Table 2. Microbial causes of infections according to site, and type of host, and recommended empiric antimicrobial therapy.

Newborn		
Site of Infections	**Organisms**	**Antimicrobials**
Sepsis, Meningitis	Streptococcus agalactiae (group B)	Ampicillin
	Escherichia coli	cefotaxime[@&]
	Other Gram-negative rods	cefotaxime[@&]
	Listeria monocytogenes	Ampicillin +/- gentamicin
	Herpes simplex virus	Acyclovir
	Enterovirus	None
@For Gram-negative rod Sepsis, gentamicin is appropriate, but for meningitis, cefotaxime should be used. **&Because extended-spectrum beta-lactamases are being noted in E. coli, if Gram-negative rods are seen on Gram stain or are cultured, meropenem should be used instead of cefotaxime, until susceptibilities are known.**		
Empiric Therapy: Sepsis - Ampicillin + (gentamicin or cefotaxime) +/- acyclovir		
Empiric therapy: Meningitis - Ampicillin + cefotaxime + acyclovir		
Pneumonia	Streptococcus agalactiae	See above for sepsis
	Escherichia coli	See above for sepsis
	Respiratory viruses	None currently
	Chlamydia trachomatis	Azithromycin or erythromycin
	Herpes simplex virus	Acyclovir
Empiric therapy: Pneumonia - Ampicillin + (gentamicin or cefotaxime) +/- macrolide		
URINARY TRACT INFECTION	Escherichia coli	See above for sepsis
SKELETAL (bone, joint)	Streptococcus agalactiae	Ampicillin
	Staphylococcus aureus	Vancomycin or nafcillin*
	Gram-negative rods	See above for sepsis
Empiric therapy: Vancomycin or nafcillin* + cefotaxime		
***See comment in Table 1 about Staphylococcus aureus resistance to methicillin**		
NECROTIZING ENTEROCOLITIS	Gram-negative rods, anaerobes	Cefotaxime or gentamicin) + metronidazole or meropenem alone[#]
#Meropenem is very active against most Gram-negative rods and anaerobes, so it can be used alone.		
OMPHALITIS	Staphylococcus aureus	Vancomycin or nafcillin*
	Gram-negative rods	Gentamicin
	Anaerobes	Metronidazole
Empiric therapy should be active against all these pathogens		
CONJUNCTIVITIS	Neisseria gonorrhoae	Ceftriaxone
	Chlamydia trachomatis	Azithromycin or erythromycin
	Staphylococcus aureus	Topical gentamicin or polymyxin
NORMAL INFANT AND CHILD		

Sepsis (bacteremia)	Streptococcus pneumonia	Penicillin, ampicillin, ceftriaxone or cefotaxime
	Neisseria meningitidis	Penicillin, ceftriaxone
	Haemophilus influenzae#	Cefotaxime or ceftriaxone
	Staphylococcus aureus	Vancomycin or nafcillin*
	Salmonella spp.	Ceftriaxone or cefotaxime
#H. influenza type b (HIB) was a very common cause of bacteremia, meningitis, skeletal infections, epiglottitis and facial cellulitis prior to the widespread use of the (HIB) vaccine in the early 1990s. It is now very rare in the USA and other countries where the vaccine is used.		
Empiric therapy for sepsis: Ceftriaxone and cefotaxime are active against most causes of bacteremia in previously normal children. However, if there are focal symptoms or signs, such as limp or abscesses, Staphylococcus aureus infection should be strongly suspected, and vancomycin should be added.		
Toxic shock syndrome	Staphylococcus aureus, Streptococcus pyogenes	Vancomycin (or nafcillin*) + clindamycin[&] +/- intravenous gamma globulin (IVIG)
&The reason for adding clindamycin is for its ability to inhibit toxin production		
NERVOUS SYSTEM INFECTIONS		
Meningitis	Streptococcus pneumonia[$]	Ceftriaxone or cefotaxime, vancomycin
	Haemophilus influenzae type b[#]	Cefotaxime or ceftriaxone
	Neisseria meningitidis	Penicillin, ceftriaxone
$Empiric therapy for meningitis: Because strains of Streptococcus pneumonia resistant to penicillin, cefotaxime, and ceftriazone are prevalent worldwide, vancomycin should be used IN ADDITION TO ceftriaxone or cefotaxime, until identification of an organism and antimicrobial susceptibilities have been determined.		
Chronic meningitis	Tuberculous	Isoniazid + rifampin + pyrazinamide + ethionamide; consult infectious diseases specialist
	Cryptococcal	Amphotericin B + flucytosine; consult infectious diseases specialist
Other infections of the brain:		
Encephalitis: in most cases an etiology is never identified	Enteroviruses	None
	Arthropod-borne viruses	None
	Herpes simplex virus	Acyclovir
	Rickettsiae	Doxycyline
	Bartonella henselae	Doxycyline
	Borrelia burgdorferi (Lyme disease)	Ceftriaxone
Empiric therapy for encephalitis: ceftriaxone + acyclovir + doxcycycline		
Ventriculo-peritoneal shunt	Staphylococci, Gram-negative rods, diphtheroids, Bacillus spp.	Vancomycin + ceftriaxone
Brain Abscess	Streptococci, anaerobes, staphylococci, Gram-negative rods	(Vancomycin + meropenem) OR (vancomycin + ceftriaxone + metronidazole)
Poliomyelitis	Polio viruses	No therapy
	Tetanus	Supportive, tetanus immune globulin + (metronidazole or penicillin)
	Botulism	Supportive, botulinum immune globulin: Infant botulism - Baby BIG – call 510-231-7600; foodborne and

