

## ANTIMICROBIAL COSTS

INTRAVENOUS ANTIBIOTICS	USUAL # DOSE	TOTAL DIRECT COST / 24 HOURS
Ampicillin	2 g q4h	\$ 18
Ampicillin-sulbactam	3 g q6h	\$ 12
Azithromycin	500 mg q24h	\$ 3
Aztreonam*	2 g q8h	\$ 150
Cefazolin	2 g q8h	\$ 25
Cefepime	2 g q12h	\$ 9
Ceftaroline*	600 mg q12h	\$ 316
Ceftazidime	2 g q8h	\$ 17
Ceftazidime-avibactam*	2500 mg q8h	\$ 903
Ceftolozane-tazobactam*	1500 mg q8h	\$ 316
Ceftriaxone	1 g q24h	\$ 2
Ciprofloxacin	400 mg q12h	\$ 4
Clindamycin	600 mg q8h	\$ 14
Daptomycin*	500 mg q24h <sup>^</sup>	\$ 186
Ertapenem*	1 g q24h	\$ 120
Fluconazole	400 mg q24h <sup>^</sup>	\$ 4
Gentamicin	80 mg q8h	\$ 5
Imipenem*	500 mg q6h	\$ 40
Levofloxacin	500 mg q24h	\$ 3
Linezolid*	600 mg q12h	\$ 45
Meropenem*	1 g q8h	\$ 29
Meropenem-vaborbactam*	4 g q8h	\$ 900
Metronidazole	500 mg q8h	\$ 4
Micafungin*	100 mg q24h	\$ 61
Nafcillin	2 g q4h	\$ 46
Penicillin G Potassium	4 mu q4h	\$ 40
Piperacillin-tazobactam	3.375 g q8h	\$ 35
Telavancin*	750 mg q24h	\$ 395
Tobramycin	80 mg q8h	\$ 4
Inhaled tobramycin*	300 mg q12h	\$ 126
Vancomycin	1 g q12h	\$ 12

ORAL ANTIBIOTICS	USUAL # DOSE	TOTAL DIRECT COST / 24 HOURS
Amoxicillin	500 mg q8h	\$ 1
Amoxicillin-clavulanate	875 mg q12h	\$ 2
Atovaquone	750 mg q12h	\$ 55
Azithromycin	250 mg q24h	\$ 1
Cefuroxime	500 mg q12h	\$ 3
Cefpodoxime	200 mg q12h	\$ 10
Cephalexin	500 mg q6h	\$ 2
Ciprofloxacin	500 mg q12h	\$ 1
Clindamycin	300 mg q6h	\$ 4
Delafloxacin*	450 mg q12h	\$ 133
Dicloxacillin	500 mg q6h	\$ 4
Doxycycline	100mg q12h	\$ 2
Fidaxomicin*	200 mg q12h	\$ 170
Fluconazole	400 mg q24h <sup>^</sup>	\$ 4
Levofloxacin	500 mg q24h	\$ 1
Linezolid*	600 mg q12h	\$ 7
Metronidazole	500 mg q8h	\$ 1
Penicillin	500 mg q6h	\$ 1
Trimethoprim-sulfamethoxazole	2 DS tab q12h	\$ 1
Vancomycin (oral)	125 mg q6h	\$ 3~

#The common dose and interval are determined based on a 70kg patient with normal renal and hepatic function. The doses are general guidelines only for moderately severe infections. Lower doses are used for less severe infections or for prophylaxis; higher doses may be needed for more severe infections.

\*Requires approval for use from a member of the Infectious Disease Division.

<sup>^</sup>Serious infections caused by daptomycin-susceptible *Enterococcus faecium* require higher than standard daptomycin dosing, and infections caused by fluconazole-susceptible *Candida glabrata* require higher than standard fluconazole dosing. Advice from the Division of Infectious Diseases on the selection of maximum dosage regimens is recommended.

~The listed cost is for inpatient therapy. The outpatient cost of oral vancomycin is higher and varies by patient insurance.

