VUMC Antimicrobial Susceptibility Summary: Adult Patients 2023

Clinical Microbiology
Department of Pathology, Microbiology and Immunology

Preface

This booklet contains up-to-date information to assist in decisions concerning antimicrobial therapy.

Tables summarize susceptibility data obtained for organisms isolated in the VUMC Clinical Microbiology Laboratory between January 1, 2022 – December 31, 2022.

Guidelines for Interpretation of Minimum Inhibitory Concentrations (MICs)

MICs are interpreted as susceptible, intermediate, resistant, non-susceptible or susceptible dose dependent according to Clinical and Laboratory Standards Institute (CLSI) guidelines. When deciding whether the interpretation is meaningful, one should consider the antimicrobial pharmacokinetics, taking into account dosage and route of administration, the infecting organism and site of infection, and previous clinical experience.

For additional information, please call the microbiology laboratory, or the Antimicrobial Stewardship team.

Kendall Bryant, Ph.D., D(ABMM), Medical Director, Clinical Microbiology
Susan Sefers, M.T. (ASCP), Manager of Clinical Microbiology
Pamela Foster, M.T. (ASCP), Team Lead, Clinical Microbiology
Carmella Russo, M.T. (ASCP), Technical Specialist, Clinical Microbiology
Romney Humphries, PhD, Division Director, Laboratory Medicine

Frequently called numbers:
Antibiotic Approval Pager: 615-317-GERM (4376)
On Call VU ID Fellow Pager: 615-831-8872
Microbiology Lab: 615-322-3406

Microbiology Fellows (pager: 615- 835-9742)
VASP Website:
https://www.vumc.org/antimicrobial-stewardship-program

Contents

Table 1. Adults – Ten Most Common Gram-Negative Bacteria, Urine Isolates, % Susceptible

Data represent first isolate per patient.

Organism	N	Amoxicillin/ Clavulanate	Ampicillin	Ampicillin/ Sulbactam	Aztreonam	Cefepime	Ceftazidime	Ceftriaxone	Cephalosporins, oral*	Ciprofloxacin	Ertapenem	Gentamicin	Levofloxacin	Meropenem	Nitrofurantoin	Piperacillin/ Tazobactam	Tetracycline	Tobramycin	Trimethoprim/ Sulfamethoxazole
Citrobacter koseri	122	98	R	99	100	100	100	100	R	98	99	100	100	100	52	95	98	100	98
Citrobacter freundii	157	R	R	71	76	97	74	74	R	85	96	95	89	100	92	72	87	94	89
Klebsiella aerogenes	145	R	R	R	86	98	83	82	R	98	97	100	98	100	24	81	97	100	99
Enterobacter cloacae	244	R	R	R	74	85	71	65	R	91	80	96	94	99	26	72	90	95	87
Escherichia coli	6188	88	60	83	93	93	94	92	89	75	100	92	80	100	98	97	78	92	78
Klebsiella oxytoca	233	95	R	90	96	97	97	95	ND	93	99	96	99	100	90	95	88	96	89
Klebsiella pneumoniae	1340	93	R	85	93	93	93	93	91	87	99	95	91	100	43	89	82	94	86
Pseudomonas aeruginosa	363	R	R	R	80	92	93	R	R	80	R	R	80	93	R	87	R	ND	R
Proteus mirabilis	568	98	85	97	100	96	99	95	91	86	100	78	87	ND	R	100	4	89	89
Morganella morganii	73	R	R	61	99	100	86	90	R	76	100	92	76	100	R	99	54	93	87

*Oral cephalosporins include: cefaclor, cefdinir, cefpodoxime, cefprozil, cefuroxime, cephalexin, and loracarbef for treatment of uncomplicated urinary tract infections. R indicates intrinsic resistance, ND, no data.

ⓘ Empiric guidance for the treatment of urinary tract infections, including pyelonephritis, can be found on the VASP website at https://www.vumc.org/vasp/52609. Antibiotics should be narrowed once susceptibilities are known.

Table 2. Adults – Gram-Negative Bacteria, Urine isolates, % Susceptible by Patient Location

Data represent first isolate per patient.