		wound botulism: bivalent equine antitoxin – call CDC 770-488-7100; also call state laboratory
UPPER RESPIRATORY TRACT:		
Pharyngitis:		
Respiratory viruses: Adeno-, parainfluenza-, respiratory syncytial-, rhino-	Streptococcus pyogenes (Group A)	Penicillin, ampicillin, clindamycin, macrolide
Diptheria	Corynebacterium diphtheriae	Diphtheria antitoxin + (erythromycin or penicillin)
Acute Otitis Media	Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis	Amoxicillin, amoxacillin/clavulanate, cefdinir, cefpodoxime
Mastoiditis	Streptococcus pneumoniae, Streptococcus pyogenes, Staphylococcus aureus	(ceftriaxone or cefotaxime) + (clindamycin or vancomycin*)
Sinusitis	Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis	Amoxicillin, amoxacillin/clavulanate, cefdinir, cefpodoxime
Retropharyngeal Abscess	Staphylococcus aureus, anaerobes, oral Gram-negative rods	((ceftriaxone or cefotaxime) + clindamycin) or ampicillin/sulbactam*
***ampicillin/sulbactam is suitable only if Staphylococcus aureus resistant to methicillin is excluded or unlikely.**		
MIDDLE RESPIRATORY TRACT:		
Epiglottitis	Haemophilus influenzae, Streptococcus pneumoniae, Streptococcus pyogenes	Ceftriaxone or cefotaxime
Acute Laryngotracheobronchitis	Respiratory viruses (parainfluenza-, respiratory syncytial-, adeno-, influenza viruses	No antimicrobial therapy
Bacterial tracheitis	Staphylococcus aureus, Streptococcus pyogenes	Vancomycin*
LOWER RESPIRATORY TRACT:		
Bronchiolitis	Respiratory viruses (respiratory syncytial-, parainfluenza virus	No antimicrobial therapy
Pertussis		Macrolide
Pneumonia	Respiratory viruses (respiratory syncytial virus, parainfluenza virus, adenovirus, metapneumovirus)	None
	Influenza viruses$	Osteltamavir, zanamivir, rimantadine, amantadine
$ Check current recommendations, from sources such as the CDC (www.cdc.gov)		
	Streptococcus pneumoniae	ceftriaxone
	Staphylococcus aureus	Vancomycin or nafcillin*, linezolid (daptomycin should NOT be used for patients with pneumonia) clindamycin for less severe cases
	Mycoplasma pneumoniae	Macrolide, doxycycline^, fluoroquinolone
	Chlamydia pneumoniae	Macrolide, doxycycline^
^Doxycycline should not be used in this situation in children younger than 8 years		
Empiric therapy: infant: (ceftriaxone or cefotaximie) +/- treatment active against Staphylococcus aureus **Older child: (ceftriaxone or cefotaxime) + macrolide +/- treatment active against Staphylococcus aureus**		