## ANTIMICROBIAL SUSCEPTIBILITY TRENDS AND COMMENTS

- Oxacillin (methicillin) resistance in *Staphylococcus aureus* has been stable at 30%. All patients with oxacillin-resistant *S. aureus* should be on **Contact Precautions**. Infections caused by *Staphylococcus lugdunensis* can usually be treated with cefazolin or nafcillin.
- Strains of *Streptococcus pneumoniae* that are resistant to penicillin at intermediate and high levels constitute 25% of meningitis strains and 3% of non-meningitis strains. Patients with pneumonia caused by these strains may fail to respond to oral penicillins or oral cephalosporins and may require the use of intravenous penicillins, ceftriaxone, levofloxacin, or vancomycin. Patients with meningitis caused by these strains may respond to ceftriaxone, but vancomycin is added until susceptibilities are known.
- Strains of enterococci are usually susceptible to ampicillin (83%) and vancomycin (84%), one of which may be used in combination with gentamicin for serious infections. High-level resistance to gentamicin, however, now occurs in about 16% of the blood and CSF isolates. When specified, *E. faecium* is more often resistant to vancomycin (66%) and ampicillin (83%) than is *E. faecalis* (of which 4% are resistant to vancomycin and 0% are resistant to ampicillin). All patients with vancomycin-resistant enterococci should be on **Contact Precautions**.
- Resistance to ceftriaxone, cefotaxime, and ceftazidime in strains of *Klebsiella pneumoniae* as a result of extended-spectrum  $\beta$ -lactamases encoded on plasmids has increased from 11% to 12%. These strains have generally remained susceptible to ertapenem, meropenem, and amikacin, and to a lesser extent, gentamicin and cefepime. All patients with ceftriaxone-resistant *K. pneumoniae*, *E. coli*, and other enteric bacteria should be on **Contact Precautions**.
- Resistance to meropenem has been seen rarely in *Klebsiella pneumoniae* (1%) and *Enterobacter* spp. (1%). These strains are often multidrug-resistant, and therapy may need to be individualized after consultation with the Infectious Disease Division. All patients with meropenem-resistant enteric bacteria should be on **Contact Precautions**.
- Ampicillin resistance occurs in approximately 30% of strains of *Haemophilus influenzae* isolated from blood and CSF. These strains are usually susceptible to cefotaxime, ceftriaxone, and chloramphenicol.
- Most strains of *Mycobacterium tuberculosis* complex tested at the MGH (n = 16) were susceptible to standard antituberculous drugs: isoniazid (88%), rifampin (100%), pyrazinamide (100%), and ethambutol (100%).

\*Many patients who report a history of penicillin allergy can safely receive antibiotics in the penicillin and/or cephalosporin drug classes. Refer to the Penicillin and Cephalosporin Hypersensitivity Pathway for guidance:  
<https://id.partners.org/allergy>

(3/19)