Organism		N	Amoxicillin/Clavulanate	Ampicillin	Ampicillin/ Sulbactam	Aztreonam	Cefepime	Ceftazidime	Ceftriaxone	Cephalosporins, oral*	Ciprofloxacin	Ertapenem	Gentamicin	Levofloxacin	Meropenem	Nitrofurantoin	Piperacillin/ Tazobactam	Tetracycline	Tobramycin	Trimethoprim/ Sulfamethoxazole
*Enterobacter cloacae****	ICU	21**	R	R	R	71	86	67	62	R	95	81	100	100	100	14	67	95	100	91
	IN	52	R	R	R	71	81	69	62	R	89	79	94	90	96	23	65	89	94	85
	OP	173	R	R	R	75	86	72	67	R	91	80	95	95	100	28	74	90	94	87
Escherichia coli	ICU	229	76	50	74	84	83	87	80	77	62	100	90	68	100	98	94	72	89	72
	IN	574	78	51	76	88	89	89	85	82	67	100	92	71	100	99	96	76	91	72
	OP	5386	88	61	84	94	94	95	93	90	76	100	92	82	100	98	97	79	92	79
Klebsiella pneumoniae	ICU	62	90	R	89	89	89	89	89	89	82	100	95	87	100	40	86	77	94	84
	IN	222	80	R	76	83	84	83	84	82	74	99	88	80	100	40	80	73	86	77
	OP	1056	89	R	87	95	95	95	95	94	90	99	96	93	100	44	91	84	96	89
Pseudomonas aeruginosa	ICU	28**	R	R	R	75	86	86	R	R	86	R	R	86	93	R	79	R	ND	R
	IN	115	R	R	R	80	91	90	R	R	83	R	R	81	94	R	87	R	ND	R
	OP	220	R	R	R	81	94	95	R	R	77	R	R	78	93	R	87	R	ND	R
Proteus mirabilis	ICU	22**	100	82	100	100	86	100	86	82	82	100	77	82	ND	R	100	R	86	77
	IN	91	95	84	95	100	95	100	92	86	76	100	76	80	ND	R	99	R	88	86
	OP	455	97	85	98	99	97	99	96	92	88	100	78	89	ND	R	100	R	90	90

*Oral cephalosporins include: cefaclor, cefdinir, cefpodoxime, cefprozil, cefuroxime, cephalexin, and loracarbef for treatment of uncomplicated urinary tract infections.

**Calculated with <30 isolates, interpret data with caution.

*** *Enterobacter cloacae, Morganella morganii, Serratia marcescens, Klebsiella aerogenes* and *Citrobacter freundii* may develop resistance during prolonged therapy with 3rd-generation cephalosporins as a result of depression of AmpC beta-lactamase.

ICU, intensive care unit; IN, inpatient; OP, outpatient (includes emergency department); R, intrinsic resistance; ND, not tested. R indicates intrinsic resistance, ND, no data.

① For inpatient locations, and in the absence of detected or recent history of resistance or severe beta-lactam allergy, ceftriaxone or cefepime (or piperacillin-tazobactam for *E. coli*) are preferred empiric gram-negative antibiotics. Antibiotic therapy should be narrowed once susceptibilities are known.

Table 3. Adults – 10 Most Common Gram-Negative Bacteria, Non-Urine Isolates, % Susceptible

Data represent first isolate per patient.

