0								67					100	100		100		11			100
Enterococcus faecalis VRE	*4			0								0					100	100		100		0			0
Enterococcus faecium	*0																								
Enterococcus faecium VRE	*7			0								0					100	57		0		14			0
Methicillin Resistant S aureus MRSA	*0																								
Staphylococcus aureus	*1		0									100		100			100	0	100	0		100		100	100

Functional Antibiogram

Inpatient Gram-negative Bacilli % Susceptible (Suscept #/Total #)	Amikacin	Gentamicin	Tobramycin	Cefazolin	Cefoxitin	Cefuroxime	Cefpodoxime	Ceftriaxone	Cefepime	Ampicillin	Ampicillin / Sulbactam	Amoxicillin / Clavulanate	Piperacillin / Tazobactam	Imipenem ‡	Meropenem	Ciprofloxacin	Nitrofurantoin, Urine only	Fosfomycin, Urine only	Sulfamethoxazole / Trimethoprim	Tetracycline
Enterobacter cloacae	100 (21/21)*	97 (41/42)	97 (41/42)						90 (37/41)						100 (22/22)	95 (40/42)	52 (11/21) *		92 (39/42)	85 (18/21) *
Escherichia coli	100 (92/92)	93 (560/597)	91 (549/597)	91 (463/506)	91 (78/85)	88 (75/85)	95 (81/85)	99 (539/544)	92 (544/586)	61 (334/544)	69 (378/544)	85 (502/588)	97 (571/587)	100 (132/132)	100 (95/95)	76 (458/596)	95 (478/502)	92 (39/42)	78 (470/596)	77 (73/94)
Klebsiella oxytoca	100 (16/16)*	96 (31/32)	96 (31/32)		93 (15/16) *	93 (15/16) *	93 (15/16) *	96 (30/31)	93 (30/32)		64 (20/31)	90 (29/32)			93 (14/15)	93 (30/32)	81 (13/16) *		96 (31/32)	93 (15/16) *
Klebsiella pneumoniae	100 (69/69)	96 (194/200)	96 (193/200)	97 (130/134)	92 (62/67)	92 (62/67)	100 (67/67)	100 (190/190)	96 (190/197)		85 (163/190)	94 (186/197)	94 (186/197)	100 (41/41)	98 (69/70)	93 (186/200)	26 (35/131)		90 (181/200)	84 (59/70)
Klebsiella variicola		100 (22/22)*	100 (22/22) *					100 (22/22) *	100 (22/22) *		100 (22/22) *	100 (22/22) *		100 (8/8) *		100 (22/22) *	57 (11/19) *		95 (21/22) *	
Proteus mirabilis	100 (29/29)*	90 (84/93)	94 (88/93)	92 (64/69)	100 (29/29) *	100 (29/29) *	100 (29/29) *	100 (91/91)	98 (91/92)	83 (78/93)	90 (84/93)	100 (89/89)	100 (93/93)		100 (29/29)	75 (70/93)			83 (78/93)	
Pseudomonas aeruginosa	95 (67/70)	92 (97/105)	98 (102/104)						86 (91/105)				86 (90/104)		88 (61/69)	85 (90/105)				
Stenotrophomonas maltophilia																37 (6/16) *			100 (25/25) *	95 (24/25) *

‡ Imipenem susceptibility predicts Meropenem susceptibility

Green = greater than or equal to 85% of isolates susceptible

Yellow = 75% to 84% of isolates susceptible

Red = less than 75% of isolates susceptible

* less than 30 isolates, interpret with caution, as small numbers may bias the group susceptibilities