## ANTIMICROBIAL PREFERENCES

- Cephalosporins.** When active, the first-generation agent, cefazolin, is the most cost-effective. Ceftriaxone is preferred for community-acquired pneumonia, and ceftriaxone is the agent of choice for bacterial meningitis. For other infections it should be used principally when broad gram-negative coverage is needed and resistance to other agents is known or suspected. Cefepime is preferred for neutropenic patients with fever or documented or suspected infections with *Pseudomonas aeruginosa*.
- Penicillins.** When active, ampicillin, penicillin, and nafcillin are preferred. Piperacillin-tazobactam is the antipseudomonal penicillin of choice. Ampicillin-sulbactam may be considered for diabetic foot infections, and piperacillin-tazobactam may be considered in place of ampicillin-sulbactam when its broader gram-negative spectrum is needed. Ampicillin-sulbactam may be used for treatment of *Acinetobacter baumannii* complex infections, but in general, many other agents are preferred over ampicillin-sulbactam for treatment of pneumonia.
- Meropenem** and imipenem are usually reserved for gram-negative bacillary infections resistant to penicillins, third-generation cephalosporins, and aminoglycosides.
- Aztreonam** is usually reserved for gram-negative coverage, as an alternative to aminoglycosides or fluoroquinolones, in patients with major allergy to penicillins or cephalosporins. \*See allergy note.
- Vancomycin** is usually reserved for circumstances in which oxacillin-resistant strains of staphylococci are documented or strongly suspected or as a replacement for penicillins or cephalosporins in patients with major allergy to these agents. \*See allergy note.
- Aminoglycosides.** When active, gentamicin is the most cost-effective. Tobramycin has slightly greater potency against *P. aeruginosa*. Amikacin is reserved for infections resistant to other aminoglycosides. Streptomycin is active (in combination with ampicillin or vancomycin) against some enterococci with high-level resistance to gentamicin.
- Fluoroquinolones.** When possible, oral administration of ciprofloxacin or levofloxacin is more cost-effective than intravenous administration. Fluoroquinolones have been shown to be a risk factor for *Clostridium difficile* infections.
- Linezolid** is usually reserved for treatment of serious infections with vancomycin-resistant enterococci or for treatment of infections with oxacillin-resistant *S. aureus* in patients in whom vancomycin or other therapies cannot be used.
- Daptomycin** is usually reserved for treatment of serious infections due to oxacillin-resistant *S. aureus* in patients in whom vancomycin or other therapies cannot be used. Daptomycin should not be used for pneumonia.
- Fluconazole** is well absorbed orally, and oral administration is more cost-effective than intravenous administration.



## MASSACHUSETTS GENERAL HOSPITAL

CLINICAL MICROBIOLOGY LABORATORY,  
INFECTIOUS DISEASE DIVISION, AND  
DEPARTMENT OF PHARMACY

ANTIMICROBIAL SUSCEPTIBILITY  
AND COST REPORT

2018-2019

**MASSACHUSETTS GENERAL HOSPITAL MICROBIOLOGY DEPARTMENT  
ANTIMICROBIAL SUSCEPTIBILITY – JAN. - DEC. 2018**

Bacterium	No. of Strains	% SUSCEPTIBLE														
		Penicillin	Ampicillin	Oxacillin	Cephalothin	Ceftaxone	Vancomycin	Clindamycin	Erythromycin	Doxycycline	TMP-SMX	Levofloxacin	Linezolid	Daptomycin	Rifampin	Nitrofurantoin <sup>a</sup>
<i>Staphylococcus aureus</i>	3621	—	—	70	70 <sup>b</sup>	—	100	70	49	97	95	78	99	99	99	99
Coagulase-negative staphylococci	1895	—	—	50	50 <sup>b</sup>	—	100	60	39	87	66	63	100	99	97	100
<i>Staphylococcus lugdunensis</i>	410	—	—	97	97 <sup>b</sup>	—	100	82	82	99	99	99	100	100	100	100
<i>Staphylococcus saprophyticus</i>	187	—	—	—	—	—	100	—	—	97	96	99	100	—	100	99
<i>Streptococcus pneumoniae</i> (non-meningitis)	162	97	—	—	99	100	85	64	63 <sup>c</sup>	80	99	—	0	—	—	—
<i>Streptococcus pneumoniae</i> (meningitis)		75	—	—	91											
β-hemolytic streptococci (group A)	172	100	—	—	100 <sup>d</sup>	100	100	76	75	75 <sup>c</sup>	0	99	—	—	—	—
β-hemolytic streptococci (group B)	1286	100	—	—	100 <sup>d</sup>	100	100	63	54	18 <sup>c</sup>	—	98	—	—	—	—
β-hemolytic streptococci (group C, G)	106	100	—	—	100 <sup>d</sup>	100	100	66	66	64 <sup>c</sup>	—	100	—	—	—	—
α-hemolytic streptococci <sup>a</sup>	286	69	—	—	—	95	100	87	53	59 <sup>c</sup>	—	92	—	—	—	—
<i>Streptococcus anginosus</i> (milleri) group	358	99	—	—	—	100	100	80	77	68 <sup>c</sup>	—	99	—	—	—	—
<i>Enterococcus faecalis</i>	2305	—	100	0	0	0	96	0	9	28	0	83	98	100	—	99
<i>Enterococcus faecium</i>	604	—	17	0	0	0	34	0	3	31	0	14	96	97 <sup>f</sup>	—	18

<sup>a</sup> Urine isolates only.

