Table II 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 [1, 2]
	Other gram-negative rods	Cefotaxime [1, 2]
	Listeria monocytogenes	Ampicillin +/- gentamicin
	Herpes simplex virus	Acyclovir
	Enterovirus	None
[1] For gram-negative rod Sepsis, gentamicin is appropriate, but for meningitis, cefotaxime should be used.		
[2] 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.		
In addition to cultures of blood, CSF, and urine for bacteria, HSV DNA PCR should be performed on blood and CSF.		
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[3]
	Gram-negative rods	See above for sepsis
Empiric therapy:Vancomycin or nafcillin[3] + cefotaxime.		
[3]See comment in Table 1 about Staphylococcus aureus resistance to methicillin.		
NECROTIZING ENTEROCOLITIS	Gram-negative rods, anaerobes	(Cefotaxime or gentamicin) + metronidazole or meropenem alone[4]
[4]Meropenem is very active against most gram-negative rods and anaerobes, so it can be used alone.		
OMPHALITIS	Staphylococcus aureus	Vancomycin or nafcillin[3]
	Gram-negative rods	Gentamicin
	Anaerobes	Metronidazole
Empiric therapy should be active against all these pathogens		

CONJUNCTIVITIS	Neisseria gonorrhoeae	Ceftriaxone
	Chlamydia trachomatis	Azithromycin or erythromycin (orally)
	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[5]	Cefotaxime or ceftriaxone
	Staphylococcus aureus	Vancomycin or nafcillin[3]
	Salmonella spp.	Ceftriaxone or cefotaxime
[5]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 isused.		
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[3]) + clindamycin[6] +/- intravenous gamma globulin (IVIG)
[6]clindamycin is added for its ability to inhibit toxin production.		
NERVOUS SYSTEM INFECTIONS		
Meningitis	Streptococcus pneumonia	(Ceftriaxone or cefotaxime) + vancomycin[7]
	Haemophilus influenzae type b[5]	Cefotaxime or ceftriaxone
	Neisseria meningitidis	Penicillin, ceftriaxone
[7] 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	Doxycycline
	Bartonella henselae	Doxycycline
	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	Clostridium tetani	Supportive, tetanus immune globulin + (metronidazole or penicillin)
Botulism	Clostridium botulinum	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
Diphtheria	Corynebacterium diphtheriae	Diphtheria antitoxin + (erythromycin or penicillin)
Acute Otitis Media	Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis	Amoxicillin, amoxicillin/ clavulanate, cefdinir, cefpodoxime
Mastoiditis	Streptococcus pneumoniae, Streptococcus pyogenes, Staphylococcus aureus	(Ceftriaxone or cefotaxime) + (clindamycin or vancomycin[3])
Sinusitis	Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis	Amoxicillin, amoxicillin/ clavulanate, cefdinir, cefpodoxime
Retropharyngeal Abscess	Staphylococcus aureus, anaerobes, oral Gram-negative rods	(Ceftriaxone or cefotaxime) + (clindamycin or vancomycin)[3] or ampicillin/sulbactam[8]

[8]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, Staphylococcus aureus, other gram-negative rods	Ceftriaxone or cefotaxime[3]
Acute Laryngotracheo bronchitis	Respiratory viruses (parainfluenza-, respiratory syncytial-, adeno-, influenza viruses	No antimicrobial therapy
Bacterial tracheitis	Staphylococcus aureus, Streptococcus pyogenes	Vancomycin or nafcillin[3]
LOWER RESPIRATORY TRACT:		

Bronchiolitis	Respiratory viruses (respiratory syncytial, parainfluenza virus	No antimicrobial therapy
Pertussis		Macrolide
Pneumonia	Respiratory viruses (respiratory syncytial virus, parainfluenza virus, adenovirus, meta pneumovirus)	None
	Influenza viruses	Oseltamivir, zanamivir [9]
[9]Check current recommendations, from sources such as the CDC (www.cdc.gov).		
	Streptococcus pneumoniae	Ceftriaxone (ampicillin for uncomplicated infection)
	Staphylococcus aureus	Vancomycin or nafcillin[3], linezolid, clindamycin for less severe cases; (daptomycin should NOT be used for patients with pneumonia)
	Mycoplasma pneumoniae	Macrolide, doxycycline[10], fluoroquinolone
	Chlamydophila pneumoniae	Macrolide, doxycycline[10]
[10]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 or doxycycline) +/- treatment active against Staphylococcus aureus.		