Gram Positive

Percent Susceptible, Number Susceptible/Number Tested	Gentamicin	Rifampin	Cefazolin	Oxacillin	Clindamycin	Erythromycin	TMP/Sulfa	Tetracycline	Moxifloxacin	Ceftriaxone	Penicillin G	Ampicillin	Vancomycin	Linezolid	Nitrofurantoin (Urine Only
Enterococcus faecalis											98 (76/77)	98 (83/84)	95 (80/84)		97 (47/48)
Enterococcus faecium											42 (8/19)*	36 (8/22)*	50 (11/22)	100 (12/12)*	46 (6/13)*
Enterococcus species (all - faecalis, faecium, other)											88 (89/101)	86 (99/114)	85 (97/114)	100 (16/16)*	86 (53/61)
Staphylococcus aureus	99 (201/203)	100 (201/201)	63 (134/212)	63 (135/213)	72 (134/185)	54 (111/202)	95 (205/215)	91 (182/200)					100 (214/214)	100 (30/30)	
Staphylococcus aureus - MRSA	97 (71/73)	100 (73/73)			61 (43/70)	27 (20/73)	92 (72/78)	86 (62/72)					100 (77/77)	100 (30/30)	
Staphylococcus aureus - MSSA	100 (128/128)	100 (128/128)	99 (134/135)	100 (135/135)	80 (91/113)	71 (91/128)	97 (131/135)	93 (120/128)					100 (135/135)		
Staphylococcus coagulase negative - ALL	87 (49/56)	96 (53/55)	35 (24/67)	36 (25/69)	57 (11/19)*	25 (14/56)	57 (40/70)	75 (52/69)					100 (70/70)		100 (15/15)*
Streptococcus agalactiae (Group B)¶					39 (14/36)					100 (36/36)	100 (36/36)		100 (36/36)		
Streptococcus pneumoniae¶					80 (20/25)*		77 (28/36)	80 (28/35)	100 (36/36)	94 (34/36)	94 (34/36)				

* Small sample size, interpret with caution.

Antibiogram data intended to guide empiric choice of antibiotics. Once culture results are known, adjust antibiotic selection narrowing spectrum, if appropriate.

Greater than or equals to 85% of isolates susceptible

75% to 84% of isolates susceptible

Less than 75% of isolates susceptible

Antibiogram – Single isolates

Gram-negative Bacilli Antibiogram: First Species Isolate per Patient per Year

	# of Isolates	Gentamicin	Tobramycin	Cefazolin	Ceftriaxone	Ceftazidime	Cefepime	Ciprofloxacin	Levofloxacin	Meropenem	Ampicillin	Ampicillin / Sulbactam	Amoxicillin / Clavulanate	Piperacillin / Tazobactam	Nitrofurantoin (Urine Only)	TMP/Sulfa
MIC Breakpoints (mcg/ml)		≤4	≤4	≤4*	≤1	≤4	≤2	≤0.25	≤0.5	≤1#	≤8	≤8	≤8	≤8#	≤32	≤2/38
MIC Breakpoint - *P. aeruginosa*						≤8	≤8	≤0.5	≤1	≤2				≤16		
Escherichia coli	69	80	78	78	84	83	91	61	59	100	41	51	78	93	97	64
Klebsiella pneumoniae	19	100	84	84	84	84	84	89	89	100	-	74	84	79	21	74
Proteus mirabilis	30	100	97	70	93	93	93	57	57	100	73	87	97	93	0	67
Pseudomonas aeruginosa	12	100	100	-	-	-	67	75	-	100	-	-	-	67	-	-

MIC Breakpoints Based by Infection and Achievable Concentrations

* Cefazolin MIC <=4 systemic infections/non-urine, MIC <=16 cystitis Enterobacteriaceae (83% E. coli, 84% Klebsiella pneumoniae, 90% Proteus mirabilis,)

Less than 30 isolates, interpret with caution as small numbers may bias the group susceptibilities.

Basic Antibiogram – Single isolates

Enhanced Broad Spectrum Activity in Class

Gram-negative Bacilli Antibiogram: First Species Isolate per Patient per Year

	# of Isolates	Gentamicin	Tobramycin	Cefazolin	Ceftriaxone	Ceftazidime	Cefepime	Ciprofloxacin	Levofloxacin	Meropenem	Ampicillin	Ampicillin / Sulbactam	Amoxicillin / Clavulanate	Piperacillin / Tazobactam	Nitrofurantoin (Urine Only)	TMP/Sulfa
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Escherichia coli	69	80	78	78	84	83	91	61	59	100	41	51	78	93	97	64
Klebsiella pneumoniae	19	100	84	84	84	84	84	89	89	100	-	74	84	79	21	74
Proteus mirabilis	30	100	97	70	93	93	93	57	57	100	73	87	97	93	0	67
Pseudomonas aeruginosa	12	100	100	-	-	-	67	75	-	100	-	-	-	67	-	-

