

Reading, Understanding and Using Antibiograms

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Acknowledgement

Neither Jon Hiles nor David Smith are employees of or affiliated with the Indiana Department of Health. The views expressed are the speaker's own and may not reflect the view(s) of the Indiana Department of Health.

Objectives

- Better understand your facility and referral facilities' antibiograms
- Expand the use and application of antibiograms across your facility, from treating patients to committee work
- Learn practical examples and tools to leverage antibiogram data and information across your organization

Basic antibiogram

2022 Data - IU Methodist and University Hospitals ALL Locations								Community Isolates (collected <72hrs after admission)										
GRAM-NEGATIVE AEROBES	Number of Isolates	Gentamicin	Tobramycin	Ampicillin	Ampicillin/ Sulbactam	Amoxicillin/ Clavulanate	Piperacillin/ Tazobactam *	Cefazolin *	Cefuroxime *	Cefoxitin *	Ceftriaxone *	Cefpodoxime*	Cefepime	Meropenem	Trimethoprim/ Sulfa	Ciprofloxacin	Tetracycline	Nitrofurantoin
<i>Citrobacter freundii</i> *	56	95	95										100	100	88	89	91	98
<i>Enterobacter cloacae</i> *	202	98	98										97	99	95	96	94	49
<i>Escherichia coli</i> (ESBL 9%)	1292	92	92	52	58	79	89	87	82	83	90	86	91	100	75	77	77	97
<i>Klebsiella aerogenes</i> *	80	100	100										100	98	99	94	87	18
<i>K. oxytoca</i> (ESBL 5%)	132	97	97		73	92	++	74	94	95	94	94	95	100	93	96	94	92
<i>K. pneumoniae</i> (ESBL 14%)	437	94	91		75	84	84	85	84	85	86	86	86	99	82	86	72	32
<i>Proteus mirabilis</i>	255	94	94	77	91	88	100	92	95	98	86	86	95	100	81	74	2	0
<i>Pseudomonas aeruginosa</i> #	385	90	99				82						89	89		82		
<i>Serratia marcescens</i> *	75	100	91										100	93	99	84	46	4
Extended Spectrum β -Lactamase	187	64	53											99	41	20	44	65

* AmpC producing organism; avoid 1st, 2nd, 3rd gen cephalosporins and piperacillin/tazobactam. Cefepime is the preferred agent.
 # dual antibiotic coverage with an aminoglycoside recommended for systemic infections. See VAP and *Pseudomonas* page 9

Basic antibiogram

2022 Data - IU Methodist and University Hospitals ALL Locations <i>Inpatient Isolates (collected >72hrs after admission)</i>																		
GRAM-NEGATIVE AEROBES	Number of Isolates	Gentamicin	Tobramycin	Ampicillin	Ampicillin/ Sulbactam	Amoxicillin/ Clavulanate	Piperacillin/ Tazobactam *	Cefazolin *	Cefuroxime *	Cefoxitin *	Ceftriaxone *	Cefpodoxime*	Cefepime	Meropenem	Trimethoprim/ Sulfa	Ciprofloxacin	Tetracycline	Nitrofurantoin
<i>Citrobacter freundii</i> *	29	90	93										93	97	86	93	81	93
<i>Enterobacter cloacae</i> *	138	98	97										93	99	92	96	90	46
<i>Escherichia coli</i> (ESBL 15%)	254	94	91	44	48	63	78	75	66	71	81	74	84	99	77	69	75	97
<i>Klebsiella aerogenes</i> *	45	98	98										100	100	98	96	92	18
<i>K. oxytoca</i> (ESBL 22%)	54	94	94		54	70	++	57	75	82	74	74	78	98	91	94	89	94
<i>K. pneumoniae</i> (ESBL 14%)	165	90	88		67	81	80	80	69	70	85	82	85	95	82	85	66	25
<i>Proteus mirabilis</i>	75	88	89	75	85	81	96	93	95	97	95	92	96	100	85	89	3	0
<i>Pseudomonas aeruginosa</i> #	166	92	99				77						90	84		86		
<i>Serratia marcescens</i> *	59	100	90										98	98	100	90	48	0
Extended Spectrum β -Lactamase	73	66	55											93	45	29	40	66

* AmpC producing organism; avoid 1st, 2nd, 3rd gen cephalosporins and piperacillin/tazobactam. Cefepime is the preferred agent.

dual antibiotic coverage with an aminoglycoside recommended for systemic infections. See VAP and *Pseudomonas* page 9

Basic antibiogram

GRAM-POSITIVE AEROBES	Number of Isolates	Gentamicin (synergy)	Vancomycin	Ampicillin	Tetracycline	Minocycline	Clindamycin	Daptomycin	Linezolid	Oxacillin	Trimethoprim/Sulfa	Nitrofurantoin
<i>Enterococcus faecalis</i>	356	78	95	100								99
<i>Enterococcus faecium</i>	138	80	50	33								30
Vancomycin-Resistant <i>Enterococcus</i>	105	67		35				++	100			48
Vancomycin-Susceptible <i>Enterococcus</i>	427	84	100	94				++	98			87
Overall VRE Rate = 20%												
<i>Staphylococcus aureus</i>	1004	99	100		92	98	80			60	95	
MSSA	599	99	100		93	99	83			100	98	
MRSA	404	98	100		90	96	75				92	
Overall MRSA Rate = 40%												
Coagulase-negative <i>Staph</i>	321	92	99		75	99	49			40	62	99
<p>Spaces are intentionally left blank if the organism is intrinsically resistant OR if the agent is not preferred due to frequency of resistance or existence of other options.</p> <p>++Unable to test with standard methods however, likely to be effective</p>												

Basic antibiogram

GRAM-POSITIVE AEROBES	Number of Isolates	Gentamicin (synergy)	Vancomycin	Ampicillin	Tetracycline	Minocycline	Clindamycin	Daptomycin	Linezolid	Oxacillin	Trimethoprim/Sulfa	Nitrofurantoin
<i>Enterococcus faecalis</i>	76	78	91	97								97
<i>Enterococcus faecium</i>	80	79	23	10								25
Vancomycin-Resistant <i>Enterococcus</i>	77	79		16				++	99			34
Vancomycin-Susceptible <i>Enterococcus</i>	100	83	100	87				++	98			84
Overall VRE Rate = 43%												
<i>Staphylococcus aureus</i>	294	99	99		95	99	77			66	97	
MSSA	195	99	99		95	99	82			100	98	
MRSA	99	98	99		94	99	67				94	
Overall MRSA Rate = 34%												
Coagulase-negative <i>Staph</i>	70	95	100		89	99	56			43	60	100
Spaces are intentionally left blank if the organism is intrinsically resistant OR if the agent is not preferred due to frequency of resistance or existence of other options. ++Unable to test with standard methods however, likely to be effective												

Basic antibiogram

Select Pathogens Antibiogram

	Number of Isolates	Gentamicin	Tobramycin	Amikacin	Penicillin G (non-CSF)	Ampicillin	Ampicillin / Subactam	Amoxicillin / Clavulanate	Piperacilin / Tazobactam	Cefoxitin	Ceftriaxone (non-CSF)	Ceftriaxone CSF	Ceftazidime	Cefepime	Meropenem	Sulfamethoxazole/ Trimethoprim	Ciprofloxacin	Moxifloxacin	Erythromycin	Tetracycline	Minocycline	Metronidazole	Clindamycin	Vancomycin	Linezolid	Daptomycin	
<i>Acinetobacter</i> spp	228	85	86	92			91		73					77	83	84	39				93						
<i>Bacteroides</i> spp	37						95	++	100	92					100					16		100	68				
<i>Haemophilus</i> spp.	355					59		91			99					61		94									
<i>Morganella morganii</i>	528	89	95				13	1	98	46	88		86	97	100	79	79	80		30							
<i>Proteus</i> spp (not mirabilis)	233	99	99	99			61	71	99	99	90		98	99	100	93	96	95		4							
<i>Providencia</i> spp	298	53	55	100			51			99	95		94	98	100	83	59	51		2							
<i>Stenotrophomonas (Xanthomonas) maltophilia</i>	427															97		85			99						
<i>Corynebacterium</i> spp.	322				42						33			63	81	27				48			15	99	98	97	
<i>Streptococcus pneumoniae</i>	415				98						99	85				80		97	61	84			86	++	++	++	
Viridans group streptococci	786				75						97								57	62			75	++	++	++	
Beta-hemolytic streptococci	609				100						100								40	34			46	++	++	++	

Isolates are collected from all sources and from all IU Health locations for the past year to provide enough organisms to analyze and assist with empiric selection.

Bacteroides spp. are the predominant anaerobe in the GI tract. Susceptibilities are not routinely performed, presented here are the results of a surveillance study conducted in 2022 with a plan to be repeated every 5 years.

CLSI standards for antibiogram creation

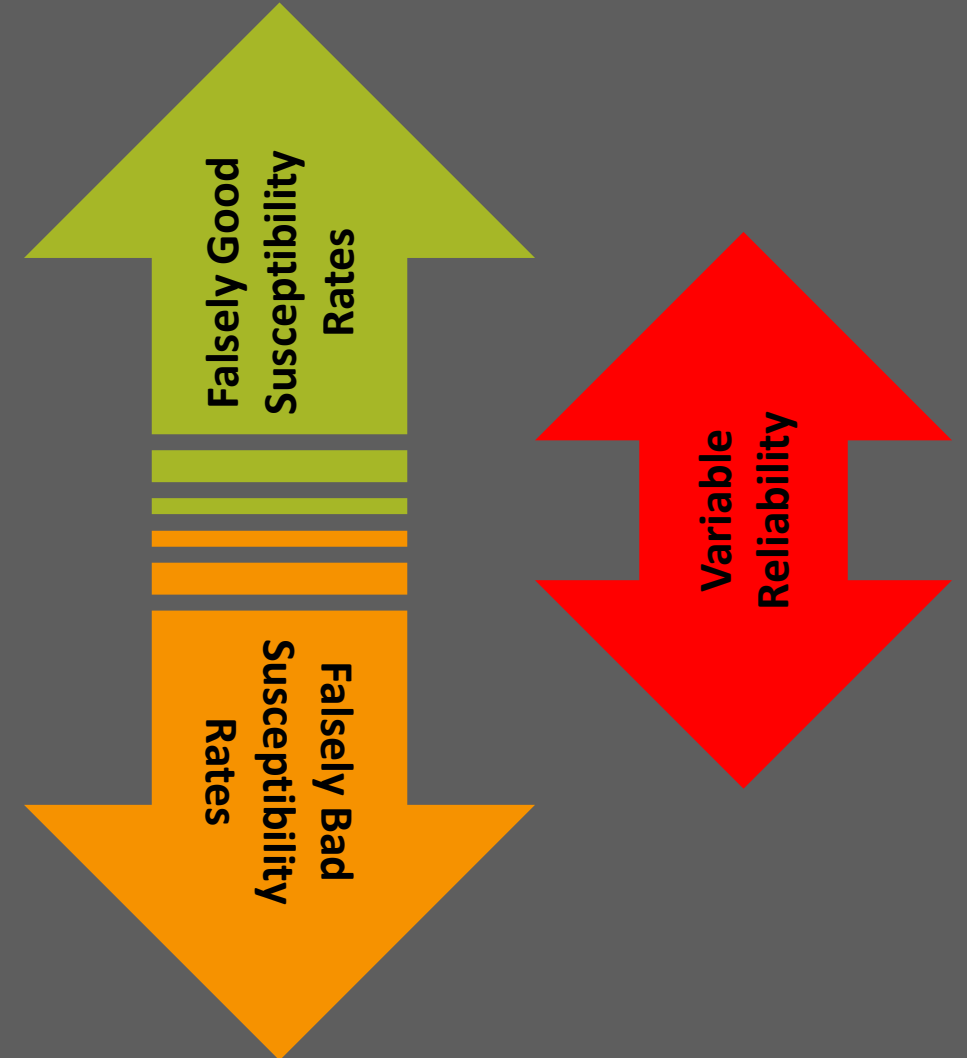
- Analyze and present a cumulative antibiogram at least annually
- Generate local facility-specific data
- Include only FINAL, verified test results
- Include only species with testing data for ≥ 30 isolates
- Include only diagnostic (not surveillance) isolates
- Eliminate duplicates by including only the first isolate of a species/patient/analysis period, irrespective of body site or AMS profile
- Include only antimicrobial agents routinely tested and calculate %S

CLSI standards for antibiogram creation

- Utilize quantitative measurements (MIC or zone diameter) for the analysis of historical data in the event that breakpoints change over time
- If “expert rules” are used, “expert” interpretation should be stored
- Efforts should be made to transfer the results of all antimicrobial agents tested (before selective reporting rules suppress any results) to the LIS

Common problems with antibiograms

- Too few isolates
- Reporting bias
- Selected populations
- Changing populations
- Changing breakpoints
- Dispute over breakpoints
- Change in testing method
- MIC creep
- Very slow to change



Too few isolates

CLSI minimum is 30 isolates

- Extend the years (Two vs one year's worth of isolates)
- Extend the included locations
- Report as long as it makes sense