Empyema	Streptococcus aureus, Streptococcus pneumoniae	(ceftriaxone or cefotaxime) + vancomycin*
Nosocomial and Ventilator-associated pneumonia		See Hospital-acquired infections below
SKIN and SOFT TISSUE INFECTIONS		
Cellulitis	Staphylococcus aureus, Streptococcus pyogenes	Clindamycin or nafcillin*, (vancomycin for severe infections)
Fasciitis, Myositis	Staphylococcus aureus, Streptococcus pyogenes	Vancomycin or nafcillin* +/- clindamycin (see toxic shock syndrome above) if perineal, consider Gram-negative rod and anaerobes, and add pipercillin/tazobactam or merepenem.
Wound#	Staphylococcus aureus, Streptococcus pyogenes	See skin infections above – if contaminated or perineal – consider Gram-negative rods and anaerobes and add piperacillin/tazobactam or meropenem
Gas gangrene	Clostridium perfringens, other histotoxic clostridia	Meropenem + surgery
Burn#	Staphylococcus aureus, Pseudomonas aeruginosa	Vancomycin or clindamycin or nafcillin* + (ceftazidime or piperacillin/tazobactam or aminoglycoside)
Ecthyma gangrenosum	Pseudomonas aeruginosa, other Gram-negative rods, Aspergillus spp., Zygomycetes	Ceftazidime or piperacillin/tazobactam%
%An urgent biopsy should be performed		
Bites:#		
Human++	Staphylococcus aureus, Streptococcus pyogenes, oral Gram-negataive rods, anaerobe	Ampicillin/sulbactam or amoxicillin/clavulanate + (clindamycin or vancomycin*)
Ampicillin/sulbactam and amoxicillin/clavulanate are active against methicillin-susceptible Staphylococcus aureus		
Dog, cat, other mammal	Staphylococcus aureus, streptococci, Pasteurella spp., Neisseria spp., Capnocytophaga spp.	Ampicillin, sulbactam or amoxicillin/clavulanate + (clindamycinor vancomycin*)
Shark	Vibrios	Ciprofloxacin, cefotaxime, doxycycline, aminoglycosides
Alligator/crocodile	Aeromonas hydrophila, Pseudomonas spp., other Gram-negative rods, anaerobes	Piperacillin/tazobactam
Rat	Streptobacillus moniliformis	Penicillin
Monkey (old World)	Herpes simiae	Acyclovir
Snake	Staphylococcus aureus, E. coli	Ampicillin/sulbactam
In cases of animal bites, the potential for rabies exposure should be evaluated, and, if indicated, post-exposure management with rabies immune globlin and rabies vaccine given.		
++ Risk for transmission of HIV, hepatitis B and hepatitis C should be determined		
URINARY TRACT INFECTIONS		
	E. coli, Klebsiella, other Gram-negative rods	Cefotaxime or ceftriaxone or aminoglycoside
	Enterococcus	Ampicillin; nitrofurantoin, only for lower tract infection
ABDOMINAL INFECTIONS		
Perforated bowel	Gram-negative rods, anaerobes	Carbapenem, piperacillin/tazobactam, ticarcilin/clavulanic acid OR ceftriaxone, cefotaxime, ceftazidime, ciprofloxacin or levofloxacin each with metronidazole OR gentamicin +

		metronidazole
Cholecystitis	Gram-negative rods, anaerobes	Carbapenem, piperacillin/tazobactam OR cefepime, ciprofloxacin or levofloxacin, each with metronidazole
Cholangitis	Gram-negative rods, anaerobes	Carbapenem, piperacillin/tazobactam OR cefepime, ciprofloxacin or levofloxacin, each with metronidazole
Liver abscess: bacterial	Streptococcus, Gram-negative rods, anaerobes	(ceftriaxone + metronidazole) or carbapenem
Liver abscess: amebic	Entamoeba histolytica	Metronidazole or tinidazole
Primary peritonitis	Streptococcus pneumoniae, Gram-negative rods	Ceftriaxone
GASTRO-INTESTINAL INFECTIONS:		
Gastroenteritis:		
Viral:	(rotavirus, norovirus, enteric adenovirus)	Supportive therapy only
Bacterial:	Salmonella	Supportive therapy only unless bacteremia is suspected, or in infants < 3 months or patients with sickle cell disease: ceftriaxone
	Shigella	Ceftriaxone (Although this organism can be susceptible to ampicillin and trimethoprim/sulfamethoxazole resistance is frequent.)
	Campylobacter	Azithromycin, ciprofloxacin
	Yersinia enterocolitica	If suscepted bacteremia: gentamicin, ceftriaxone, trimethoprim/sulfamethoxazole
	Clostridium difficile	Metronidazole (orally or parenterally) or vancomycin (only orally)
	Cholera (Vibrio Cholerae)	Doxycycline, ciprofloxacin, azithromycin, trimethoprim/sulfamethoxazole
	E. coli: traveler's diarrhea	Ciprofloxacin, azithromycin
Protozoal:	Giardia intestinalis	Metronidazole or tinidazole
	Entamoeba histolytica	Metronidazole or tinidazole
	Cryptosporidium homonis	Nitazoxanide
	Cyclospora cayetanensis	Trimethoprim/sulfamethoxazole
	Isospora belli	Trimethoprim/sulfamethoxazole
Typhoid fever	(Salmonella typhi and S. paratyphi infection)	Ceftriaxone (although this organism may susceptible to ampicillin, trimethoprim/sulfamethoxazole, chloramphenicol and ciprofloxacin, resistance is fairly common)
Esophagitis		
	Herpes simplex virus	Acyclovir
	Candida	Fluconazole
	Cytomegalovirus	Gancyclovir
GENITAL INFECTIONS:		
Pelvic inflammatory disease	Neisseria gonorrhoeae, Chlamydia trachomatis, Gram-negative rods,	(Cefoxitin or cefotetan) + doxycycline