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Basic Antibiogram – Single isolates

Peak / MIC

Time / MIC (Exposure)

Gram-negative Bacilli Antibiogram: First Species Isolate per Patient per Year

	# of Isolates	Gentamicin	Tobramycin	Cefazolin	Ceftriaxone	Ceftazidime	Cefepime	Ciprofloxacin	Levofloxacin	Meropenem	Ampicillin	Ampicillin / Sulbactam	Amoxicillin / Clavulanate	Piperacillin / Tazobactam	Nitrofurantoin (Urine Only)	TMP/Sulfa
MIC Breakpoints (mcg/ml)		≤4	≤4	≤4*	≤1	≤4	≤2	≤0.25	≤0.5	≤1#	≤8	≤8	≤8	≤8#	≤32	≤2/38
MIC Breakpoint - *P. aeruginosa*						≤8	≤8	≤0.5	≤1	≤2				≤16		
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Basic Antibiogram – Single isolates

Gram-negative Bacilli Antibiogram: First Species Isolate per Patient per Year

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Proteus mirabilis	30	100	97	70	93	93	93	57	57	100	73	87	97	93	0	67
Pseudomonas aeruginosa	12	100	100	-	-	-	67	75	-	100	-	-	-	67	-	-

Merino Trial: 3rd Gen Ceph Resistant *E.coli* or *Klebsiella spp*. BSI
Pip/tazo 4.5g IVQ6h vs Meropenem 1g IV Q8h
Mortality: P/T 23/187 (12.3%) vs Mero 7/191 (3.7%)

Harris PN, et al. JAMA. 2018 Sep 11;320(10):984-994.

Critical Data for Antimicrobial Treatment Decisions

- Antibiogram - most active agent(s) for clinical setting or pathogen
- Drugs concentrations at the infection site
- Drugs optimal dosing characteristics
- Drugs risk for selecting resistance
- Drug risk for adverse effects
- Cost

