

the lung and normal host defenses are not able to clear the inoculum; bacterial replication leads to a lower respiratory tract infection.

Transmission of Respiratory Pathogens

Some pathogens are transmitted from person to person by droplet transmission. Droplets are created when a person coughs, sneezes, or talks. Transmission can occur during medical procedures such as suctioning, endotracheal intubation, cardiopulmonary resuscitation, or cough-producing procedures. The greatest distance of transmission is unresolved. Historically, a distance of 3 feet or less was assumed for person-to-person droplet transmission. Some data suggest that transmission may occur from as far away as 6 feet. Respiratory droplets have also been defined by their size, usually greater than 5 μm in diameter.

Crowding, as occurs in prisons, barracks, and shelters, is associated with increased spread. Pathogens that are transmitted by the droplet route include *Streptococcus pneumoniae*, *Mycoplasma pneumoniae*, and influenza virus.

Infectious agents such as *Mycobacterium tuberculosis*, fungi, and anthrax spores are airborne. Microorganisms transmitted in this fashion can be spread over long distances (>6 feet) by air currents and normal airflow. The size of the droplet nuclei particles that are transmitted by the airborne route are usually 5 μm or less in diameter.

Etiologic Agents

Many bacteria and viruses cause pneumonia. *S. pneumoniae* (i.e., pneumococcus) is the most common, and the classic description of pneumonia is based on disease caused by pneumococci. Most cases of pneumococcal pneumonia occur between December and April. Pneumococci transiently colonize the upper respiratory tract. Microaspiration leads to entry into the lower respiratory tract. If aspirated in sufficient quantity so that normal host defenses do not clear the bacteria, the patient develops pneumonia. Pneumococci have a polysaccharide capsule that prevents phagocytosis. Antibodies against the polysaccharide capsule, which are acquired from prior exposure or vaccination, opsonize pneumococci, enabling phagocytosis.

Other bacteria that can colonize the oropharynx and cause pneumonia when aspirated include *Haemophilus influenzae*, less commonly *Staphylococcus aureus*, and rarely *Streptococcus pyogenes* (i.e., group A β -hemolytic streptococcal infection). Similarly, *Moraxella catarrhalis* in patients with chronic obstructive pulmonary disease and in the elderly and *Klebsiella pneumoniae* in alcoholics colonize the oropharynx and cause pneumonia. Most cases of community-acquired pneumonia are monomicrobial.

Patients with pneumococcal pneumonia can develop infections at other sites, including empyema, pericarditis, meningitis, endocarditis, and septic arthritis. Approximately one of five patients with pneumococcal pneumonia has bacteremia.

M. pneumoniae usually causes milder disease. Its peak incidence is during the first 2 decades of life. Patients usually do not require hospitalization, but some develop severe disease.

Chlamydia pneumoniae (formerly called *Chlamydia pneumoniae*) is a common cause of community-acquired pneumonia. It usually causes a milder disease and is seen more commonly among patients treated in the outpatient setting.

Legionella, an environmental organism, can cause pneumonia. *Legionella pneumophila* is the most common species of pneumonia, but *Legionella micdadei* and *Legionella bozemanii* can also cause pneumonia. Most cases are sporadic. Outbreaks have occurred from contaminated point sources such as cooling towers and air conditioning units. Transmission usually occurs through inhalation of aerosol particles; microaspiration of water containing *Legionella* has also occurred.

Infrequently, *S. aureus* causes bacterial pneumonia, sometimes as a complication of influenza infection. Community-acquired methicillin-resistant strains (MRSA) have caused secondary bacterial pneumonias.

Viruses, particularly influenza viruses, cause a minority of pneumonias in adults. Patients with influenza are at risk for secondary bacterial pneumonia, most commonly due to *S. pneumoniae*, *H. influenzae*, or *S. aureus*. Respiratory syncytial virus (RSV), a pathogen that usually infects children, has been found more frequently as a cause of pneumonia among the elderly. Adenovirus rarely causes pneumonia in young adults. During 2003, the severe acute respiratory syndrome (SARS) virus emerged in Guangdong Province in southern China, and after initial international spread, it was contained. In 2012, the Middle East respiratory syndrome coronavirus (MERS-CoV) emerged as a cause of severe pneumonia. Most cases occurred in the Middle East.

Viruses such as the influenza viruses predispose patients to secondary bacterial pneumonia. Influenza infection may damage the respiratory epithelium, and resulting dysfunctional innate immune responses enhance susceptibility to secondary bacterial infection.

Fungi that cause pneumonia are not part of the normal flora. Certain dimorphic fungi (e.g., *Histoplasma capsulatum*, *Blastomyces dermatitidis*, and *Coccidioides immitis*) that reside in the soil cause pneumonia when they are inhaled. Dimorphic fungi form hyphae at ambient temperatures and yeasts at body temperature. The hyphal form is the transmissible form of the fungus. The yeast form is not transmissible from person to person.

These fungi are limited to certain geographic areas: *H. capsulatum* in the Mississippi, Missouri, and Ohio River valleys; *B. dermatitidis* in Southern states bordering the Mississippi and Ohio River basins and Midwestern states bordering the great lakes; and *C. immitis* in the Southwestern United States. *H. capsulatum*, *B. dermatitidis*, and *C. immitis* cause disease in the normal host. *Aspergillus*, a mold, is ubiquitous in the environment; it rarely causes disease in the immunocompetent host. Patients who are immunocompromised or have abnormal airways are at risk for infection with *Aspergillus* but rarely with other molds such as *Zygomycetes* species (Mucorales order), which do have a predisposition for infecting patients with diabetes mellitus.

M. tuberculosis is not part of the normal flora. It is transmitted by small aerosol particles (<5 μm) that are inhaled directly into the alveolus. *M. tuberculosis* is a slow-growing organism that usually causes chronic symptoms; however, it rarely can manifest acutely. Patients with HIV infection, those treated with biologic agents such as tumor necrosis factor (TNF) inhibitors, and the very young and old are particularly susceptible.

The normal flora of an acutely ill hospitalized patient is different from that of a healthy outpatient. Hospitalized patients are