2018 Data - IU University Hospital ALL Locations Community Acquired Isolates (collected <48hrs after admission)															
GRAM-POSITIVE AEROBES	Number of Isolates	Gentamicin (synergy)	Vancomycin	Ampicillin	Tetracycline	Clindamycin	Erythromycin	Daptomycin	Linezolid	Oxacillin	Quinupristin/Dalfopristin	Trimethoprim/Sulfa	Moxifloxacin	Ceftriaxone	Nitrofurantoin
<i>Enterococcus</i> species	398	80	84	83	33										84
<i>Enterococcus</i> Vanc susceptible	347	82	97	94	35										94
<i>Enterococcus</i> VRE	51	67	0	12	22			100	81		97				27
Overall VRE Rate = 15%															
<i>Staphylococcus aureus</i>	375	97	99		94	57	40			60		96			
MSSA	227	97	100		95	70	59			100		97			
MRSA	148	97	100		92	41	10	100	100	0	100	97			
Overall MRSA Rate = 40%															
Coagulase-negative <i>Staph</i>	154	88	100		79	52	31			44					
<i>Streptococcus pneumoniae</i>	19					84	31					77	94	100	



Common problems with antibiograms

- Too few isolates
- **Reporting bias**
- **Selected populations**
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Reporting bias

- Be aware if your lab blocks the reporting of certain things
 - In this example if lab blocks cefepime MICs and interpretations for ESBL organisms, it will result in falsely low rate of resistance
 - Know what is included in your antibiogram

ESCHERICHIA COLI		
	MDIL	MINT
Amikacin	<=2	S
Tobramycin	<=1	S
Trimethoprim/Sulfa	>=320	R
Piperacillin/Tazobactam	<=4	S
Meropenem	<=0.25	S
Gentamicin	<=1	S
Ciprofloxacin	>=4	R
Cefoxitin	<=4	S
Cefazolin	>=64	R
Ampicillin/Sulbactam	16	I
Ampicillin	>=32	R

ESCHERICHIA COLI		
	MDIL	MINT
Amikacin	<=2	S
Tobramycin	<=1	S
Trimethoprim/Sulfa	>=320	R
Piperacillin/Tazobactam	<=4	S
Meropenem	<=0.25	S
Gentamicin	<=1	S
Ciprofloxacin	>=4	R
Ceftriaxone		R
Ceftazidime		R
Cefoxitin	<=4	S
Cefepime		R
Cefazolin	>=64	R
Ampicillin/Sulbactam	>32**Corr	R**Corr
Ampicillin	>=32	R

Falsely Good
Susceptibility Rates

Reporting bias

- Know the reflex susceptibility tests that occur with certain organisms
 - Will bias susceptibilities by only including isolates more likely to be resistant organisms

ENTEROCOCCUS FAECALIS

	MDIL	MINT
Vancomycin	2	S
Streptomycin synergy*	Syn-S	S

*** Streptomycin synergy* Note:
 * Streptomycin will be synergistic with cell-wall-active agent to which the isolate is also susceptible (e.g. Ampicillin, Penicillin, Vancomycin)

Penicillin	2	S
Gentamicin synergy*	Syn-S	S

*** Gentamicin synergy* Note:
 * Gentamicin will be synergistic with cell-wall-active agent to which the isolate is also susceptible (e.g. Ampicillin, Penicillin, Vancomycin)

Ampicillin	<=2	S
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ENTEROCOCCUS FAECIUM

	MDIL	MINT	EDIL	EINT
Vancomycin	>=32	R		
Streptomycin synergy*	Syn-S	S		

*** Streptomycin synergy* Note:
 * Streptomycin will be synergistic with cell-wall-active agent to which the isolate is also susceptible (e.g. Ampicillin, Penicillin, Vancomycin)

Penicillin	>=64	R		
Gentamicin synergy*	Syn-S	S		

*** Gentamicin synergy* Note:
 * Gentamicin will be synergistic with cell-wall-active agent to which the isolate is also susceptible (e.g. Ampicillin, Penicillin, Vancomycin)

Ampicillin	>=32	R		
Quinuoristin/Dalfopristin	0.5	S		
Linezolid			2	S
Daptomycin			2	S



Selected populations

2018 Data - IU University Hospital ALL Locations Community Acquired Isolates (collected <48hrs after admission)

GRAM-NEGATIVE AEROBES (ESBL Rate/CRE Rate)	Number of Isolates	Gentamicin	Tobramycin	Ciprofloxacin	Cefazolin +	Cefoxitin +	Ceftriaxone +	Cefepime	Meropenem	Ampicillin	Ampicillin/ Sulbactam	Piperacillin/ Tazobactam +	Mimicline	Vancomycin
<i>Pseudomonas aeruginosa</i> #	284	72	86	68				72	80			74		

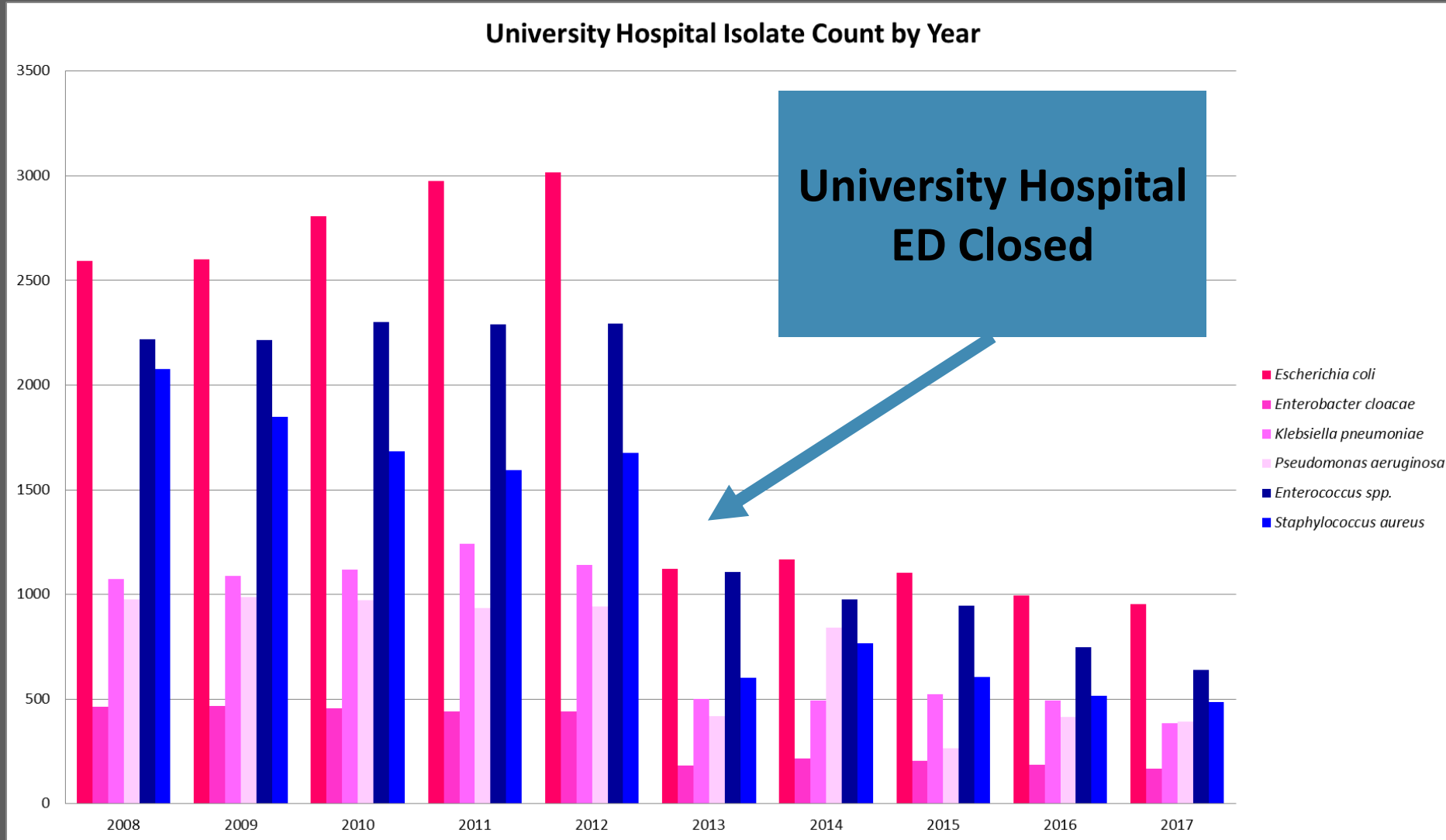
Susceptibility Rates
Falsely Bad

Pseudomonas Isolates in SPUTUM only (Cystic Fibrosis samples removed)	Number of Isolates	Gentamicin	Tobramycin	Ciprofloxacin	Cefepime	Meropenem	Piperacillin/ Tazobactam
Pseudomonas	182	77%	91%	84%	93%	84%	79%

Common problems with antibiograms

- Too few isolates
- Reporting bias
- Selected populations
- **Changing populations**
- Changing breakpoints
- Dispute over breakpoints
- Change in testing method
- MIC creep
- Very slow to change

Total isolates



Common problems with antibiograms

- Too few isolates
- Reporting bias
- Selected populations
- Changing populations
- **Changing breakpoints**
- **Dispute over breakpoints**
- Change in testing method
- MIC creep
- Very slow to change