Organism**	N	Amoxicillin/ clavulanate	Ampicillin	Ampicillin/ Sulbactam¥	Aztreonam	Cefazolin	Cefepime	Cefoxitin	Ceftazidime	Ceftriaxone	Cefuroxime	Ciprofloxacin	Ertapenem	Gentamicin	Levofloxacin	Meropenem	Piperacillin/ Tazobactam	Tetracycline	Tobramycin	Trimethoprim/ Sulfamethoxazole
Acinetobacter baumannii	74	R	R	83	R	R	71	R	76	46	R	76	R	86	80	81	ND	68	88	86
Enterobacter cloacae	390	R	R	R	81	R	91	R	80	78	ND	90	84	94	93	97	79	90	93	90
Escherichia coli	794	79	47	75	88	79	87	90	88	84	80	64	99	88	69	100	93	72	86	70
Klebsiella oxytoca	179	92	14	93	94	84	99	97	98	95	93	95	99	99	98	100	92	94	99	94
Klebsiella pneumoniae	447	82	R	76	82	78	82	84	81	82	72	76	97	85	82	98	72	70	84	77
Morganella morganii	82	R	R	ND	100	R	98	78	78	82	R	72	100	86	72	100	98	52	92	84
Pseudomonas aeruginosa	911	R	R	R	84	R	93	R	92	R	R	82	R	R	81	95	89	R	ND	R
Proteus mirabilis	201	94	81	93	99	87	95	96	98	91	90	82	99	79	83	ND	99	R	86	84
Serratia marcescens	221	R	R	R	98	R	97	R	97	95	R	93	95	97	95	98	96	ND	57	ND
Stenotrophomonas maltophilia	196	R	R	R	R	R	R	R	R	R	R	R	R	R	64	R	R	98*	R	94

R, intrinsic resistance; ND, no data. ¥Ampicillin-sulbactam dosing recommendation for *Acinetobacter* is at least 3g q4h (normal renal function)

*data reported represent minocycline; *S. maltophilia* is intrinsically resistant to tetracycline.

***Enterobacter cloacae*, *Morganella morganii*, *Serratia marcescens*, *Klebsiella aerogenes* and *Citrobacter freundii* may develop resistance during prolonged therapy with 3rd-generation cephalosporins as a result of depression of AmpC beta-lactamase.

ⓘ In the absence of recent history of resistance or severe beta-lactam allergy, cefepime is the preferred empiric gram-negative antibiotic. Piperacillin-tazobactam is preferred for *E. coli* and trimethoprim-sulfamethoxazole for invasive *S. maltophilia* infections. Antibiotic therapy should be narrowed once susceptibilities are known.

Table 4. Adults – Gram-negative Bacteria, Non-Urine Isolates, by Patient Location

Data represent first isolate per patient.

Organism	Location	N	Amoxicillin/ clavulanate	Ampicillin	Ampicillin/ Sulbactam	Aztreonam	Cefazolin	Cefepime	Cefoxitin	Ceftazidime	Ceftriaxone	Cefuroxime	Ciprofloxacin	Ertapenem	Gentamicin	Levofloxacin	Meropenem	Piperacillin/ Tazobactam	Tetracycline	Tobramycin	Trimethoprim/ Sulfamethoxazole
Enterobacter cloacae	ICU	87	R	R	R	75	R	91	R	74	71	ND	91	85	93	96	99	79	93	93	87
	IP	118	R	R	R	76	R	85	R	74	73	ND	88	77	91	92	95	71	88	91	90
	OP	186	R	R	R	89	R	95	R	89	87	ND	92	88	96	93	98	85	91	95	93
Escherichia coli	ICU	153	73	39	69	83	73	86	90	83	77	76	62	99	89	65	100	89	70	87	67
	IP	240	78	49	76	89	79	87	89	87	85	79	64	98	86	70	100	95	74	86	72
	OP	404	84	48	77	89	81	89	91	92	86	82	65	100	88	71	100	94	71	86	69
Klebsiella pneumoniae	ICU	141	79	R	76	85	80	83	84	82	84	73	77	98	86	83	99	70	71	84	80
	IP	150	79	R	73	76	72	76	79	75	75	65	74	95	81	79	95	66	68	80	73
	OP	159	89	R	81	86	84	88	91	88	86	78	77	99	87	84	98	81	70	86	79
Pseudomonas aeruginosa	ICU	156	R	R	R	76	R	87	R	82	R	R	82	R	R	83	93	79	R	ND	R
	IP	207	R	R	R	83	R	93	R	92	R	R	82	R	R	80	94	89	R	ND	R
	OP	552	R	R	R	87	R	94	R	95	R	R	81	R	R	81	96	92	R	ND	R
Serratia marcescens	ICU	52	R	R	R	100	R	100	R	100	95	R	95	98	98	100	100	98	ND	73	ND
	IP	49	R	R	R	97	R	95	R	95	92	R	95	90	97	95	95	90	ND	62	ND
	OP	120	R	R	R	98	R	97	R	97	95	R	92	97	97	93	98	99	ND	47	ND

ICU, intensive care unit; IN, inpatient; OP, outpatient (includes emergency department)

R, intrinsic resistance; ND, not tested.