Empyema	Staphylococcus aureus, Streptococcus pneumoniae	(Ceftriaxone or cefotaxime) + vancomycin[3]
Nosocomial and Ventilator-associated pneumonia		See 'Hospital-Acquired Infections' below
SKIN and SOFT TISSUE INFECTIONS		
Cellulitis	Staphylococcus aureus, Streptococcus pyogenes	Clindamycin or nafcillin[3], (vancomycin for severe infections)
Fasciitis, Myositis	Staphylococcus aureus, Streptococcus pyogenes	Vancomycin or nafcillin[3] +/- clindamycin (see toxic shock syndrome above); if perineal, consider gram-negative rod and anaerobes, and add piperacillin/ tazobactam or meropenem.
Wound[11]	Staphylococcus aureus, Streptococcus pyogenes	See skin infections above – if contaminated or perineal – consider gram-negative rods and anaerobes and add piperacillin/tazobactam or meropenem
[11]Susceptibility to tetanus should be determined, and appropriate management given		
Gas gangrene	Clostridium perfringens, other histotoxic clostridia	Meropenem + surgery

Burn[11]	Staphylococcus aureus, Pseudomonas aeruginosa	(Vancomycin or clindamycin or nafcillin[3]) + (ceftazidime or piperacillin/tazobactam or aminoglycoside)
Ecthyma gangrenosum	Pseudomonas aeruginosa, other gram-negative rods, Aspergillus spp., Zygomycetes	(Ceftazidime or piperacillin/ tazobactam) +/- (posaconazole or amphotericin B). **A biopsy should be performed urgently.**
Bites:[11], [12]		
Human[13]	Staphylococcus aureus, Streptococcus pyogenes, oral gram-negative rods, anaerobes	(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) +/- (Clindamycin or 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 + bacteria	Acyclovir + ampicillin/sulbactam
Snake	Staphylococcus aureus, E. coli	Ampicillin/sulbactam
[12]In cases of animal bites, the potential for rabies exposure should be evaluated, and, if indicated, post-exposure management with rabies immune globulin and rabies vaccine given.		
[13]Risk for transmission of HIV, hepatitis B and hepatitis C should be determined.		
SKELETAL INFECTIONS		
Osteomyelitis and septic arthritis	Staphylococcus aureus, Streptococcus pyogenes, Kingella kingae	(Clindamycin or vancomycin) +/- ceftriaxone
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, or ticarcillin/clavulanic acid alone OR ceftriaxone, cefotaxime, ceftazidime, cefepime, ciprofloxacin or levofloxacin each with metronidazole OR gentamicin + Aminoglycoside + 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); azithromycin; fluoroquinolone
	Campylobacter	Azithromycin, ciprofloxacin
	Yersinia enterocolitica	If bacteremia suspected: ceftriaxone, trimethoprim/sulfamethoxazole, fluoroquinolone
	Clostridium difficile	Metronidazole (orally or parenterally) or vancomycin (only orally)
	Cholera (Vibrio cholerae)	Azithromycin, ciprofloxacin, doxycycline
	E. coli: traveler's diarrhea	Ciprofloxacin, azithromycin
Protozoal:	Giardia intestinalis	Metronidazole or tinidazole
	Entamoeba histolytica	Metronidazole or tinidazole
	Cryptosporidium hominis	Nitazoxanide
	Cyclospora cayetanensis	Trimethoprim/sulfamethoxazole
	Cystoisospora 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	Ganciclovir

GENITAL INFECTIONS:

Pelvic inflammatory disease	Neisseria gonorrhoeae, Chlamydia trachomatis, gram-negative rods, anaerobes	(Cefoxitin or cefotetan) + doxycycline