Changing breakpoints – piperacillin/tazobactam

CLSI Breakpoints

S: ≤ 64

R: ≥ 128

CLSI Breakpoints

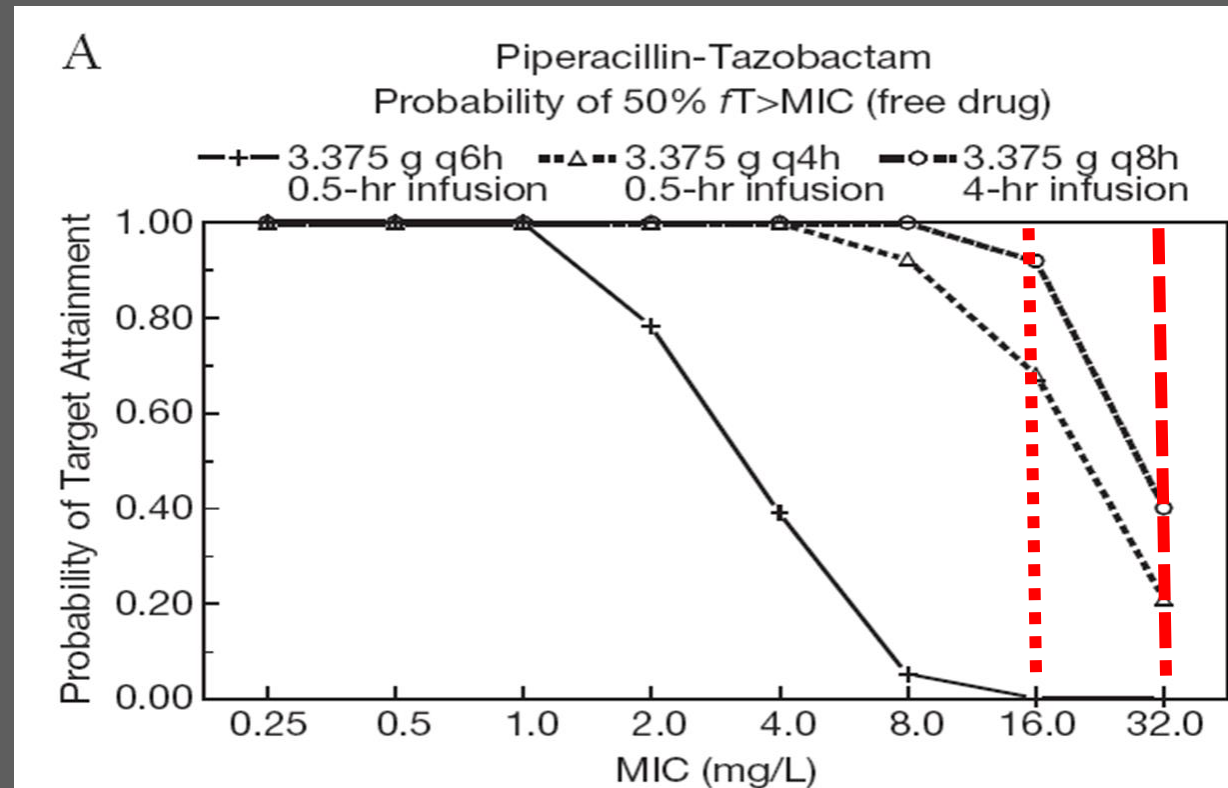
S: ≤ 16

I: 32-64

R: ≥ 128

1993

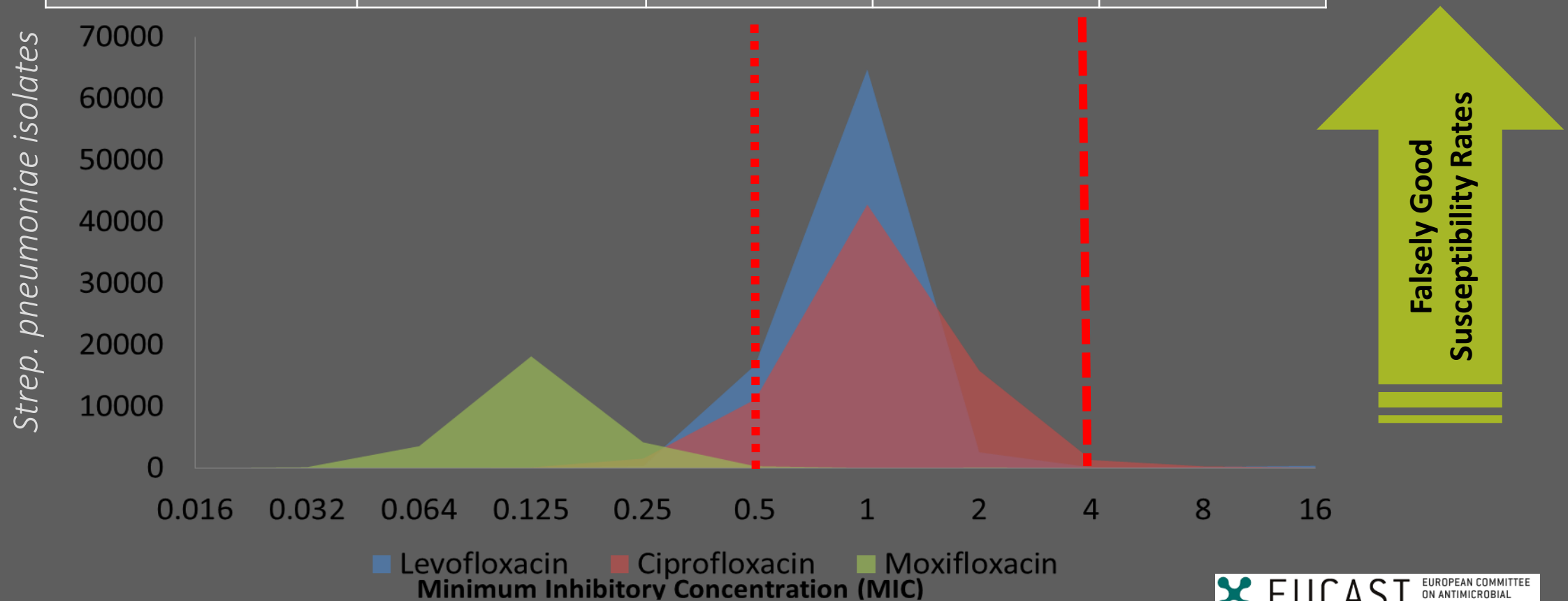
2012



Falsely Good
Susceptibility Rates

Dispute over breakpoints - quinolones

Drug	Dose	AUC/MIC 125	Combo AUC/MIC 70	Peak/MIC 8
Ciprofloxacin	600 mg q12	0.36	0.64	0.44
Levofloxacin	750 mg q24	0.46	0.83	0.75
Moxifloxacin	400 mg q24	0.27	0.48	0.29

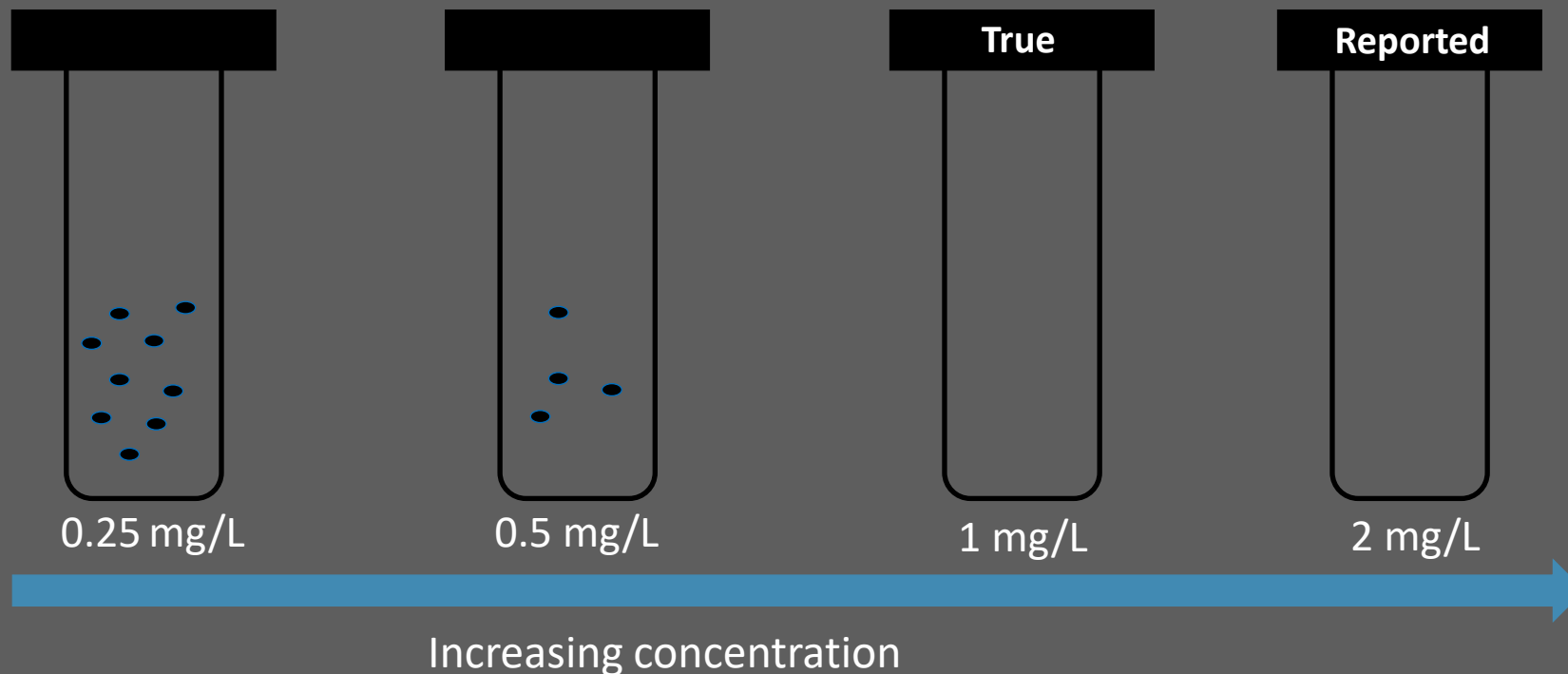


Common problems with antibiograms

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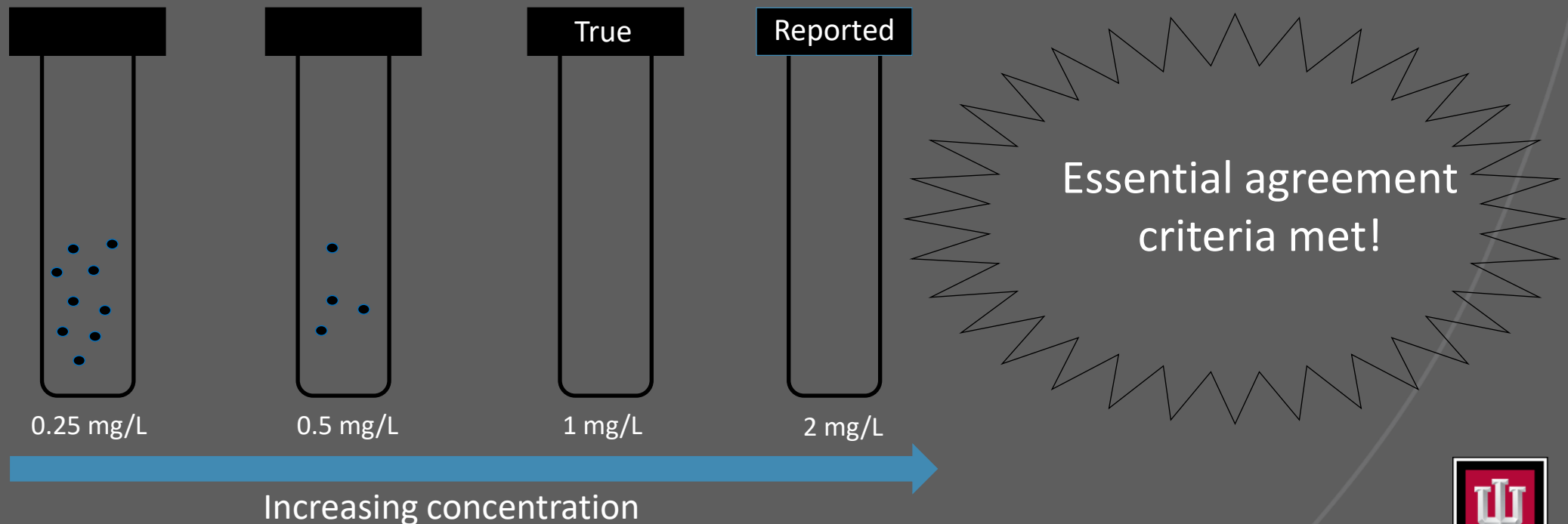
Variability in MIC determination

- Precision of automated susceptibility testing for vancomycin vs. CLSI reference MIC values determined by BMD
 - Determination of automated methods used essential agreement method ($MIC \pm 1 \log_2$ dilution)



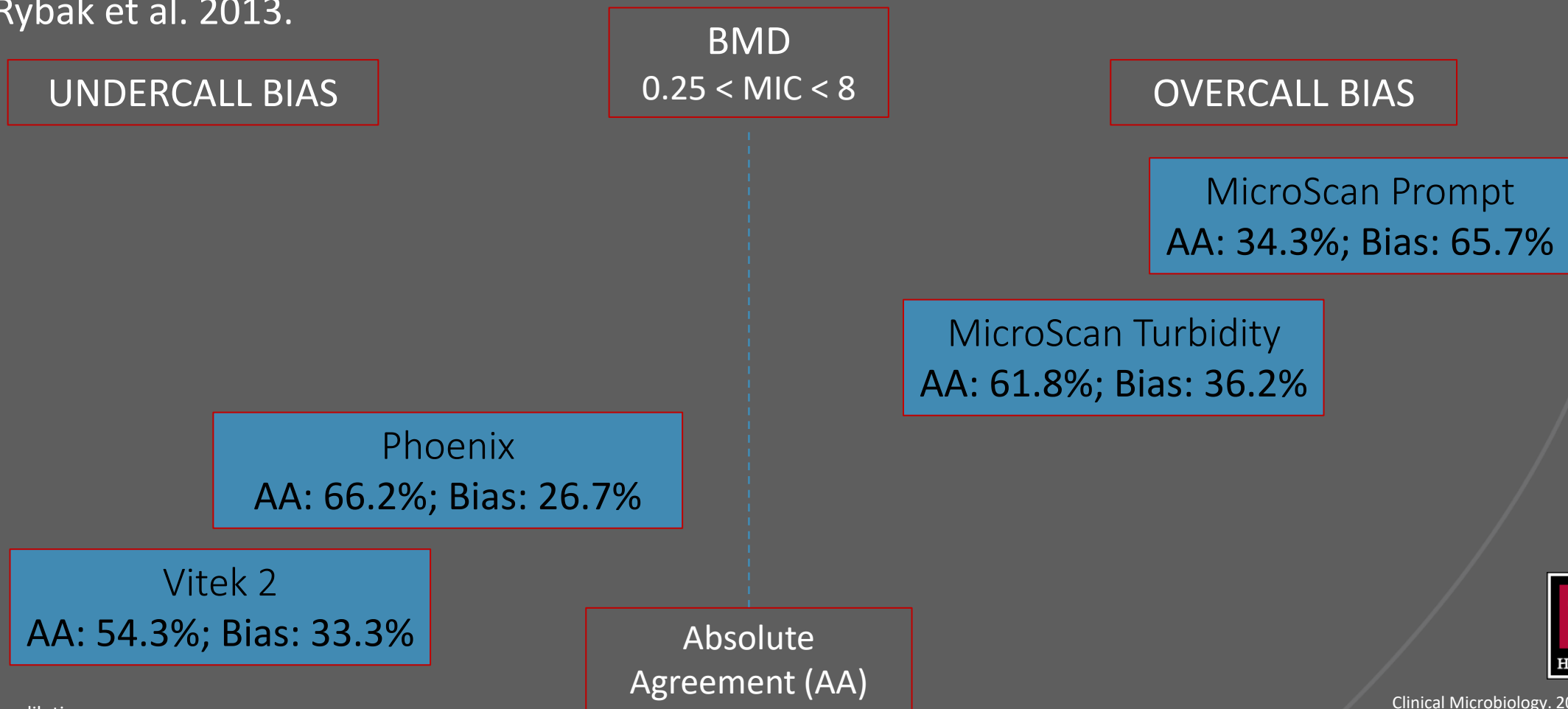
Variability in MIC determination

- Precision of automated susceptibility testing for vancomycin vs. CLSI reference MIC values determined by BMD
 - Determination of automated methods used essential agreement method ($MIC \pm 1 \log_2$ dilution)



Variability in MIC determination

Rybak et al. 2013.



Variability in MIC determination

Rybak et al. 2013.