ⓘ In the absence of recent history of resistance or severe beta-lactam allergy, cefepime is considered the empiric gram-negative antibiotic of choice. Piperacillin-tazobactam is preferred for *E. coli*. Antibiotic therapy should be narrowed once susceptibilities are known.

Table 5. Adults – *Staphylococcus aureus*, % Susceptible

Data represent first isolate per patient.

		N	Clindamycin	Daptomycin	Doxycycline	Linezolid	Minocycline	Nitrofurantoin	Oxacillin	Penicillin	Trimethoprim/ sulfamethoxazole	Vancomycin
Staphylococcus aureus	All	2846	87	99	96	100	96	100	61	18	93	100
MRSA	OP	821	77	99	92	100	93	100	0	0	88	100
	ICU	177	76	99	89	100	90	100	0	0	90	100
	IN	277	65	99	89	100	89	100	0	0	85	100
MSSA	OP	1149	96	100	98	100	99	100	100	29	98	100
	ICU	240	96	100	99	100	100	100	100	28	96	100
	IN	305	95	100	98	100	98	100	100	30	96	100

ICU, intensive care unit; IN, inpatient; OP, outpatient (includes emergency department)

ⓘ Isolation of *S. aureus* in the urine should be followed by a blood culture to confirm the patient is not bacteremic
S. aureus bacteremia or suspected invasive infection should be treated with IV antibiotics in conjunction with ID consultation

Table 6. Adults – *Staphylococcus* spp., % Susceptible

Data represent first isolate per patient. Only normally sterile site isolates included.

Organism	N	Clindamycin	Doxycycline	Minocycline	Nitrofurantoin	Oxacillin	Penicillin	Vancomycin
Staphylococcus pseudintermedius	50	74	84	98	100	88	35	100
Staphylococcus epidermidis	1209	58	85	99	100	44	29	100
Staphylococcus lugdunensis	220	88	99	100	100	92	62	100

*Trimethoprim-sulfamethoxazole susceptibility available on request

Table 7. Adults – *Enterococcus* spp., % Susceptible

Data represent first isolate per patient.

Organism	n	Ampicillin	Daptomycin*	Doxycycline	Gentamicin Synergy	Linezolid	Penicillin	Vancomycin
Enterococcus faecalis	1432	100	89	43	88	100	99	99
Enterococcus faecium	229	16	98	63	94	97	16	32
VRE	141	0	98	60	94	96	0	R
VSE	84	20	98	66	91	100	38	100

*Daptomycin susceptibility for *E. faecium* indicates proportion susceptible, dose dependent.

ⓘ Drugs of choice for *E. faecalis* include penicillin and ampicillin in the absence of severe penicillin allergy.
VRE infections often require treatment with restricted antibiotics such as daptomycin, which require ID approval for use.

Table 8. Adults – *Streptococcus pneumoniae*, % Susceptible

Data represent first isolate per patient.

	N	Penicillin			Amoxicillin, Non-meningitis	Ceftriaxone		Cefepime		Meropenem	Levofloxacin	Trimethoprim /Sulfamethoxazole	Clindamycin	Erythromycin*	Vancomycin	Tetracycline
		Meningitis	Non-meningitis	Oral		Meningitis	Non-meningitis	Meningitis	Non-meningitis							
Streptococcus pneumoniae	83	64	94	64	93	96	100	81	90	80	94	69	92	66	100	82

*erythromycin susceptible isolates are also susceptible to azithromycin

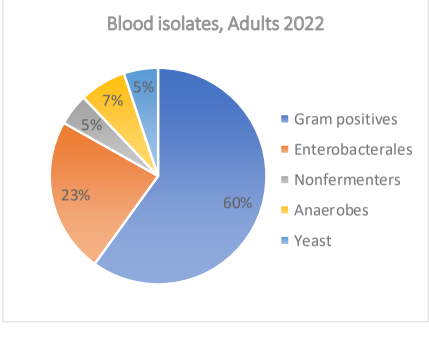
Table 9. Adults – *Streptococcus* spp., % Susceptible

Data represent first isolate per patient.