CARDIOVASCULAR INFECTIONS

Infective endocarditis (see Baddour LM et al.):	It is essential that three separate blood cultures be taken before therapy is initiated.	
Native heart	Staphylococcus aureus, streptococci, enterococci, "HACEK" group of gram-negative rods[14]	Vancomycin + gentamicin +/- ceftriaxone
[14]Haemophilus spp., Aggregatibacter spp., 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 + (cefepime or ceftazidime) +/- rifampin (if prosthetic material)
	Associated with intravenous drug abuse: Staphylococci aureus, gram-negative rods	Vancomycin + gentamicin + ceftazidime
	Fungal	Amphotericin B +/- flucytosine
Pericarditis	Staphylococcus aureus, Haemophilus influenzae, Streptococcus pneumoniae, Neisseria meningitidis	Vancomycin + ceftriaxone
Myocarditis	Usually virus	
Septic jugular thrombophlebitis (Lemierre's syndomre)	Fusobacterium necrophorum, other anaerobes, Staphylococcus aureus	Metronidazole, ampicillin/ sulbactam[3]
EYE:		
Conjunctivitis	Adenovirus, Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis	Topical polymyxin/trimethoprim 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)[3]
ABNORMAL HOST:		

HIV/AIDS:		
Pneumonia	Same causes as in non HIV-infected children of same age + Pneumocystis jiroveci, cytomegalovirus, Mycobacterium tuberculosis	Ceftriaxone + trimethoprim/ sulfamethoxazole
Bacteremia	Same causes as in non HIV-infected children of same age + Neisseria meningitidis, 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/ doxycycline
Osteomyelitis	Staphylococcus aureus, Salmonella – try to obtain organism	(Clindamycin or vancomycin[3]) + 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 jiroveci	
Complement deficiency		
Terminal complement factors	Neisseria meningitidis	
Neutropenia (chemotherapy or BMT–induced neutropenia) ("fever and neutropenia), usually hospital-acquired")	Staphylococci, viridans streptococci, gram-negative rods, including Pseudomonas aeruginosa, fungi	(Piperacillin/tazobactam or cefepime or meropenem) +/- aminoglycoside +/- vancomycin[3]; 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 transplantation: < 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:

Viruses	Adenovirus	Consider cidofovir
	Cytomegalovirus	Ganciclovir, foscarnet, cidofovir
	Herpes simplex virus	Acyclovir
	Human herpes virus 6	Consider ganciclovir, foscarnet
Fungi	Candida	Echinocandins, fluconazole, voriconazole, amphotericin B
	Aspergillus	Voriconazole, amphotericin B
	Mucorales (Zygomycetes)	Amphotericin B, posaconazole,
	Pneumocystis jiroveci	Trimethoprim/sulfamethoxazole, atovaquone, pentamidine, clindamycin + primaquine[14]
[14] Glucose-6-phosphate dehydrogenase deficiency and pregnancy should be excluded before primaquine is used.		
Solid organ: 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[3]
	Pseudomonas aeruginosa	Piperacillin/tazobactam, ceftazidime, tobramycin, amikacin, meropenem, ciprofloxacin
	Burkholderia cepacia	Meropenem, trimethoprim/ sulfamethoxazole, ticarcillin/ clavulanate, minocycline
Iron overload (hemochromatosis, repeated blood transfusions):	Yersinia enterocolitica, some other gram-negative rod infections, Mucorales (zygomycetes)	Ceftriaxone
	Vibrio vulnificus (specific exposure)	(Ceftriaxone + 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 Vibrio vulnificus (specific exposure)	(Ceftriaxone, ceftazidime or cefotaxime) + doxycycline; 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 atovaquone/ proguanil (orally)
	Not severe, acquired in area of chloroquine susceptibility	Chloroquine (orally)
Non-falciparum		Chloroquine (orally); radical cure: primaquine[14]
[14] Exclude pregnancy and G6PD deficiency		Primaquine[14]
Unknown species		As for falciparum
Rickettsial and Ehrlichial infection (Rocky Mountain spotted fever, and Ehrlichiosis and Anaplasmosis)		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) Staphylococcus 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

[3]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)
BMT = bone marrow transplant