Empiric Antimicrobial Recommendations

Example Facility

Suspected Source		First Line Regimen(s) (No β-lactam Allergy)	Non-Severe PCN Allergy (ie. Rash, Itch)	Severe β-lactam Allergy (ie. Anaphylaxis)	Recommended Total Duration of Effective Therapy**
UTI	**Cystitis**	Amoxicillin 500mg PO BID **PLUS** Gentamicin 3-5mg/kg (adj wgt) IV/IM x1 **OR** Gentamicin 3-5mg/kg (adj wgt) IV/IM x1 **No antibiotics previous 90 days or previous nitrofurantoin or TMP/SMX resistant strain:** Nitrofurantoin 100mg PO BID **OR** TMP/SMX 1 DS PO BID	Gentamicin 3-5mg/kg (adj wgt) IV/IM x1 **No antibiotics previous 90 days or previous nitrofurantoin or TMP/SMX resistant strain:** Nitrofurantoin 100mg PO BID **OR** TMP/SMX 1 DS PO BID	Gentamicin 3-5mg/kg (adj wgt) IV/IM x1 **No antibiotics previous 90 days or previous nitrofurantoin or TMP/SMX resistant strain:** Nitrofurantoin 100mg PO BID **OR** TMP/SMX 1 DS PO BID	3-5 days
	Pyelonephritis/ Systemic Infections	Ampicillin 1gm IV q8hr **PLUS** Gentamicin 5mg/kg (adj wgt) IV/IM X 1ǂ **Limited IV access:** Gentamicin 3-5mg/kg (adj wgt) IM x1ǂ **PLUS** Amoxicillin 1gm PO TID	Cefazolin 1gm IV/IM q8hr **PLUS** Gentamicin 5mg/kg (adj wgt) IV/IM X 1ǂ **Limited IV access:** Gentamicin 3-5mg/kg (adj wgt) IM x1ǂ **PLUS** Cephalexin 1gm PO TID	Gentamicin 5mg/kg (adj wgt) IV/IM X 1ǂ ±Ciprofloxacin 400mg IV q12hr if septic/severe disease	5-10 days
Pneumonia	**Community Acquired (CAP) – Low Risk**	**ORAL** Doxycycline 200mg PO Daily **(Preferred)** Amoxicillin/clavulanate 500mg PO TID **OR** Cefdinir 300mg PO BID **PLUS** Doxycycline 200mg PO Daily **OR** Azithromycin 500mg PO Daily (3 days) **INTRAVENOUS** Ampicillin/sulbactam 3g q8hr PI **OR** Ceftriaxone 1gm IV/IM q24hr **PLUS** Doxycycline 200mg PO Daily **OR** Azithromycin 500mg PO Daily (3 days) ± MRSA Coverage #See risk factors below – Doxycycline with MRSA activity; if not utilizing doxycycline ADD Vancomycin 20mg/kg then pharmacy to dose	**ORAL** Doxycycline 200mg PO Daily **(Preferred)** Cefdinir 300mg PO BID **PLUS** Doxycycline 200mg PO Daily **OR** Azithromycin 500mg PO Daily (3 days) **INTRAVENOUS** Ceftriaxone 1gm IV/IM q24hr **PLUS** Doxycycline 200mg PO Daily **OR** Azithromycin 500mg PO Daily (3 days) ± MRSA Coverage #See risk factors below – Doxycycline with MRSA activity; if not utilizing doxycycline ADD Vancomycin 20mg/kg then pharmacy to dose	**ORAL** Doxycycline 200mg PO Daily (Preferred) **OR** Moxifloxacin 400mg PO Daily **INTRAVENOUS** Moxifloxacin 400mg IV/PO q24hr ± MRSA Coverage #See risk factors below – Doxycycline with MRSA activity; if not utilizing doxycycline ADD Vancomycin 20mg/kg then pharmacy to dose	5-7 days
	CAP At Risk *Pseudomonas*/MRSA*	Piperacillin/tazobactam 3.375gm IV q8hr PI **OR** Cefepime 1gm IV q8hr PI **PLUS** Tobramycin 7mg/kg (adj wgt) IV/IM x 1 **PLUS** Doxycycline 200mg PO Daily **(Preferred)** **OR** Azithromycin 500mg PO Daily (3 days) Empiric Severe CAP w/MRSA risk factors*: **ADD** Vancomycin 20mg/kg then pharmacy to dose	Cefepime 1gm IV q8hr PI **OR** Meropenem 500mg IV q6hr **PLUS** Tobramycin 7mg/kg (adj wgt) IV/IM x 1 **PLUS** Doxycycline 200mg PO Daily **(Preferred)** **OR** Azithromycin 500mg PO Daily (3 days) Empiric Severe CAP w/MRSA risk factors*: **ADD** Vancomycin 20mg/kg then pharmacy to dose	***Penicillin allergic (anaphylaxis) call ID for recommendation***	5-7 days (if *S. aureus* pneumonia identified, duration of therapy may be longer)
Intra-abdominal Infection	**Community Acquired**	**ORAL** Amoxicillin/clavulanate 500mg PO TID **OR** Cefpodoxime 400mg PO BID **PLUS** Metronidazole 1000mg PO Daily **INTRAVENOUS** Ampicillin/sulbactam 3g IV q8hr PI **PLUS** Gentamicin 7mg/kg (adj wgt) IV/IM x 1ǂ	**ORAL** TMP/SMX 1DS PO BID **OR** Cefpodoxime 400mg PO BID **PLUS** Metronidazole 1000mg PO Daily **INTRAVENOUS** Ceftriaxone 1gm IV/IM q24hr **PLUS** Metronidazole 1000mg PO/IV Daily	**ORAL** TMP/SMX 1DS PO BID **OR** Ciprofloxacin 750mg PO BID **PLUS** Metronidazole 1000mg PO Daily **INTRAVENOUS** Ciprofloxacin 400mg IV q12hr **PLUS** Metronidazole 1000mg PO/IV Daily **PLUS** Gentamicin 7mg/kg (adj wgt) IV/IM X 1ǂ	5-7 days
	Healthcare/ Hospital Acquired	Piperacillin/tazobactam 3.375gm IV q8hr PI **PLUS** Tobramycin 7mg/kg (adj wgt) IV/IM X 1ǂ	Cefepime 1gm IV/IM q8hr PI **PLUS** Metronidazole 1000mg PO/IV Daily **PLUS** Tobramycin 7mg/kg (adj wgt) IV/IM X 1ǂ	Ciprofloxacin 400mg IV q12hr **PLUS** Metronidazole 1000mg PO/IV Daily **PLUS** Tobramycin 7mg/kg (adj wgt) IV/IM X 1ǂ	5-7 days
Skin & Soft Tissue Infection	**Cellulitis (including Diabetic Foot Infection w/o ulcer/open wound)**	**ORAL** Amoxicillin/clavulanate 500mg PO TID **OR** Cephalexin 1000mg PO QID **INTRAVENOUS** Cefazolin 2gm IV/IM q8hr **OR** Ampicillin/sulbactam 3g IV q8hr PI ± MRSA Coverage^ - see risk factors below ADD Vancomycin pharmacy to dose. If able to take PO then doxycycline or TMP/SMX in place Vancomycin.	**ORAL** Cephalexin 1000mg PO QID **INTRAVENOUS** Cefazolin 2 gm IV/IM q8hr ± MRSA Coverage^ - see risk factors below ADD Vancomycin pharmacy to dose. If able to take PO then doxycycline or TMP/SMX in place Vancomycin.	**ORAL** Doxycycline 200mg PO Daily **OR** TMP/SMX 1 DS PO BID **INTRAVENOUS** Vancomycin pharmacy to dose If able to take PO then doxycycline or TMP/SMX in place Vancomycin.	5-10 days
	Diabetic Foot Infection with ulcer/open wound	Piperacillin/tazobactam 3.375gm IV q8hr PI **PLUS** Doxycycline 200mg PO Daily **OR** TMP/SMX 1 DS PO BID	Cefepime 1gm IV/IM q8hr PI **PLUS** Metronidazole 1000mg IV/PO q24hr **PLUS** Doxycycline 200mg PO Daily **OR** TMP/SMX 1 DS PO BID	***Call ID or ARS for recommendation***	7-14 days Duration based on severity, osteomyelitis, clinical response. Recommend ID consult.