Organism	N	Cefepime	Ceftriaxone	Clindamycin	Levofloxacin	Meropenem	Penicillin	Vancomycin
Streptococcus agalactiae	198	100	100	40	100	100	100	100
Streptococcus pyogenes	135	100	100	59	100	100	100	100
Streptococcus anginosus	288	98	100	72	94	100	99	100
Streptococcus constellatus	165	74	100	66	100	98	94	100
Streptococcus intermedius	109	100	98	73	98	99	100	99
Viridans Group *Streptococcus*	135	97	97	73	87	97	83	100

R, intrinsic resistance; ND, not tested.

Table 10. Adults – Most common microorganisms isolated in blood cultures (n=2149)



Most common organisms in blood	% Patients	Resistance
Staphylococcus aureus	12.8%	43% MRSA
Staphylococcus epidermidis	12.0%	70% oxacillin-resistant
Escherichia coli	9.4%	20% ESBL
Staphylococcus hominis	5.3%	
K. pneumoniae	5.0%	25% ESBL
E. faecalis	3.8%	0% ampicillin-R
P. aeruginosa	2.3%	20% Pip-tazo-R; 6% cefepime-R
Enterococcus faecium	2.0%	77% vancomycin resistant
E. cloacae	1.9%	10% cefepime resistant
S. marcescens	1.6%	3% cefepime resistant
Streptococcus mitis	1.4%	7% ceftriaxone- resistant
Candida glabrata	1.3%	15% fluconazole resistant
S. agalactiae	1.0%	0% penicillin resistant
K. oxytoca	0.8%	0% ESBL
C. albicans	0.2%	0% fluconazole resistant

Data represent first isolate per patient.

Table 11. Adults – ESBL Bacteremia

Organism	CTX-M	N Patients	Ampicillin	Ampicillin-sulbactam	Amoxicillin-Clavulanate	Aztreonam	Cefazolin	Cefepime	Ceftriaxone	Ciprofloxacin	Ertapenem	Meropenem	Piperacillin-tazobactam	Trimethoprim-sulfamethoxazole
Escherichia coli	POS	34	0	15	44	15	0	6	0	0	94	100	80	30
	NEG	159	99	53	85	98	40	99	99	65	99	99	95	71
Klebsiella pneumoniae	POS	25	R	0	12	4	0	0	0	12	90	90	17	4
	NEG	96	R	77	95	100	42	100	100	88	95	100	84	88

CTX-M is the primary, but not the only, mechanism of ceftriaxone resistance in *E. coli* and *K. pneumoniae*. Resistance to expanded spectrum cephalosporins (ceftriaxone, ceftazidime) in *Enterobacter*, *Klebsiella aerogenes*, *Citrobacter* and *Serratia* is mediated by de-repression of AmpC.

Table 12. Adults – *Pseudomonas aeruginosa*, % Susceptible to at least one of two antimicrobials

Data represent one isolate per patient and exclude isolates from patients with cystic fibrosis.

Information provided for two drug combinations does not imply synergism, antagonism or likely activity in vivo;
1274 patients - includes the most resistant result for each drug if patient had >1 isolate.
Amikacin is only for use with infections originating from the urinary tract and gentamicin is intrinsically resistant.

	Ciprofloxacin (81)	Levofloxacin (81)
Meropenem (94)[1]	97	97
Piperacillin-tazobactam (88)	95	94
Cefepime (92)	96	96

[1]% susceptible for individual drug in parenthesis.
[2]% susceptible for either or both drugs in table (e.g., % S to levofloxacin and/or meropenem)

ⓘ Combination therapy is not recommended for the treatment of infections caused by *Pseudomonas aeruginosa* as >90% susceptibility for individual antimicrobial agents exists. Safety concerns significantly outweigh the benefit of combination therapy.

Table 13. Adults – *Stenotrophomonas maltophilia*, % Susceptible to at least one of two antimicrobials
Data represent one isolate per patient; includes patients with cystic fibrosis.