UNDERCALL BIAS

- MIC=2 mg/L may not always be precise
- Interpret in context of infection and patient response
- Higher AUC₂₄ targets subject patients to higher incidence of nephrotoxicity

BMD
 $0.25 < \text{MIC} < 8$

OVERCALL BIAS

MicroScan Prompt
AA: 34.3%; Bias: 65.7%

MicroScan Turbidity
AA: 61.8%; Bias: 36.2%

Absolute
Agreement (AA)

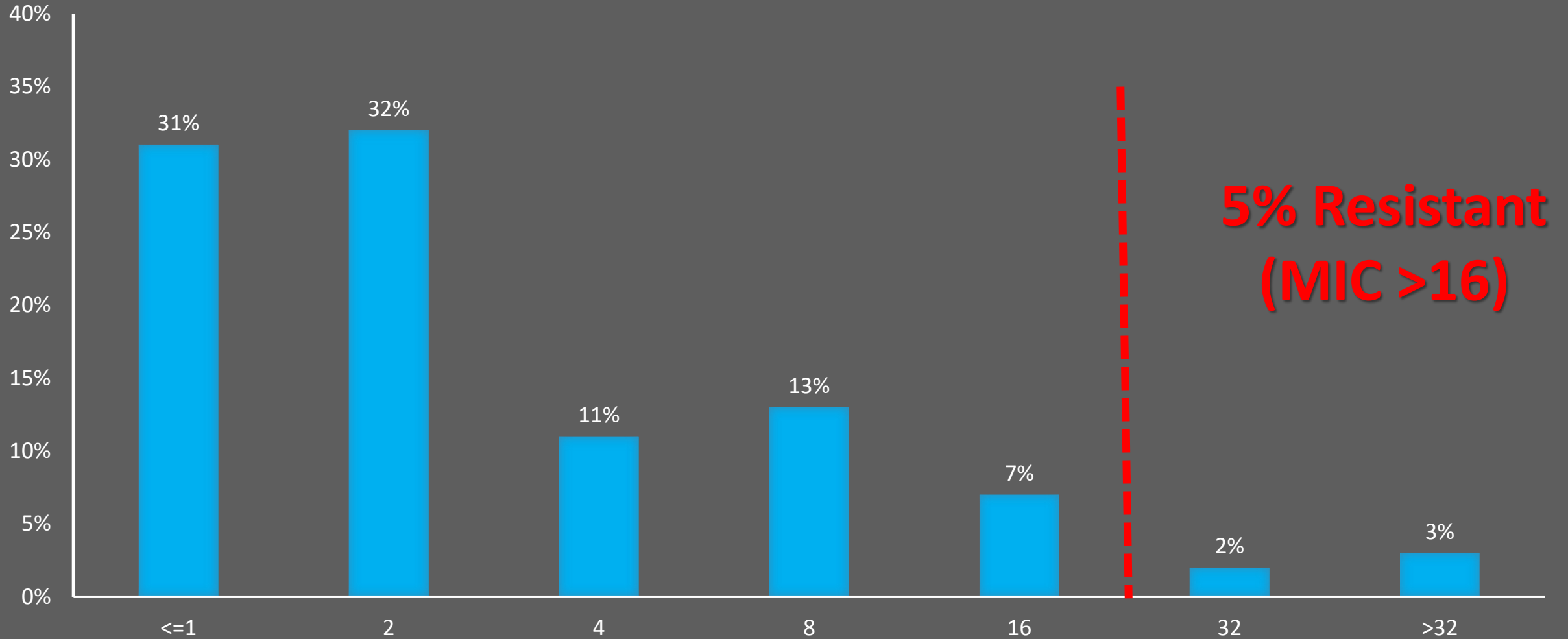


Common problems with antibiograms

- Too few isolates
- Reporting bias
- Selected populations
- Changing populations
- Changing breakpoints
- Dispute over breakpoints
- Change in testing method
- **MIC creep**
- **Very slow to change**