dditional doses: Review and dependent on culture results may require additional doses and/or assessment of serum concentrations.
dd MRSA Coverage: Prior MRSA isolation from respiratory tract previous 12 months, hospitalization AND parenteral antibiotics previous 90 days, post-influenza. Mild to moderate pneumonia with MRSA risk factors may be cove
npirically with doxycycline.
AP at risk *Pseudomonas*/MRSA criteria: Prior *Pseudomonas*/MRSA isolation from respiratory tract previous 12 months, hospitalization AND parenteral antibiotics previous 90 days, post influenza. May consider in LTC/LTAC patie
at received >3 days broad-spectrum antibiotic(s) AND Activity of Daily Living (ADL) score >12.5 at baseline (more debilitated patient). Mild to moderate pneumonia with MRSA risk factors may be covered empirically with doxycyc
dd MRSA Empiric Coverage Cellulitis: Abscess, ulcer with purulent drainage, penetrating trauma (IV drug use), or patient with concurrent evidence of MRSA infection elsewhere or history of MRSA.
Duration of therapy: Assess patient and stop therapy when clinically improved.

Disease State Treatment
Urinary Tract Infection

Gram-negative Bacilli Antibiogram: First Species Isolate per Patient per Year

	# of Isolates	Gentamicin	Tobramycin	Cefazolin	Ceftriaxone	Cefepime	Ciprofloxacin	Aztreonam	Meropenem	Ampicillin	Ampicillin / Sulbactam	Amoxicillin/ clavulanate	Piperacillin / Tazobactam	Nitrofurantoin (Urine Only)	TMP/Sulfa
MIC Breakpoints (mcg/ml)		≤4	≤4	≤4*	≤1	≤2	≤0.25	≤4	≤1	≤8	≤8	≤8	≤8	≤32	≤2/38
MIC Breakpoint - *P.aeruginosa*						≤8	≤0.5		≤2				≤16		
Escherichia coli	812	88	87	84	94	95	67	94	100	50	53	78	93	97	74
Klebsiella pneumoniae	205	98	96	93	96	97	93	96	100	-	83	94	95	61	91
Proteus mirabilis	158	87	89	82	99	99	48	98	99	77	79	89	100	1	68
Pseudomonas aeruginosa	185	82	96	-	-	100	83	92	100	-	-	-	88	-	-