Information provided for two drug combinations does not imply synergism, antagonism or likely activity in vivo; 215 patients - includes the most resistant result for each drug if patient had >1 isolate.

	Levofloxacin (64)	Trimethoprim/ sulfamethoxazole (95)
Trimethoprim-sulfamethoxazole (95)	98	-
Minocycline (98)	99	100

[1]% susceptible for individual drug in parenthesis.
[2]% susceptible for either or both drugs in table (e.g., % S to levofloxacin and/or trimethoprim-sulfamethoxazole)

Candida Susceptibility Summary

Table 14. Adults – *Candida* spp., % Susceptible

Data represent first isolate per patient.

	N	Fluconazole	Micafungin	Voriconazole
C. albicans	466	95	100	95
C. glabrata	48	85*	100	ND
C. parapsilosis	41	90	98	95
C. tropicalis	30	71	100	57

*refers to % susceptible, dose dependent. ND, no data.

Patients with Cystic Fibrosis

Table 15. CF Patients, *Pseudomonas aeruginosa*, % Susceptible

Data represent most resistant isolate per patient.

N	Aztreonam	Amikacin	Gentamicin	Tobramycin	Cefepime	Meropenem	Piperacillin-tazobactam	Ciprofloxacin	Levofloxacin
225	72	R	R	ND	75	81	86	47	41

Table 16. CF Patients, *Staphylococcus aureus*, % Susceptible

Data represent first isolate per patient.

	N	Oxacillin	Ceftaroline	Clindamycin	Doxycycline	Linezolid	Minocycline	Trimethoprim-sulfamethoxazole	Vancomycin
All	166	72	100	88	97	100	97	99	100
MRSA	48	0	100	69	94	100	91	100	100
MSSA	118	0	100	96	98	100	99	98	100

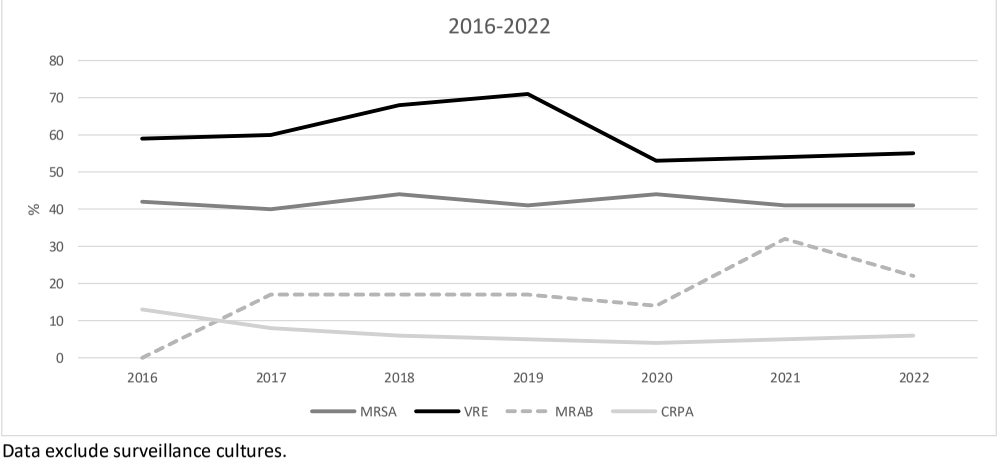
Table 17. CF Patients, *Stenotrophomonas maltophilia*, % Susceptible

Data represent first isolate per patient.

	N	Ceftazidime	Levofloxacin	Minocycline	Trimethoprim-sulfamethoxazole
Adults	18*	R	69	100	88

*Calculated with <30 isolates; interpret data with caution.

Figure 1. Multi-drug resistant Organism Trends, Adult Patients



Data exclude surveillance cultures.

CRPA, carbapenem-resistant *Pseudomonas aeruginosa*; MRAB, meropenem-resistant *Acinetobacter baumannii* complex; MRSA, methicillin resistant *Staphylococcus aureus*; VRE, vancomycin resistant *Enterococcus faecium*

Figure 2. ESBL Trends, Blood Isolates in Adult Patients, 2016-2022