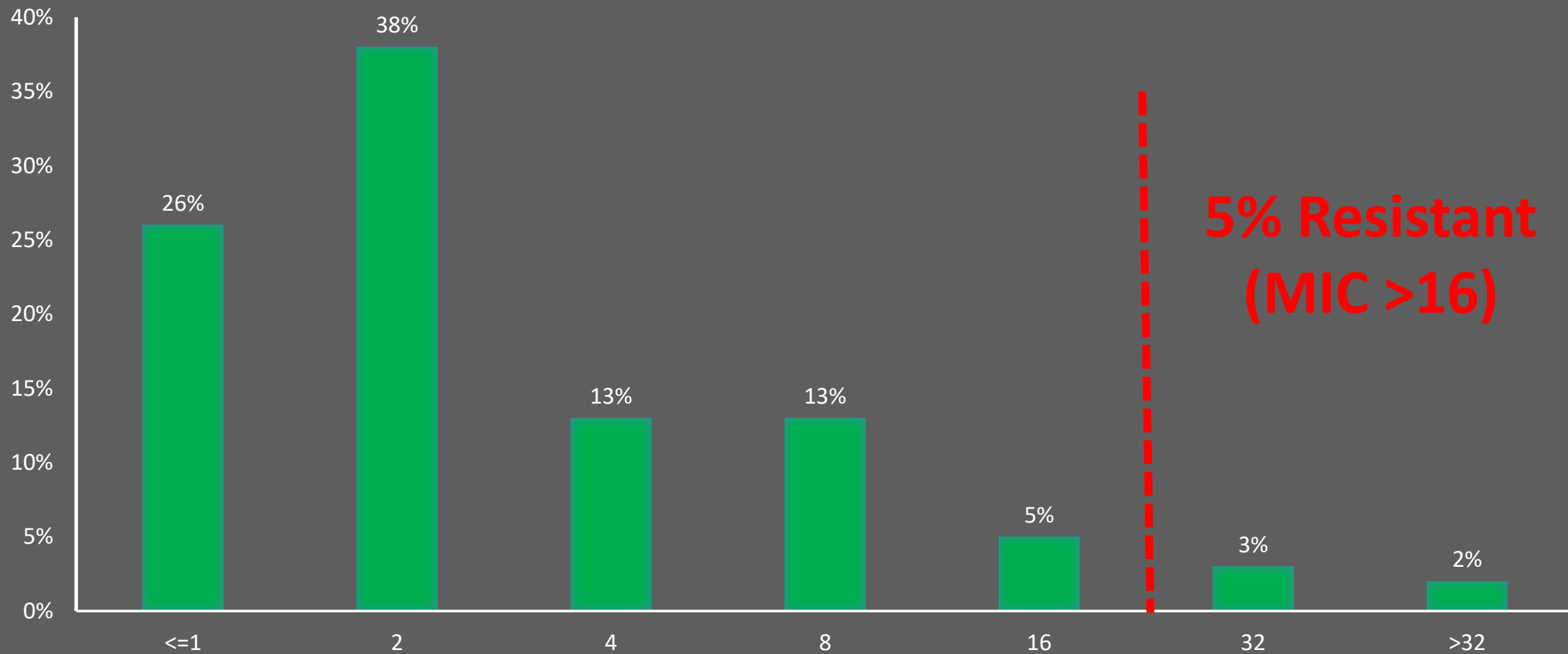
MIC creep

PSEUDOMONAS CEFEPIME MIC 2015



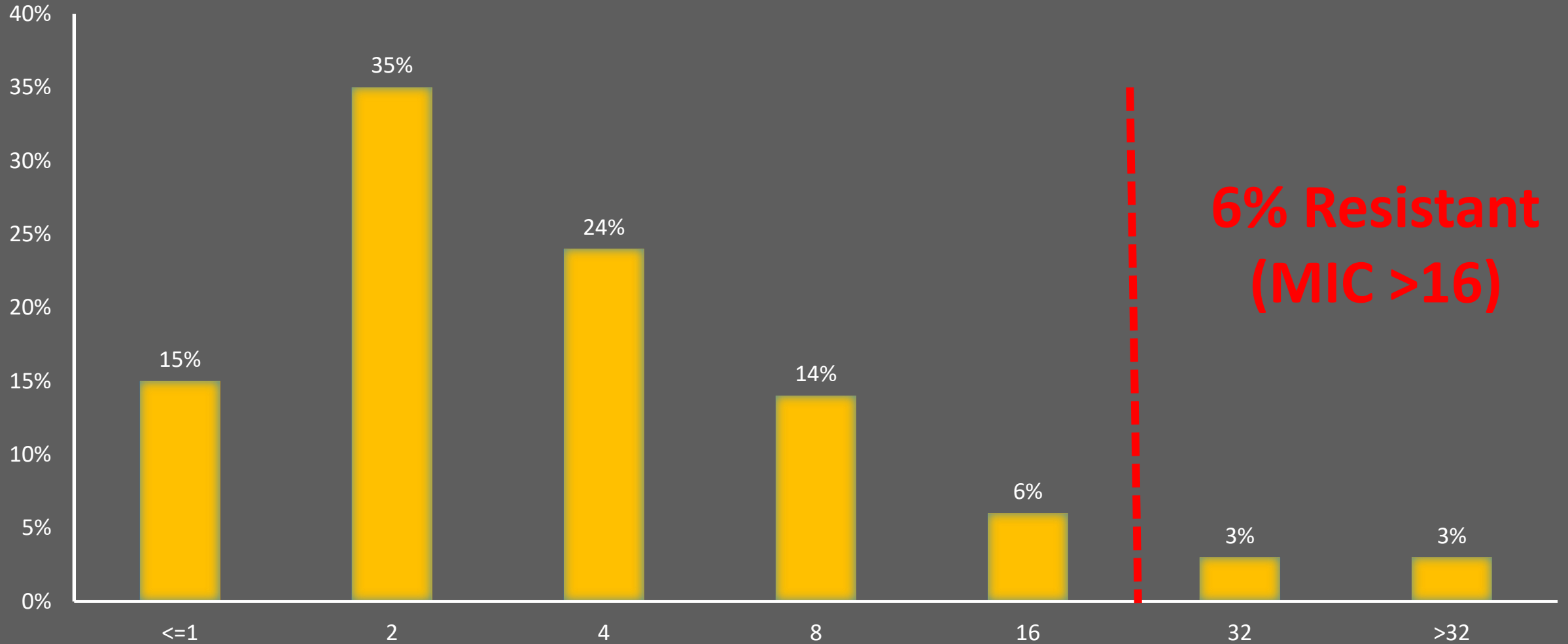
MIC creep

PSEUDOMONAS CEFEPIME MIC 2016



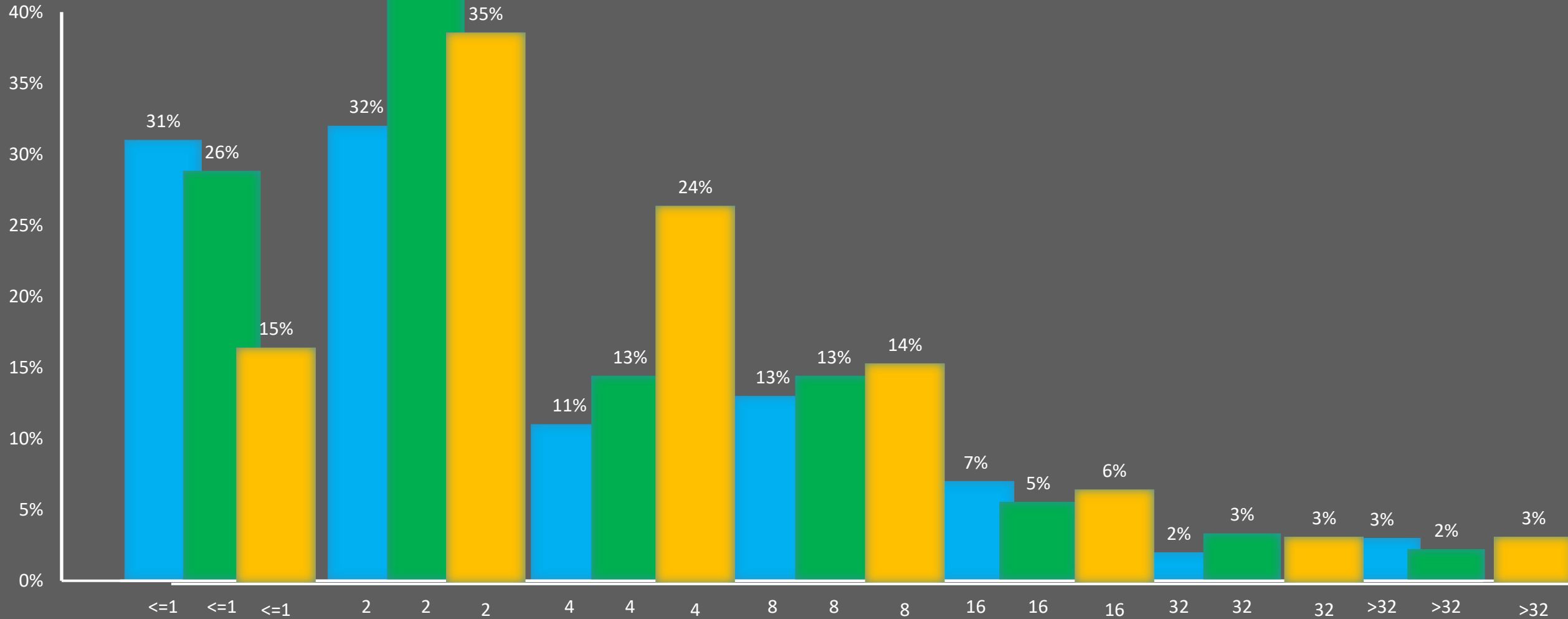
MIC creep

PSEUDOMONAS CEFEPIME MIC 2017



MIC creep

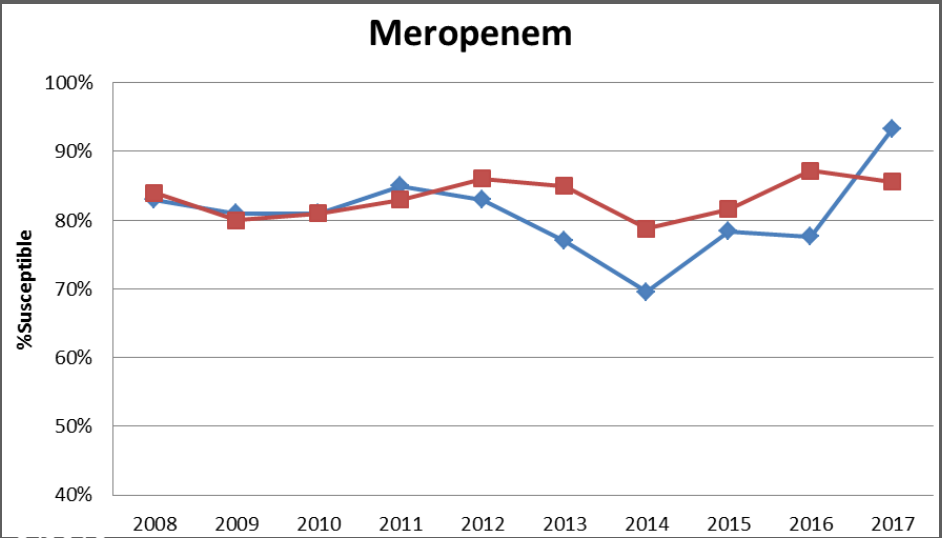
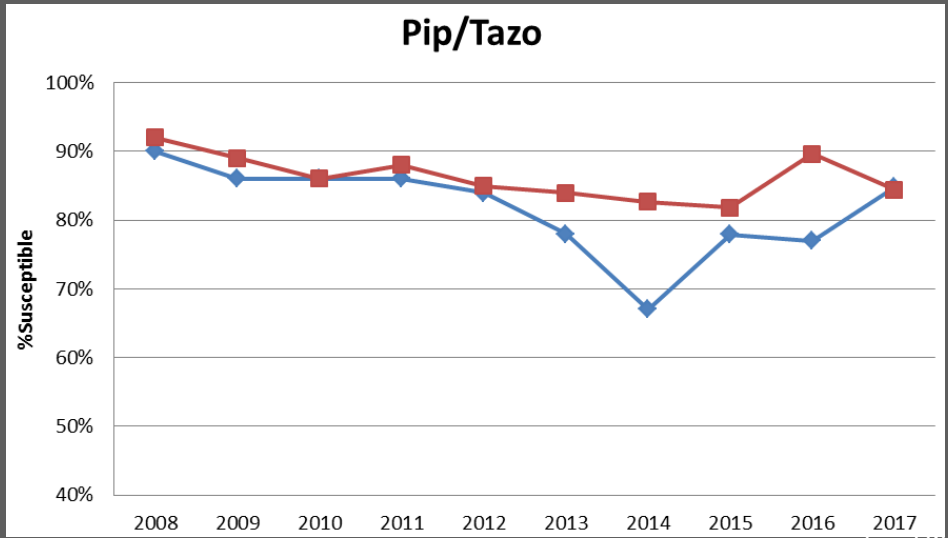
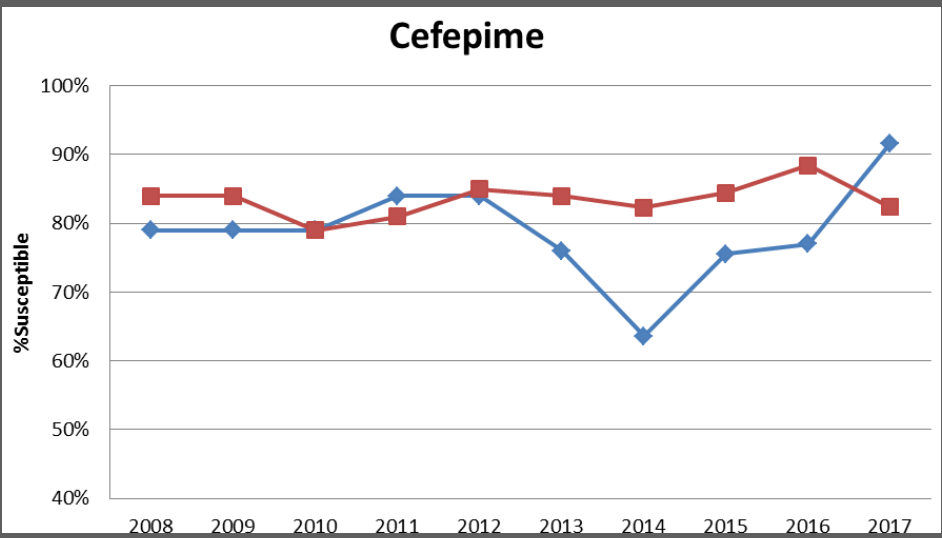
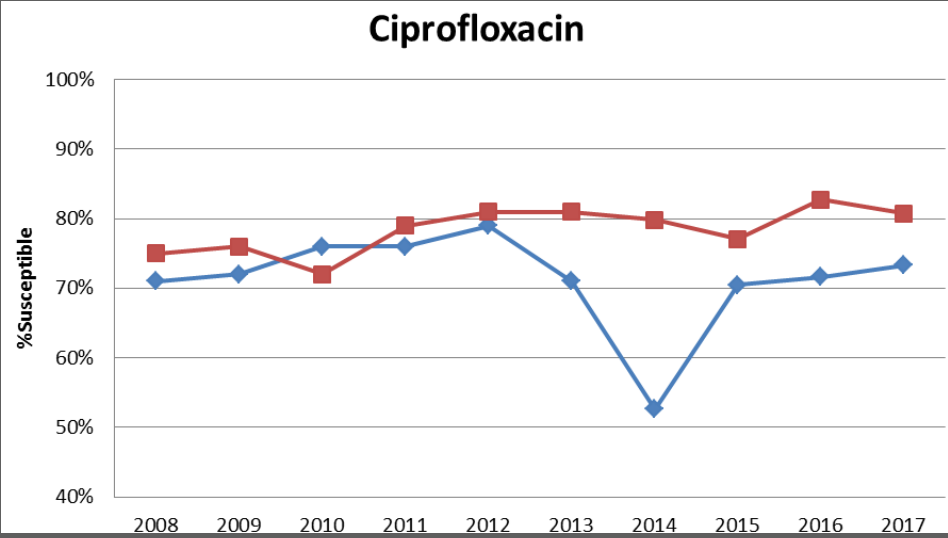
PSEUDOMONAS CEFEPIME MIC 2015/2016/2017



Antibiograms are slow to change



Good →



Antibiogram functions

- Assist with empiric antimicrobial selection BEFORE organisms have been identified
- Track resistance trends
 - Used to make decisions about antimicrobial stewardship targets and outcomes