<sup>b</sup> For staphylococci, cephalothin is predicted from oxacillin.

<sup>c</sup> For streptococci, rates are tetracycline susceptibility rates.

<sup>d</sup> For streptococci, cephalothin is predicted from penicillin.

<sup>e</sup> Includes alpha-hemolytic streptococci, *S. bovis*, *S. canis*, *S. mitis*, *S. mutans*, *S. oralis*, *S. parasanguinis*, *S. salivarius*, *S. sanguinis*, *S. vestibularis*.

<sup>f</sup> Fewer than 150 isolates tested. See "Antimicrobial Costs" table for information about the need for higher daptomycin dosing in *E. faecium* infections.

(-) Drug not tested or insufficient data available.

Yeast	No. of Strains	Fluconazole (% susceptible)
<i>Candida albicans</i>	341	94
<i>Candida glabrata</i> <sup>a</sup>	155	89
<i>Candida parapsilosis</i>	64	94
<i>Candida tropicalis</i>	32	88

Note: *Candida krusei* are intrinsically resistant to fluconazole.

<sup>a</sup> See "Antimicrobial Costs" table for information about the need for higher fluconazole dosing in *C. glabrata* infections.

Bacterium	No. of Strains	% SUSCEPTIBLE														
		Ampicillin	Piperacillin-Tazobactam	Cefazolin	Ceftaxone	Cefepime	Aztreonam	Ertapenem	Meropenem	Gentamicin	Amikacin	Ciprofloxacin	Levofloxacin	TMP – SMX	Tetracycline	Nitrofurantoin <sup>a</sup>
<i>Achromobacter</i> spp. <sup>b</sup>	110	—	92	—	—	13	0	—	89	0	0	22	60	84	—	—
<i>Acinetobacter baumannii</i> complex <sup>c</sup>	155	0	71	0	0	74	0	0	85	89	—	76	78	83	73	—
<i>Aeromonas</i> spp.	28	0	96	0	100	100	100	85	96	100	100	89	—	74	—	—
<i>Burkholderia cepacia</i> complex <sup>d</sup>	39	0	0	0	—	—	0	0	86	0	0	46	56	68	—	0
<i>Citrobacter freundii</i> complex	298	0	85	0	81	98	83	99	99	98	100	95	94	89	85	96
<i>Citrobacter koseri</i> ( <i>diversus</i> )	193	0	98	96	98	99	98	99	100	99	100	98	98	98	98	90
<i>Enterobacter aerogenes</i>	239	0	84	0	84	98	86	99	99	100	100	98	98	97	91	15
<i>Enterobacter cloacae</i> complex	631	0	79	0	75	95	79	90	99	97	100	95	95	88	89	39
<i>Escherichia coli</i>	8297	51	94	82	90	96	93	99	99	91	100	79	79	73	71	95
<i>Haemophilus influenzae</i>	70	70	—	—	100	—	—	—	100	—	—	—	100	59	—	—
<i>Klebsiella oxytoca</i>	360	0	94	49	94	99	95	99	99	99	97	100	97	97	94	82
<i>Klebsiella pneumoniae</i>	2006	0	91	85	88	95	90	98	99	99	94	99	90	92	83	36
<i>Morganella morganii</i>	234	0	97	0	88	95	92	99	100	88	100	87	89	81	61	0
<i>Proteus mirabilis</i>	826	72	99	71	98	99	97	88	100	88	100	79	82	75	0	0
<i>Proteus vulgaris</i>	51	0	100	0	90	96	98	88	100	100	100	100	100	92	0	0
<i>Providencia</i> spp.	73	0	88	0	91	96	97	75	99	49	97	66	66	92	0	0
<i>Pseudomonas aeruginosa</i> <sup>e</sup>	1482	0	82	0	0	86	69 <sup>f</sup>	0	84	84	90	76	70	0	0	0
<i>Raoultella</i> spp.	76	0	95	89	91	97	91	100	100	93	100	96	97	89	80	95
<i>Salmonella</i> spp.	65	85	98	—	91	100	94	100	100	—	—	72	72	92	82	—
<i>Serratia marcescens</i>	282	0	—	0	95	99	98	97	100	98	100	93	93	98	23	0
<i>Shigella</i> spp.	21	67	100	—	100	100	100	100	100	—	—	86	—	10	19	—
<i>Stenotrophomonas maltophilia</i> <sup>g</sup>	337	0	—	0	0	0	0	0	0	0	0	36	79	98	—	0