Cumulative Disease State Susceptibility

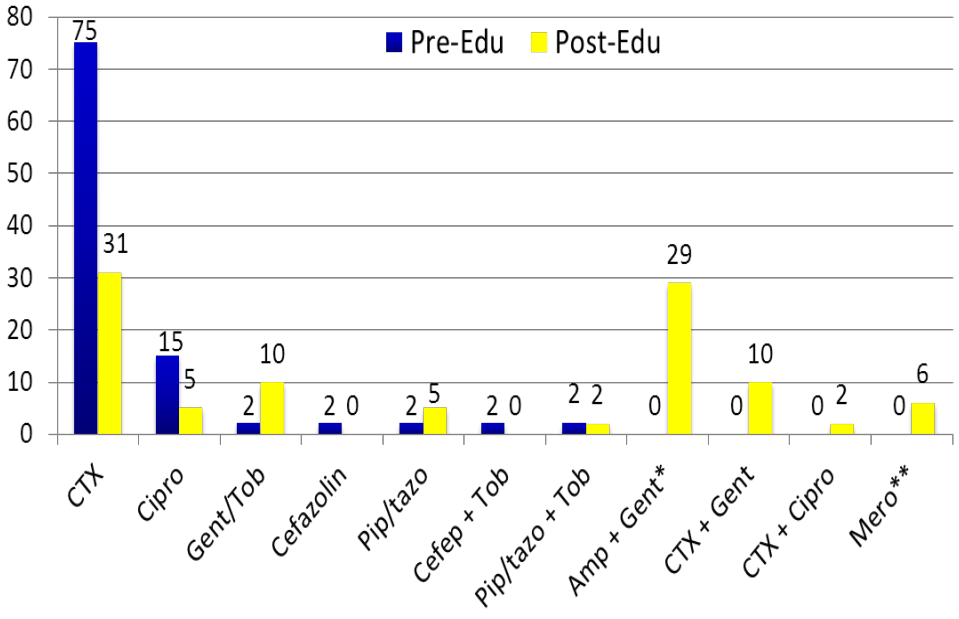
Most Prevalent Organisms Cultured from Urine

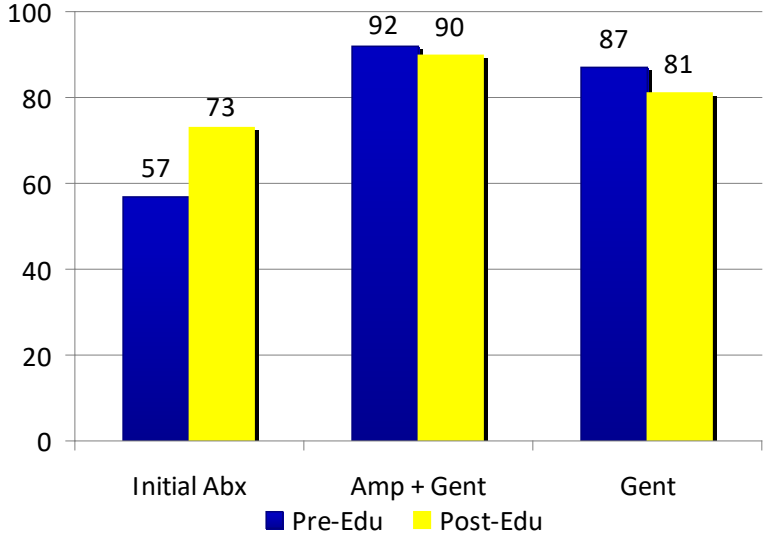
Total Urine Isolates (1041): E. coli (367), K. pneumoniae (118), Enterococcus faecalis (111), Proteus mirabilis (103), Pseudomonas aeruginosa (58), Enterococcus faecium (53).

Most Active Therapies	Susceptibilities
Ampicillin + Gentamicin	86%
Cefazolin + Gentamicin	75%
Gentamicin	72%
Ceftriaxone	69%
Ciprofloxacin	62%
Cefazolin	61%
Piperacillin/tazobactam	91%

Cheatham SC, et al. "*Use of Conditional & Cumulative Susceptibility Reporting to Improve Antibiotic Prescribing & Rates on Initial Appropriate Antibiotic Therapy*." 52nd Interscience Conference on Antimicrobial Agents and Chemotherapy, San Francisco, CA. September 2012.