IU Health process blood culture

Empiric Antimicrobial Rx



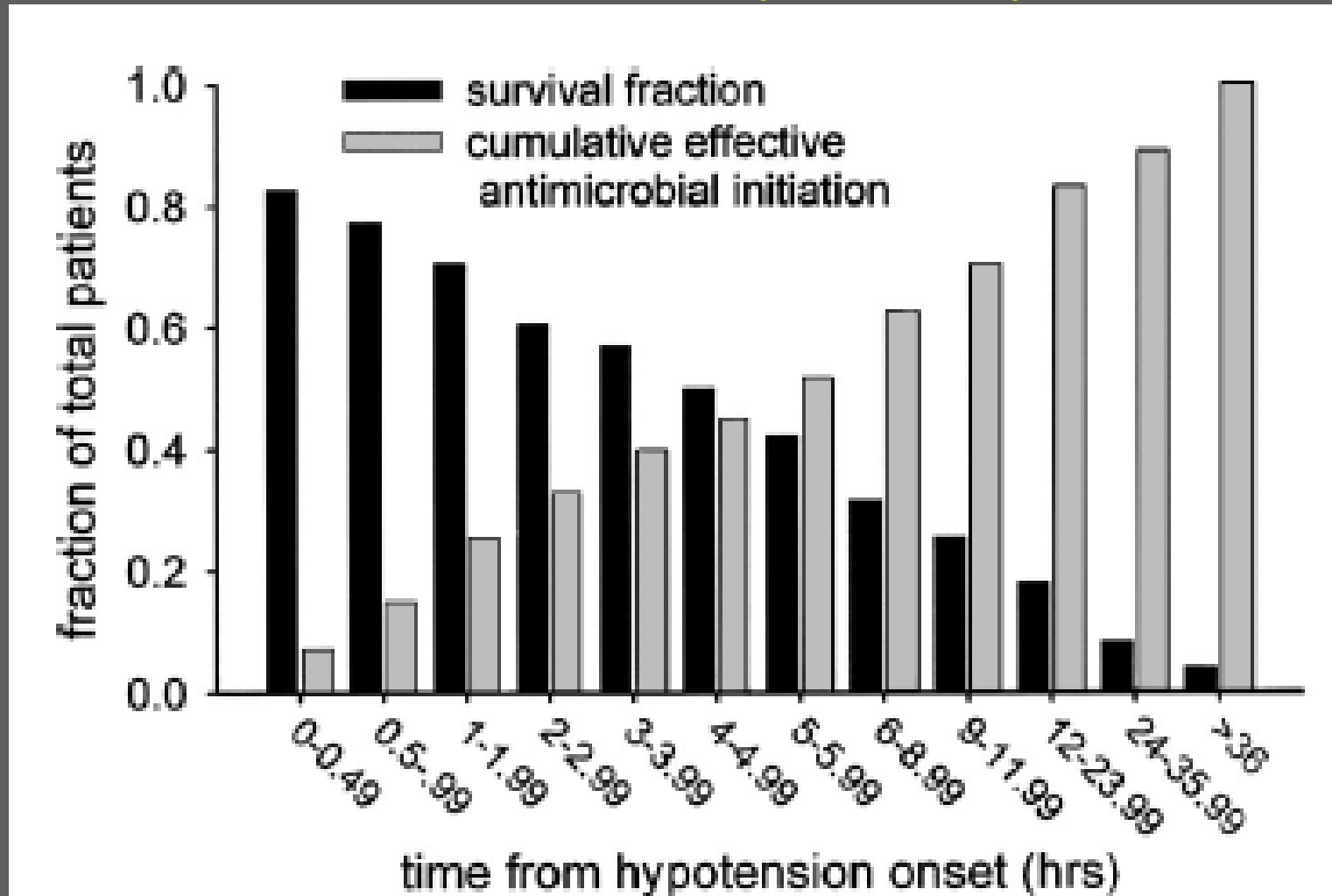
85% of all growth in 24 hours

95% of all growth in 48 hours

Bactec

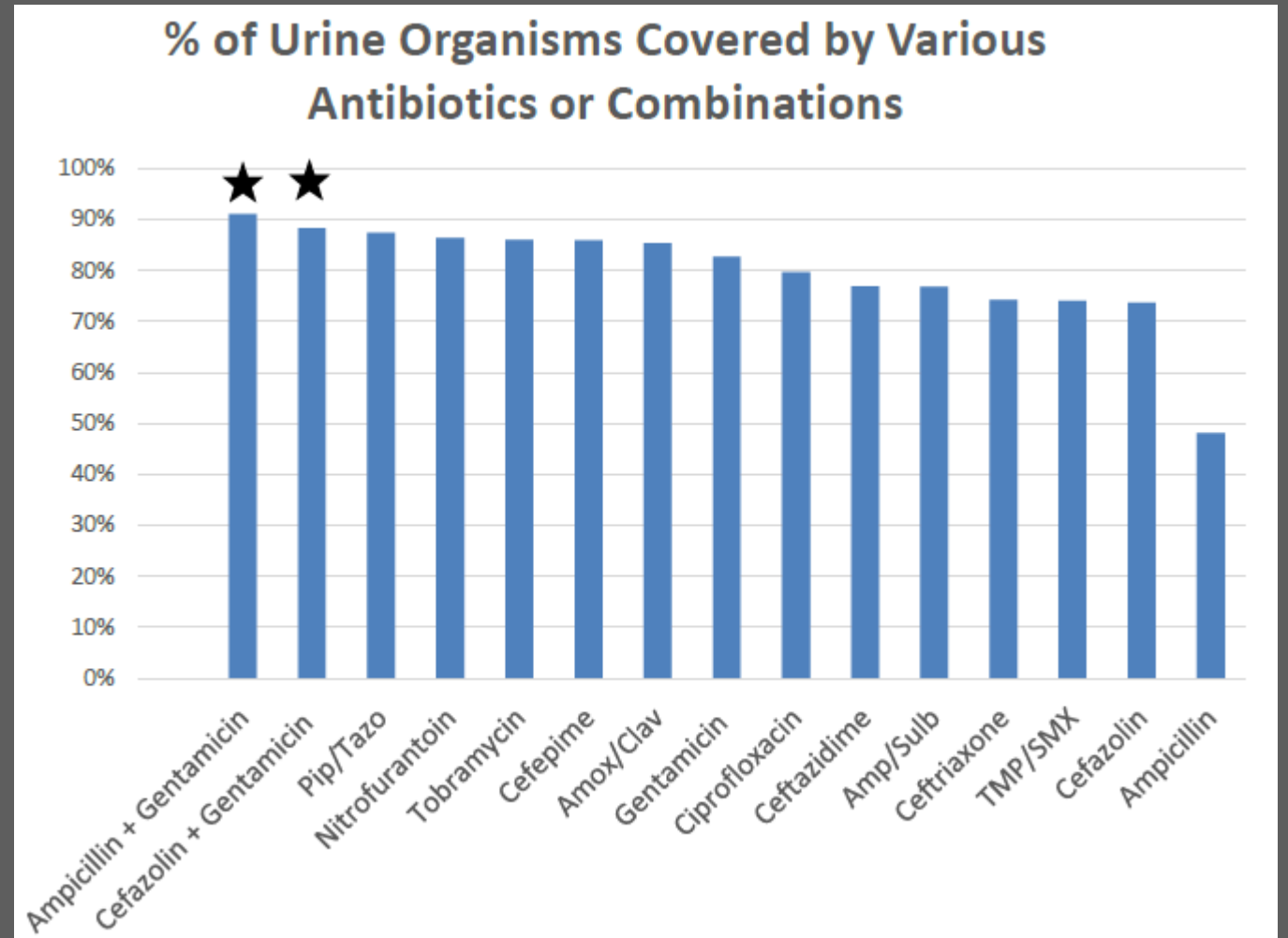
Impacts in delays of therapy

Sepsis: 7.6% increase in mortality for every one-hour delay

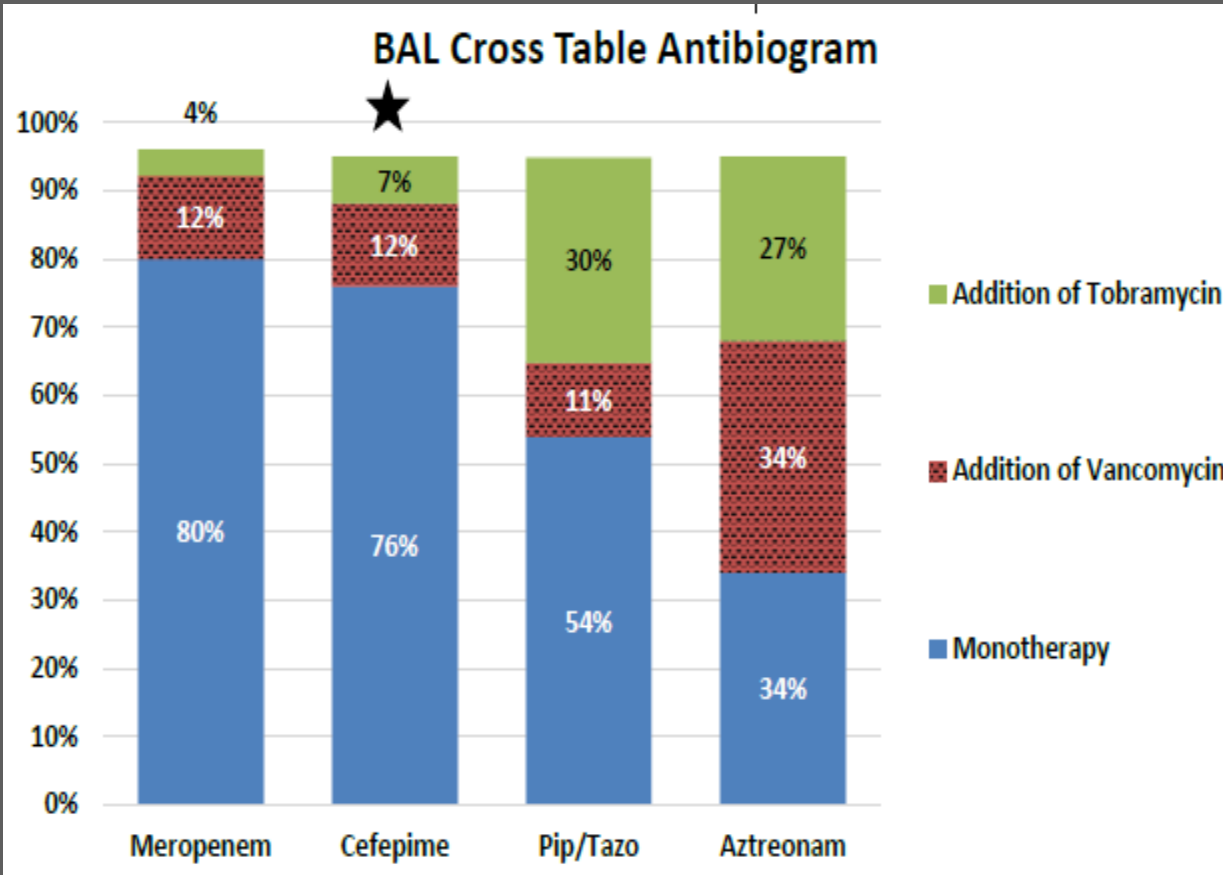


All IU Health urine cross table antibiogram

Organism Distribution		
<i>Escherichia coli</i>	17413	58%
<i>Klebsiella pneumoniae</i>	3608	12%
<i>Enterococcus</i> spp.	2312	8%
<i>Proteus</i> spp.	1731	6%
Other gram positive	1395	5%
<i>Pseudomonas</i> spp.	850	3%
<i>Enterobacter</i> spp.	646	2%
<i>Klebsiella oxytoca</i>	531	2%
<i>Citrobacter freundii</i>	464	2%
<i>Klebsiella aerogenes</i>	402	1%
<i>Citrobacter non-freundii</i>	294	1%
<i>Morganella morganii</i>	199	1%
<i>Serratia</i> spp.	158	1%
<i>Providencia</i> spp.	147	0.5%
Other gram negative	84	0.3%



Ventilator-associated pneumonia (VAP) and *Pseudomonas* spp. antibiogram



		Cefepime ★	Pip/Tazo	Aztreonam	Meropenem
		92%	82%	86%	88%
Gentamicin	84%	97%	96%	96%	95%
Tobramycin	98%	99%	99%	98%	98%
Amikacin	95%	98%	98%	98%	98%
Ciprofloxacin	88%	97%	94%	95%	94%
Levofloxacin*	53%				

IU Health process blood culture



Empiric
Antimicrobials



Gram stain called to nurse,
nurse call to prescriber

85% of all
growth in
24 hours

95% of all
growth in
48 hours

Time 0

12-24°

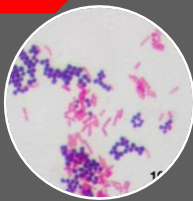
48°

Five days



Bactec

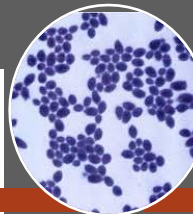
Within one
hour of
positive
culture



Bacteria

Within two
hours of gram
stain

Yeast



Biofire



BioFire BCID2

Gram-negative bacteria:

- Acinetobacter calcoaceticus-baumannii complex
- Bacteroides fragilis
- Enterobacterales
- Enterobacter cloacae complex
- Escherichia coli
- Klebsiella aerogenes
- Klebsiella oxytoca
- Klebsiella pneumoniae group
- Proteus spp.
- Salmonella spp.
- Serratia marcescens
- Haemophilus influenzae
- Neisseria meningitidis
- Pseudomonas aeruginosa
- Stenotrophomonas maltophilia

Gram-positive bacteria:

- Enterococcus faecalis
- Enterococcus faecium
- Listeria monocytogenes
- Staphylococcus spp.
- Staphylococcus aureus
- Staphylococcus epidermidis
- Staphylococcus lugdunensis
- Streptococcus spp.
- Streptococcus agalactiae
- Streptococcus pneumoniae
- Streptococcus pyogenes

YEAST:

- Candida albicans
- Candida auris
- Candida glabrata
- Candida krusei
- Candida parapsilosis
- Candida tropicalis
- Cryptococcus (C. neoformans/C. gattii)

Antimicrobial resistance genes:

- Carbapenemases
- IMP
- KPC
- OXA-48-like
- NDM
- VIM
- Colistin Resistance
- mcr-1
- ESBL
- CTX-M
- Methicillin Resistance
- mecA/C
- mecA/C and MREJ (MRSA)
- Vancomycin Resistance
- vanA/B

BioFire BCID2

Yeast on Gram Stain Result "Positive for"	Suggested Initial Options	Notes
<i>C. parapsilosis</i> ‡	Fluconazole	<i>C. parapsilosis</i> is present in 1/10 of cases with this result and is routinely resistant to micafungin.
<i>C. albicans</i> ‡	Fluconazole	Most commonly seen <i>Candida</i> species and is susceptible to fluconazole in ≥ 90% of cases.
<i>C. tropicalis</i> ‡	Fluconazole or Micafungin	Fluconazole susceptibilities vary (83%). Micafungin recommended if patient is critically ill or unstable.
<i>C. glabrata</i> ‡	Micafungin	<i>C. glabrata</i> is susceptible to fluconazole in 21% of cases. Micafungin is recommended empirically. De-escalation to fluconazole after susceptibilities are available is appropriate.
<i>C. krusei</i> ‡	Micafungin	<i>C. krusei</i> is routinely resistant to fluconazole.
<i>C. auris</i> ‡	Micafungin	<i>C. auris</i> is commonly resistant to antifungals. Micafungin is suggested as empiric therapy. Patient should be placed in isolation.
<i>Cryptococcus neoformans/gatti</i> ‡	Amphotericin	ID CONSULT strongly recommended.
None Detected	Micafungin	If yeast is present in the blood, even if not identified by Biofire, it is recommended to treat initially and consult ID for further management.

Gram Negative on Gram Stain Result "Positive for"		Suggested Initial Options	Notes
<i>Escherichia coli</i>	Continue Current Therapy with activity against gram negative bacteria	Ceftriaxone or Amp/Sulb	When ESBL is not detected, Ceftriaxone, Cefepime and Pip/tazo are 97-100% likely to cover. If Ampicillin or Ampicillin/sulbactam is already started they are 60-90% likely to cover, the addition of an aminoglycoside increases coverage to >95%.
<i>Klebsiella oxytoca</i>			
<i>Klebsiella pneumoniae</i>			
<i>Proteus species</i>			
<i>Salmonella spp.</i>	Ceftriaxone or Amp/Sulb	Uncommon, but likely pathogen.	
<i>Haemophilus influenzae</i>	Ceftriaxone or Amp/Sulb	Beta-lactamase production is narrow spectrum NOT ESBL.	
<i>Neisseria meningitides</i>	Ceftriaxone		
<i>Enterobacter cloacae complex</i> ‡	Cefepime	AmpC producing organisms. Cefepime has 97-100% activity and aminoglycoside addition is not necessary. If AG is added for <i>Serratia</i> spp. gentamicin is better than tobramycin.	
<i>Klebsiella aerogenes</i> ‡			
<i>Serratia marcescens</i> ‡			
<i>Pseudomonas aeruginosa</i> ‡	Cefepime or Pip/Tazo +/- Tobramycin	If patient status not improving or suspicion for multi-drug resistance, consider addition of aminoglycoside. See page 9.	
<i>Acinetobacter species</i> ‡	Amp/Sulbactam High Dose (6gm q8hr 4hr infusion)	Sulbactam covers 91%, compared to Meropenem (83%), Cefepime (77%) and Pip/tazo (73%). If patient critically ill or not improving, consider adding polymyxin B.	
<i>Stenotrophomonas maltophilia</i> ‡	SMX/TMP	SMX/TMP covers 97% compared to Moxifloxacin (85%). Minocycline does not get good blood concentrations.	
Enteric Gram-Negative Rod (this will also be detected for the above organisms)	Cefepime	Possible pathogens if not otherwise identified: <i>Citrobacter freundii</i> , <i>Citrobacter non-freundii</i> , <i>Morganella morganii</i> , <i>Providencia spp.</i> , <i>Hafnia alvei</i> , <i>Serratia non-marcescens</i>	
<i>Bacteroides fragilis</i>	Include anaerobic coverage	Options that include good (>90%) gram-negative anaerobic coverage include metronidazole, Pip/Tazo, or Amp/Sulb.	
None of the above	Continue current therapy, when growing in anaerobic bottle consider including anaerobic coverage.		
Gram-negative resistance markers may be present in above organisms	CTX-M (ESBL)‡	Meropenem	Indicates ESBL producing organism, usually seen in <i>Klebsiella spp.</i> and <i>Escherichia coli</i> .
	KPC‡	Meropenem/Vaborbactam	ID CONSULT REQUIRED. Indicates a carbapenemase producer (CRE).
	OXA‡	Ceftazidime/Avibactam (Amp/Sulbactam High Dose in <i>Acinetobacter spp.</i> ONLY)	ID CONSULT REQUIRED. When identified in <i>Acinetobacter spp.</i> Sulbactam is still the best empiric option, meropenem will likely be resistant.
	IMP‡ or NDM‡ or VIM‡	Cefiderocol	ID CONSULT REQUIRED. Indicates a CRE <u>not</u> susceptible to Meropenem/Vaborbactam or Ceftazidime/Avibactam.