<sup>a</sup> Urine isolates only.

<sup>b</sup> For *Achromobacter* spp., 81% are susceptible to ceftazidime.

<sup>c</sup> For *A. baumannii* complex, 89% are susceptible to ampicillin-sulbactam.

<sup>d</sup> For *B. cepacia* complex, 74% are susceptible to ceftazidime.

<sup>e</sup> For *P. aeruginosa*, 86% are susceptible to ceftazidime.

<sup>f</sup> 443 isolates (predominantly from cystic fibrosis patients) tested.

<sup>g</sup> For *S. maltophilia*, 35% are susceptible to ceftazidime.

(-) Drug not tested or insufficient data available.

**Antibiotic Guidelines for Empiric Therapy for Inpatients\***

Community Acquired Pneumonia **	Preferred Regimen	Alternative Regimen	Notes
Community Acquired	Ceftriaxone + azithromycin	Levofloxacin PO/IV (excludes ICU)	Narrow based on cultures
Received IV abx in last 90 days	Vancomycin + ceftazidime + azithromycin	Vancomycin + piperacillin-tazobactam	
Aspiration	Ceftriaxone	Ampicillin-sulbactam	PCN/Ceph allergy go to (a)
<b>Hospital Acquired Pneumonia</b>	<b>Preferred Regimen</b>	<b>Alternative Regimen</b>	<b>Notes</b>
Hospitalized ≥ 72 hours at diagnosis	Cefepime or ceftazidime	Piperacillin-tazobactam	
Received IV abx in last 90 days	Vancomycin + (cefepime or ceftaz)	Vancomycin + piperacillin-tazobactam	
ICU / Vented / Shock	Vancomycin + (cefepime or ceftaz) ± tobramycin	Vancomycin + piperacillin-tazobactam ± tobramycin	
<b>Ventilator Associated Pneumonia</b>	<b>Preferred Regimen</b>	<b>Alternative Regimen</b>	<b>Notes</b>
Vented ≥ 72 hours	Cefepime or ceftazidime	Piperacillin-tazobactam	
Received IV antibiotics in last 90 days	Vancomycin + (cefepime or ceftaz) ± tobramycin	Vancomycin + piperacillin-tazobactam ± tobramycin	
<b>Sepsis Syndrome (See Sepsis Order Set)</b>	<b>Preferred Regimen</b>	<b>Alternative Regimen</b>	<b>Notes</b>
Unknown Source - Community Acquired	Vancomycin + ceftriaxone	Vancomycin + (cefepime or ceftaz)	Vanco + Mero if MDRO
Unknown Source - Healthcare Associated	Vancomycin + (cefepime or ceftaz)	Vancomycin + piperacillin-tazobactam	Vanco + Mero if MDRO
Intra-abdominal / Pelvic - Community Acquired	Ceftriaxone + metronidazole	Piperacillin-tazobactam	Add vanco if critically ill
Intra-abdominal / Pelvic - Healthcare Associated	Cefepime + metronidazole	Piperacillin-tazobactam	Add vanco if critically ill
<b>Neutropenic Host (See F+N pathway)</b>	Cefepime	Ceftaz or piperacillin-tazobactam	Add vanco for sepsis
<b>Acute Bacterial Meningitis</b>	<b>Preferred Regimen</b>	<b>Alternative Regimen</b>	<b>Notes</b>
Immunocompetent Host <50 years old	Ceftriaxone (b) + vancomycin (c)	Consult Infectious Diseases	Add rifampin if steroids