	anaerobes	
CARDIOVASCULAR INFECTIONS		
Infective endocarditis (see Baddour LM et al):		
Native heart	Staphylococcus aureus, strepcococci, enterococci, "HACEK" group of Gram-negative rods^	Vancomycin + gentamicin* +/- ceftriaxone
^Haemophilus aphrophilus (now called Aggregatibacter aphrophilus), Actinobacillus actinomycetemcomitans, Cardiobacterium homonis, Eikenella corrodens, and Kingella kingae) *low dose gentamicin, for synergistic activity		
Nosocomial		
	Complicating vascular catheter infection: staphylococci, enterococci, Candida spp.	
	Post-operative and prosthetic valve/material: coagulase-negative staphylococci, Staphylococcus aureus, Corynebacteria, Gram-negative rods, and fungi, especially Candida spp.	Vancomycin + gentamicin + rifampin + cefepime
	Associated with intravenous drug abuse: Staphylococci aureus, Gram-negative rods	Vancomycin + gentamicin + ceftazidime
	Fungal	Amphotericin B
Pericarditis	Staphylococcus aureus, Haemophilus influenzae, Streptococcus pneumoniae, Neisseria meningitidis	Vancomycin + ceftriaxone
Myocarditis	Usually virus	
Septic jugular thrombophlebitis (Lemierre's syndomre)	Fusobacterium necrophorum	Metronidazole
EYE:		
Conjunctivitis	Adenovirus, Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis	Topical polymyxin or gentamicin
Other ocular diseases including keratitis, uveitis, endophthalmitis, retinitis		Consult ophthalmologist
Periorbital and orbital cellulitis	Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae	Ceftriaxone + (clindamycin or vancomycin)*
ABNORMAL HOST:		
HIV/AIDS:		
Pneumonia	Same causes as in non HIV-infected children of same age + Pneumocystis jirovecii, cytomegalovirus, Mycobacterium tuberculosis	Ceftriaxone + trimethoprim/sulfamethoxazole
Bacteremia	Same causes as in non HIV-infected children of same age + Staphylococcus aureus, Gram-negative rods, Listeria monocytogenes	Ceftriaxone + ampicillin +/- vancomycin

Sickle Cell Disease:		
Bacteremia	Streptococcus pneumoniae	Ceftriaxone or cefotaxime
Acute Chest Syndrome	Streptococcus pneumoniae, Mycoplasma pneumoniae	Ceftriaxone + macrolide
Osteomyelitis	Staphylococcus aureus, Salmonella – try to obtain organism	(clindamycin or vancomycin*) + ceftriaxone
Primary immunodeficiencies:		
Chronic granulomatous disease	Staphylococcus aureus, Aspergillus, Serratia marcescens, Burkholderia cepacia	
Immunoglobulin deficiency	Streptococcus pneumonia, Haemophilus influenzae, Staphylococcus aureus, Pseudomonas spp.	
Severe combined immunodeficiency	Wide range of viral, bacterial, and fungal organisms, including cytomegalovirus, herpes simplex virus, Streptococcus pneumoniae, Haemophilus influenzae, Gram-negative rods, including Salmonella spp., Listeria monocytogenes, Mycobacteria, and Pneumocystis jirovecii	
Complement deficiency		
Terminal complement factors	Neisseria meningitidis	
Chemotherapy-induced neutropenia ("fever and neutropenia), usually hospital-acquired	Staphylococci, viridans streptococci, Gram-negative rods, including Pseudomonas aeruginosa, fungi	(piperacillin/tazobactam or cefepime or ceftazidime or meropenem) + aminoglycoside + vancomycin* - if persistently febrile after 4 days, add antifungal agent, such as voriconazole
Transplant: See Table 1		
Bone Marrow - These should be considered according to the following categories: donor-derived, recipient-derived and reactivated, nosocomial, and community-acquired, and in the time periods after tranplanation: < 1 month, 1 month - 100 days, and > 100 days. **In addition to a wide range of bacteria associated with neutropenia (see above) these patients are at risk for infection with the following organisms:**		
	Adenovirus	Consider cidofovir
	Cytomegalovirus	Gancyclovir, foscarnet
	Herpes simplex virus	Acyclovir
	Human herpex virus 6	Consider gancyclovir, foscarnet
Fungi	Candida	Fluconazole, echinocandins, amphotericin B
	Aspergillus	Voriconazole, amphotericin B
	Zygomycetes	Posaconazole, amphotericin B
	Pneumocystis jirovecii	Trimethoprim/sulfamethoxazle, clindamycin + primaquine%, atovaquone, pentamidine
%glucose-6-phosphate dehydrogenase deficiency should be excluded before primaquine is used.		
Solid organ (see Fishman JA) – These should be considered in the following categories: donor-derived, recipient-derived and reactivated, nosocomial, and community - acquired, and in the following time periods after transplantation: < 1 month, 1-6 months, and > 6 months.		
Cystic fibrosis: pneumonia		
	Staphylococcus aureus	Clindamycin or vancomycin*
	Pseudomonas aeruginosa	Piperacillin, cefazidime, tobramycin, amikacin, meropenem, ciprofloxacin