Gram-Positive on Gram Stain Result "Positive for"	Suggested Initial Options	Notes
Coagulase-negative staphylococci (CoNS)	Requires clinical correlation (Often Contaminant) – Vancomycin initially to treat all isolates	These are all coagulase-negative staphylococci (CoNS). When growing in only one set of blood cultures, this may represent contamination from the skin; however, clinical correlation is required. They are also often methicillin resistant, not to be confused with methicillin-resistant <i>S. aureus</i> . Consider stopping antimicrobials directed at this organism if infection is unlikely.
Methicillin-susceptible <i>Staphylococcus epidermidis</i> (MSSE)		
Methicillin-resistant <i>Staphylococcus epidermidis</i> (MRSE)		
Methicillin-susceptible <i>Staphylococcus lugdunensis</i>	Cefazolin or Nafcillin or Vancomycin	Although this is a CoNS, it is usually considered a pathogen
Methicillin-resistant <i>S. lugdunensis</i>	Vancomycin	
Methicillin-susceptible <i>Staphylococcus aureus</i> (MSSA)	Cefazolin or Nafcillin	ID CONSULT REQUIRED. <i>Staphylococcus aureus</i> is rarely a contaminant, and minimum duration of therapy is 14 days. Consult ID for appropriate further diagnostic approach and follow-up for extended IV antimicrobial therapy.
Methicillin-resistant <i>Staphylococcus aureus</i> (MRSA)	Vancomycin	
Streptococcus species other than <i>S. pneumoniae</i> , <i>S. anginosus</i> group, <i>S. pyogenes</i> and <i>S. agalactiae</i>	Requires clinical correlation (Often Contaminant) – Ceftriaxone initially to treat	This will often result as Viridans group streptococci. When growing in only one set of blood cultures, this may represent contamination from the skin; however, clinical correlation is required.
Streptococcus pneumoniae	Ceftriaxone +/- *Vancomycin	*If concern for meningitis or severe infection add vancomycin until susceptibilities are known.
Streptococcus agalactiae (Group B) or Streptococcus pyogenes (Group A) or Streptococcus anginosus group	Ampicillin or Cefazolin	Beta-hemolytic streptococci, including <i>S. anginosus</i> , <i>S. agalactiae</i> and <i>S. pyogenes</i> , are routinely susceptible to beta-lactams.
Enterococcus faecalis (non-VRE)	Ampicillin	ID CONSULT RECOMMENDED. If <i>vanA</i> or <i>vanB</i> are not detected, vancomycin will likely be susceptible. >97% <i>E. faecalis</i> are ampicillin susceptible. Consult ID for appropriate further diagnostic approach and follow-up for extended IV antimicrobial therapy.
Enterococcus faecium (non-VRE)	Vancomycin	
Vancomycin-resistant Enterococcus faecalis (VRE) ‡ or Vancomycin-resistant Enterococcus faecium (VRE) ‡	Daptomycin or Linezolid if lung source	
Listeria species	Ampicillin	ID CONSULT RECOMMENDED. Concern for meningitis.
None of the above	Often a <i>Micrococcus sp.</i> or other contaminant. Clinical correlation required.	

IU Health process blood culture



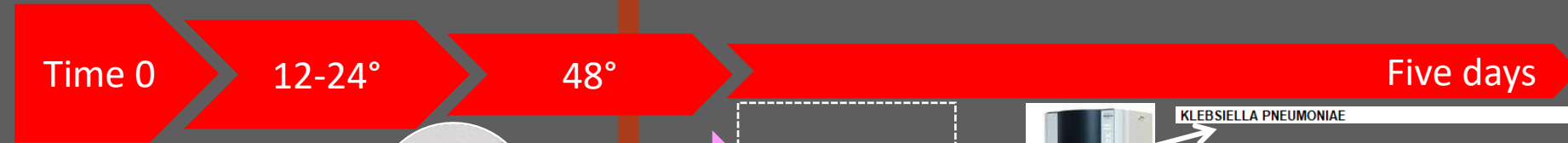
Empiric
Antimicrobials



Gram stain called to nurse,
nurse call to prescriber

85% of all
growth in
24 hours

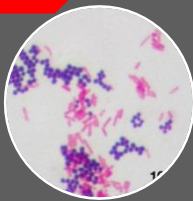
95% of all
growth in
48 hours



Bactec

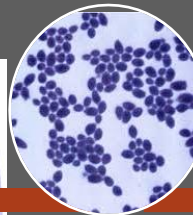


Within one
hour of
positive
culture



Bacteria

Within two
hours of gram
stain



Yeast



Biofire



MALDI-TOF
ID from
growth

KLEBSIELLA PNEUMONIAE



Culture 12-24°

Basic antibiogram

2022 Data - IU Methodist and University Hospitals ALL Locations								Community Isolates (collected <72hrs after admission)										
GRAM-NEGATIVE AEROBES	Number of Isolates	Gentamicin	Tobramycin	Ampicillin	Ampicillin/ Sulbactam	Amoxicillin/ Clavulanate	Piperacillin/ Tazobactam *	Cefazolin *	Cefuroxime *	Cefoxitin *	Ceftriaxone *	Cefpodoxime*	Cefepime	Meropenem	Trimethoprim/ Sulfa	Ciprofloxacin	Tetracycline	Nitrofurantoin
<i>Citrobacter freundii</i> *	56	95	95										100	100	88	89	91	98
<i>Enterobacter cloacae</i> *	202	98	98										97	99	95	96	94	49
<i>Escherichia coli</i> (ESBL 9%)	1292	92	92	52	58	79	89	87	82	83	90	86	91	100	75	77	77	97
<i>Klebsiella aerogenes</i> *	80	100	100										100	98	99	94	87	18
<i>K. oxytoca</i> (ESBL 5%)	132	97	97		73	92	++	74	94	95	94	94	95	100	93	96	94	92
<i>K. pneumoniae</i> (ESBL 14%)	437	94	91		75	84	84	85	84	85	86	86	86	99	82	86	72	32
<i>Proteus mirabilis</i>	255	94	94	77	91	88	100	92	95	98	86	86	95	100	81	74	2	0
<i>Pseudomonas aeruginosa</i> #	385	90	99				82						89	89		82		
<i>Serratia marcescens</i> *	75	100	91										100	93	99	84	46	4
Extended Spectrum β -Lactamase	187	64	53											99	41	20	44	65

* AmpC producing organism; avoid 1st, 2nd, 3rd gen cephalosporins and piperacillin/tazobactam. Cefepime is the preferred agent.
 # dual antibiotic coverage with an aminoglycoside recommended for systemic infections. See VAP and *Pseudomonas* page 9

IU Health Process Blood Culture



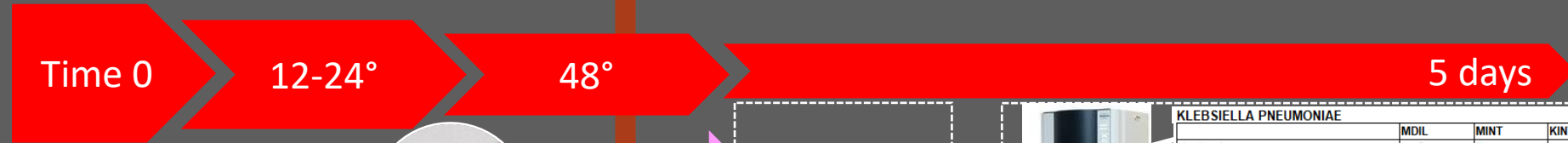
Gram stain called to nurse,
nurse call to prescriber

**Empiric
Antimicrobials**

85% of all
growth in
24 hours

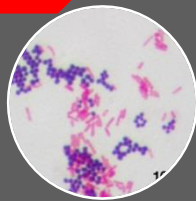
95% of all
growth in
48 hours

**Targeted
Antimicrobials**



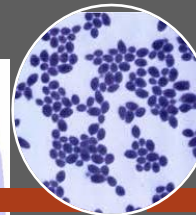
Bactec

Within 1
hour of
positive
culture



Bacteria

Within 2 hours
of gram stain



Yeast



Biofire



Culture 12-24°



**MALDI-TOF
ID from
growth**

KLEBSIELLA PNEUMONIAE			
	MDIL	IMINT	KINT
Amikacin	<=2	S	
Tobramycin	<=1	S	
Tetracycline	<=1	S	
Trimethoprim/Sulfa	<=20	S	
Piperacillin/Tazobactam	<=4	S	
Meropenem	<=0.25	S	
Gentamicin	<=1	S	
Ciprofloxacin	<=0.25	S	
Cefuroxime	2	S	
Ceftriaxone	<=1	S	
Cefepodoxime	<=0.25	S	
Cefoxitin	<=4	S	
Cefepime	<=1	S	
Cefazolin			S
Ampicillin/Sulbactam	4	S	
Amoxicillin/Clavulanate	<=2	S	