Immunocompromised Host OR ≥ 50 years old OR pregnant	Ceftriaxone (b) + ampicillin (d) + vancomycin (c)	Consult Infectious Diseases	Add rifampin if steroids
PWID, Head Trauma, Neurosurgery, or History of MDRO	Cefepime (e) + vancomycin (c)	Meropenem (f) + vancomycin (c)	
[PWID = Person who injects drugs]			
Concern for Herpes Simplex Virus	Add Acyclovir 10 mg/kg q8h	Consult Infectious Diseases	
<b>Skin and Soft Tissue Infection</b>	<b>Preferred Regimen</b>	<b>Alternative Regimen</b>	<b>Notes</b>
Nonpurulent cellulitis	Cefazolin	Ceftriaxone	PCN/Ceph allergy go to (a)
Purulent cellulitis	Vancomycin	Linezolid	
Cellulitis in diabetes mellitus (DM) or peripheral vascular disease (PVD) including open ulcer	Vancomycin + ceftriaxone	Vancomycin + cefepime	
Concern for gangrene or necrosis	Vancomycin + piperacillin-tazobactam	Vancomycin + cefepime + metronidazole	Surgery + ID Consults
Necrotizing fasciitis	Vancomycin + piperacillin-tazobactam + clindamycin	Vancomycin + meropenem + clindamycin	Surgery + ID Consults
<b>Urinary Tract Infection/Urosepsis</b>	<b>Preferred Regimen</b>	<b>Alternative Regimen</b>	<b>Notes</b>
Community Acquired	Ceftriaxone		
Hospital Acquired / at risk for MDRO	Cefepime or ceftazidime	Meropenem	
	Add vancomycin if severely ill, history of MRSA colonization in the urine or recent Foley/instrumentation		
<b>Acute Septic Arthritis</b>	<b>Preferred Regimen</b>	<b>Alternative Regimen</b>	<b>Notes</b>
No underlying disease	Vancomycin + ceftriaxone	Vancomycin + levofloxacin	Joint aspiration cultures prior to antibiotics
Prosthetic Joint	Vancomycin + ceftriaxone		
Suspected Gonorrhea	Ceftriaxone + azithromycin		
<b>Pancreatitis</b>	<b>Preferred Regimen</b>	<b>Alternative Regimen</b>	<b>Notes</b>
Acute pancreatitis	None		
Necrotizing pancreatitis (antibiotics if CT evidence of necrosis AND fever/signs of infection)	Ceftriaxone + metronidazole	Cefepime + metronidazole	Pan-culture and aspiration cultures to guide antibiotics

\*some of the above antibiotics require ID approval. Antibiotics should be adjusted as soon as microbiologic data are available.

\*\*for patients with underlying bronchiectasis or clinical suspicion for *Pseudomonas aeruginosa* treat with cefepime + gentamicin; add vancomycin for additional coverage for gram-positive bacteria, if necessary.

(a) PCN/Ceph allergy go to id.partners.org/allergy; (b)Ceftriaxone 2g q12h; (c) vancomycin 20 mg/kg x 1 then per protocol; (d) Ampicillin 2g q4h; (e) Cefepime 2g q8h; (f) Meropenem 2g q8h; MRSA = methicillin-resistant *S. aureus*; MDRO = multi-drug resistant organism