	Burkholderia cepacia	Meropenem, trimethoprim/sulfamethoxazole, ticarcillin/clavulante, minocycline
Iron overload (hemochromatosis, repeated blood transfusions):		
	Yersina enterocolitica, some other Gram-negative rod infections, zygomycetes	Ceftriaxone
	Vibrio vulnificus (specific exposure)	((ceftazidime or cefotaxime) + doxycycline) or ciprofloxacin
Nephrotic syndrome: bacteremia, primary peritonitis	Streptococcus pneumoniae, Gram-negative rods	Ceftriaxone
Liver disease with ascites: bacteremia, primary peritonitis		
	Streptococcus pneumonia, Gram-negative rods	Ceftriaxone
	Vibrio vulnificus (specific exposure)	((ceftazidime or cefotaxime) + doxycycline) or ciprofloxacin
SPECIFIC INFECTION SYNDROMES		
Anthrax		Consult infectious diseases specialist
Cat scratch disease		Azithromycin, trimethoprim/sulfamethoxazole
Hantavirus pulmonary syndrome		Supportive
Infectious mononucleosis, normal host:		
	Epstein-Barr virus	No treatment
	Cytomegalovirus	No treatment
	Toxoplasmosis	No treatment
	HIV	Consult specialist
Influenza (see pneumonia)		
Leptospirosis		Doxycycline, penicillin, macrolide
Malaria		
Falciparum:	Severe (>5% parasitemia, evidence of organ dysfunction)	Quinidine intravenously or artesunate intravenously (contact CDC malaria hotline: 770-488-7788, after hours 770-488-7100, ask for Dr on call for malaria.) See dosages in Table 3.
	Not severe, acquired in area of chloroquine resistance	Quinine (orally) or atovoquone/proguanil (orally)
	Not severe, acquired in area of chloroquine susceptibility	Chloroquine (orally)
Non-falciparum		Chloroquine (orally)
Unknown species		As for falciparum
Rickettsial and Ehrlichial Infection (Rocky Mountain spotted fever and Ehrlichiosis)		Doxycycline (irrespective of age)
Tuberculosis		Consult infectious diseases specialist
Varicella		Acyclovir
Viral hemorrhagic fever		Contact CDC (770-488-7100)

HOSPITAL –ACQUIRED INFECTIONS	
Patients who develop infection while in the hospital are at risk for infection caused by organisms resistant to many antimicrobial agents because such organisms are often endemic in hospitals (due to selective pressure from widespread usage) and the fact that patient might have already received antimicrobial therapy. One should assume that an infection developing in a patient who has recently received a particular agent is resistant to that agent. In choosing an antimicrobial agent, one should be guided by the local (within the particular unit) epidemiology of organisms and their antimicrobial susceptibility patterns.	
Ventilator-associated pneumonia	Gram-negative rods (Pseudomonas aeruginosa, Enterobacteriaceae) Staphylococus aureus, Candida spp.
Vascular-catheter infections	Staphylococci, Candida spp., enterococcus, Gram-negative rods
Urinary tract infections	Gram-negative rods, enterococcus, Candida spp.
Surgical wound infections	Staphylococcus aureus, Gram-negative rods

*In areas where methicillin-resistant Staphylococcus aureus (MRSA) is prevalent (most of USA) patients with severe infections presumed to be caused by this organism should be treated with vancomycin. If cultures demonstrate susceptibility to methicillin, then nafcillin, oxacillin or cefazolin can be used. (see Staphylococcus aureus table 1)