Susceptibilities



G+ 12-24°

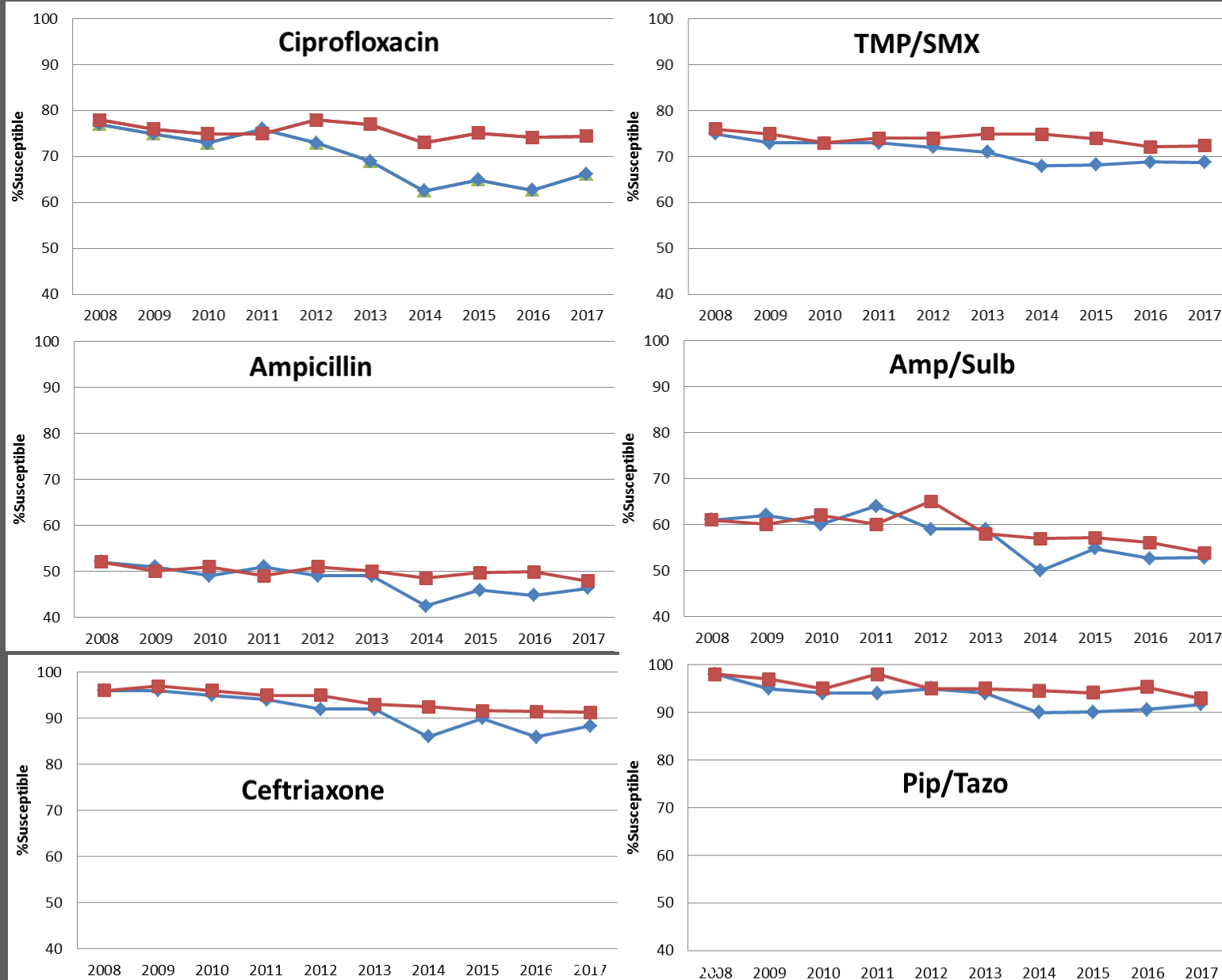


VITEK II

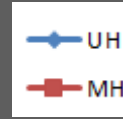


Ecoli composite

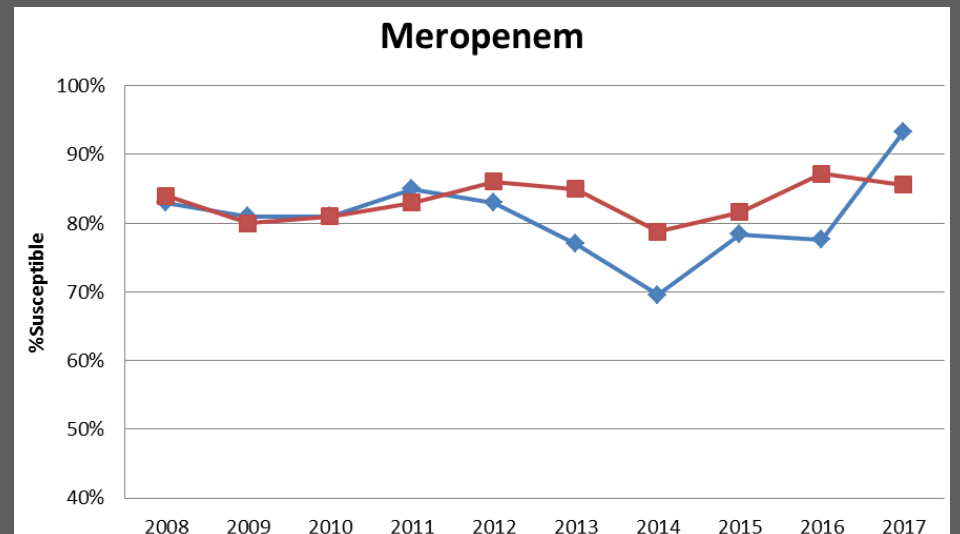
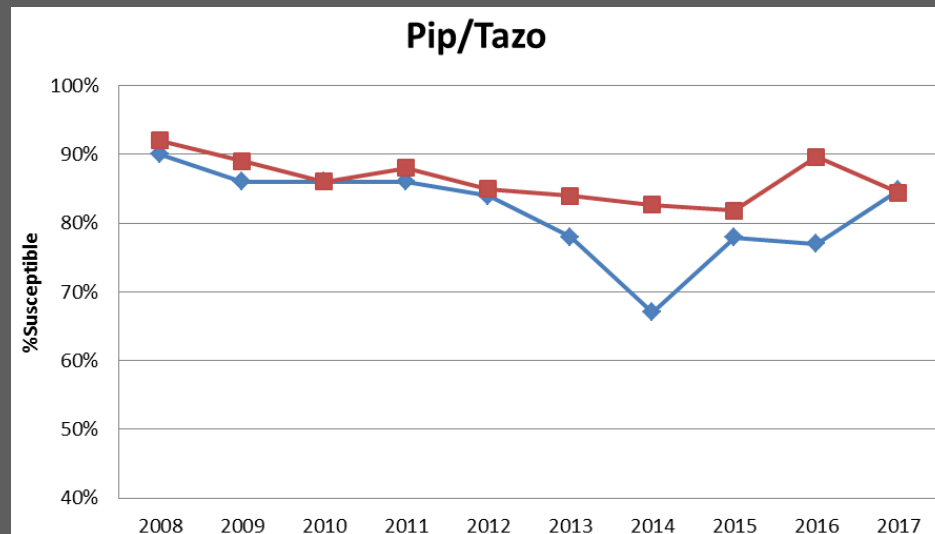
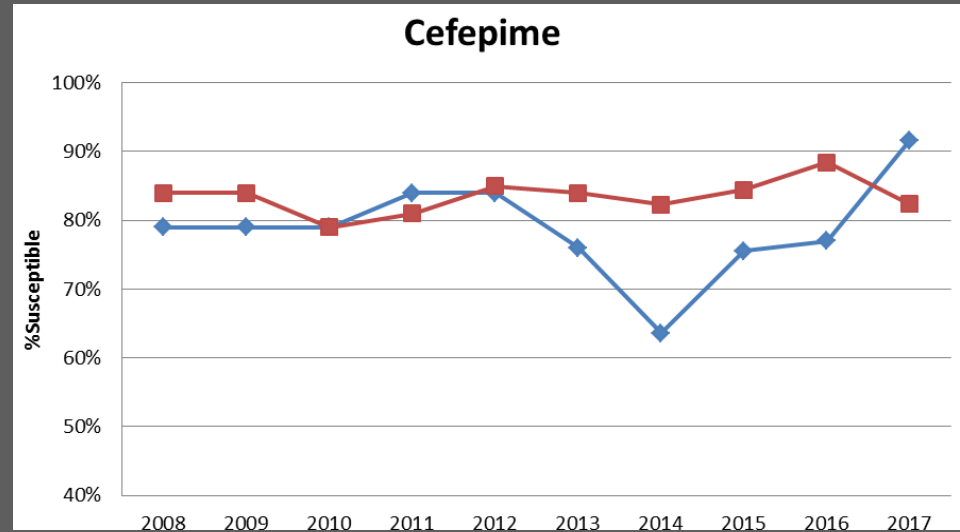
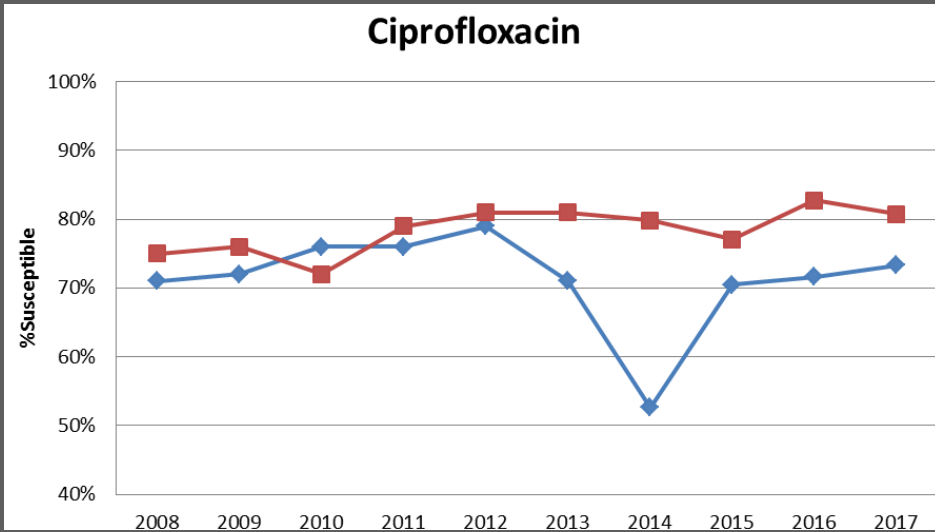
Good →



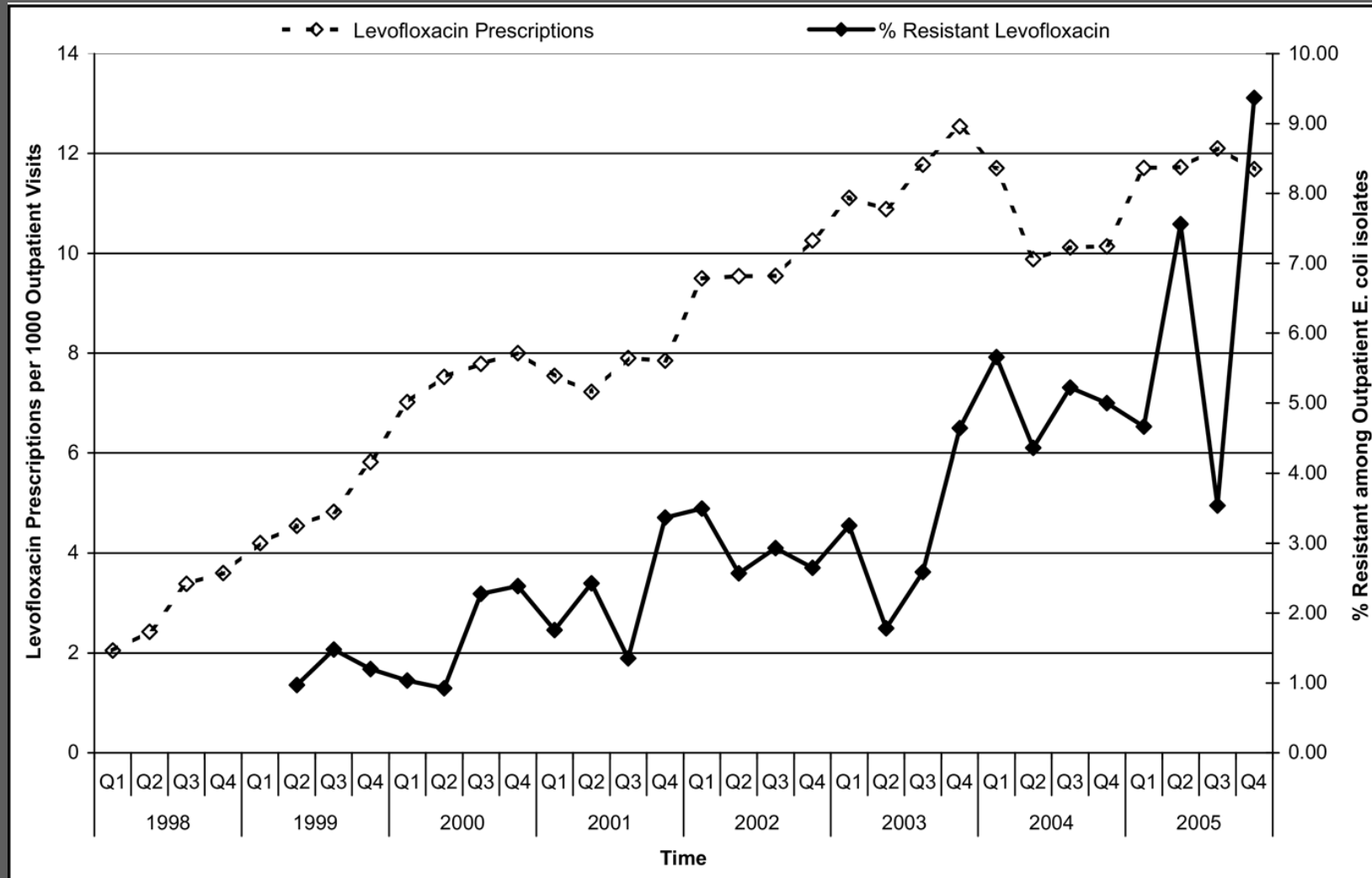
Pseudomonas composite



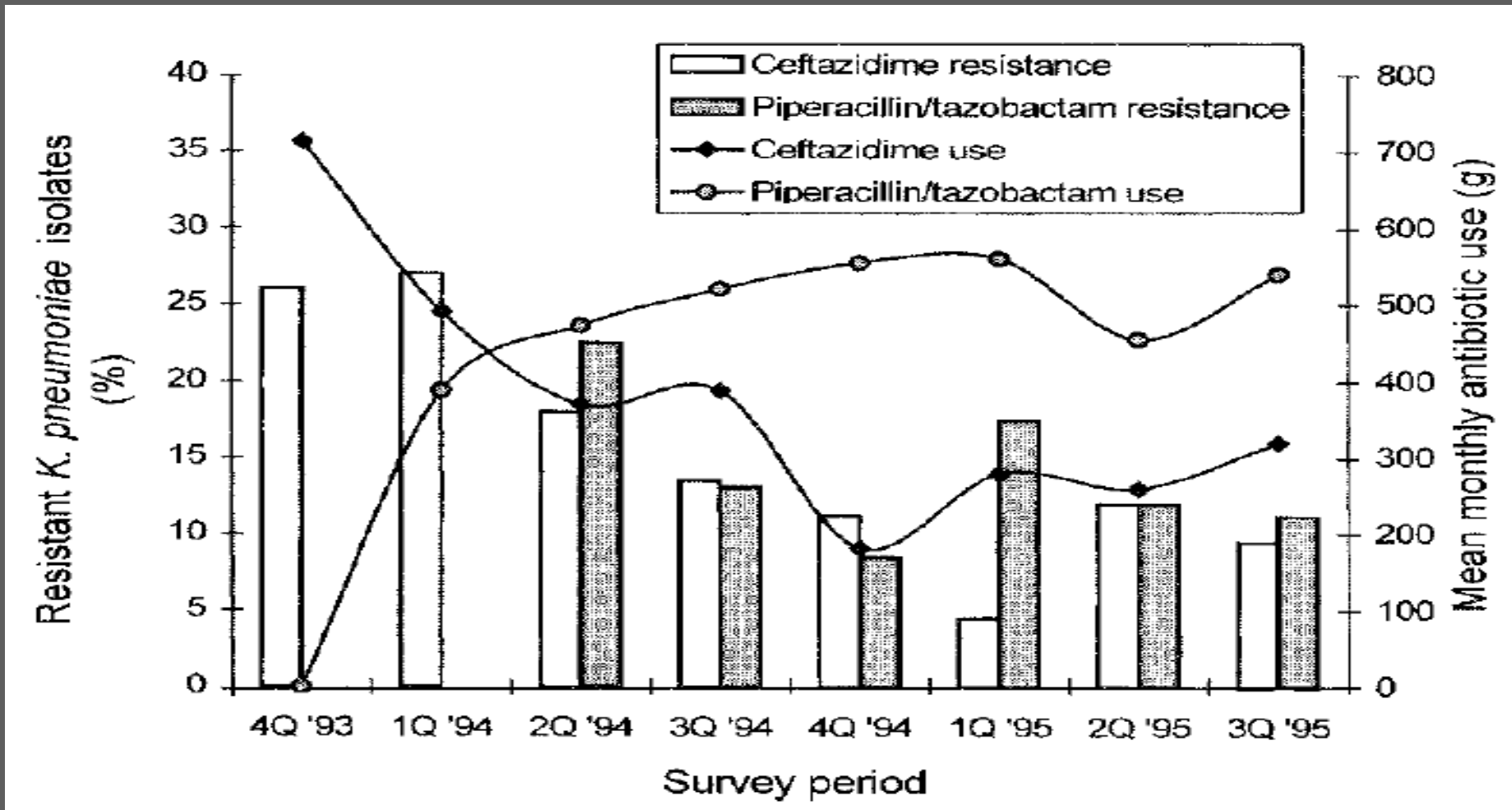
Good →



E. coli urinary isolates 1998-2005



Antimicrobial resistance pressure



Questions and answers