Cumulative Disease State Susceptibility





Cheatham SC, et al. "*Use of Conditional & Cumulative Susceptibility Reporting to Improve Antibiotic Prescribing & Rates on Initial Appropriate Antibiotic Therapy*." 52nd Interscience Conference on Antimicrobial Agents and Chemotherapy, San Francisco, CA. September 2012.

Nursing Facility Antibiograms

- Typical low number of isolates
  - Expanded time frame (rolling 2-year data)
  - Expand organism analysis to genus level
- Consider local resistance patterns to supplement data
  - Preference surrounding facilities sharing patients (e.g., local referral acute care hospital)
  - Utilize to validate resistance patterns in local area
- Consider limitations

Cumulative Disease State by Presenting Location

Presenting Location	# of Isolates	Gentamicin	Tobramycin	Cefazolin	Ceftriaxone	Cefepime	Ciprofloxacin	Meropenem	Piperacillin / Tazobactam	ESBL	Nosocomial (PA)
Community	425	97	97	87	97	97	74	99	97	↓	↓
Healthcare associated	87	87	91	61	67	90	79	91	91	↓	↑
LTCF	212	89	93	57	75	85	55	87	85	↑	↑
Excellence SNF	38	85	88	45	55	65	58	85	75	↑↑	←→

Facility Differences in Close Proximity

Gram-negative Bacilli Antibiogram: First Species Isolate per Patient per Year

	# of Isolates	Gentamicin	Cefazolin	Ceftriaxone	Ceftazidime	Ciprofloxacin	Meropenem	Ampicillin	Ampicillin / Sulbactam	Piperacillin / Tazobactam	Nitrofurantoin (Urine Only)	Tetracycline	TMP/Sulfa
MIC Breakpoints (mcg/ml)		≤4	≤4*	≤1	≤4**	≤1	≤1#	≤8	≤8	≤16	≤32	≤4	≤2/38
Escherichia coli	43	81	51	56	56	44	100	30	33	56	93	77	74
Klebsiella pneumoniae	16	94	69	75	75	75	94	-	75	75	53	75	56
Proteus mirabilis	17	59	88	100	100	41	100	59	100	100	0	0	53
Pseudomonas aeruginosa	10	60	-	-	90	90	90	-	-	90	-	-	-

Referral Facility #1

	# Isolates	Gentamicin	Cefazolin	Ceftriaxone	Ciprofloxacin	Pip/tazo	TMP/Sulfa
E. Coli	183	93	86	90	81	97	77
P. aeruginosa	66	94			95	95	

Referral Facility #2

	# Isolates	Gentamicin	Cefazolin	Ceftriaxone	Ciprofloxacin	Pip/tazo	TMP/Sulfa
E. Coli	981	91	81	90	-	90	80
P. aeruginosa	249	86			80	91	

Additional Information Included

- Empiric recommendations
  - Disease specific based on antibiogram
  - Alternatives due to allergy
- Optimal Dosing Guidelines
- Antimicrobial costs
- Clinical Pearls based on information presented
- Molecular testing results
  - Cumulative results
  - Recommendations

Summary Slide

- Antibiograms summarize antimicrobial susceptibility testing within care settings

- Challenges for creating accurate antibiograms include accurate data from micro lab, error-inducing interfaces between microdata collection systems and EMR, lack of microbiologic culture testing

Summary Slide

- Functional antibiograms:
  - Track and identify organism-specific antimicrobial resistance & patterns
  - Assist developing empiric therapy choices
  - Assist treatment order set design for unique clinical settings that are informed by prevailing resistance patterns
  - Assist in determining causes of antimicrobial resistance when combined with antimicrobial use (AU) data
  - Inform prescribers, especially when combined with education

- Optimize use when provided in various formats (pocketcard, electronic, etc) and when combined with recommendations emphasizing use of appropriate antimicrobials

Antimicrobial Resistance Solutions
Management. Education. Innovation.

Antibiograms

Regulatory Standard - Impacting Patient Lives

Post Education Survey

https://www.surveymonkey.com/r/IDOH_HAI_AC_Antibiogram

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July 25, 2023