

Chapter 13 – Microbe-Human Interactions: Infection, Disease, and Epidemiology*

*Lecture notes are to be used as a **study guide** only and *do not* represent the comprehensive information you will need to know for the exams.

Important Terminology

Infection – A condition in which pathogenic organisms penetrate the host defenses, enter the tissues, and multiply.

Disease is any change from the general state of good health when the cumulative effects of the infection disrupt or damage tissues and organs. For the sake of this course, infectious diseases will be studied as opposed to genetic, physiological diseases or diseases caused by nutritional problems.

Normal flora – A diverse group of microbes (mostly bacteria) adapted to live in the human body and on the skin surface. Many of the normal flora of the large intestine (*E.coli* for example) are actually very beneficial to us and our relationship with them can be characterized as mutualistic symbiosis. However, *S. aureus* that typically colonizes the skin can be dangerous if allowed to grow systemically. (Table 13.1, pg. 389; Table 13.3, pg. 390)

Symbiosis is a relationship in which two organisms interact in close association usually with benefits to both species. We give *E.coli* a place to live and food, while the *E.coli* gives us protection against pathogens and a significant source of vitamin K.

Parasitism is the opposite of a mutualistic relationship: One organism benefits (parasite) and one suffers (host). When *S. aureus* is growing systemically in a human, the bacteria are getting food and a place to grow, while we aren't getting anything in return, and worse, are being harmed by the exotoxins and exoenzymes the bacteria produce. An ideal parasite is one that can enter a host, survive and reproduce in large numbers, and then move on to a new host.

Pathogenicity is the ability of a parasite to gain entry to host tissues and cause disease. Organisms that can cause disease are referred to as **pathogens**.

Opportunistic pathogen is one that invades the tissues when body defenses are suppressed. They might be part of the normal flora, but become capable of causing disease under certain circumstances such as when someone has AIDS, is taking immunosuppressant drugs, or suffers a superinfection as a result of antibiotic therapy.

True pathogen – also known as **primary pathogens**, these infectious microorganisms are capable of causing infection and disease *in healthy persons* with normal immune defenses. They are generally associated with a distinct recognizable disease (e.g. *Mycobacterium tuberculosis* = tuberculosis).

Virulence¹ - the *degree* of pathogenicity of a parasite; ranges from weak to potent (e.g. Rhinovirus – a common cold virus – is mild and non-fatal, but Ebola virus is nearly 100% fatal.)

A **virulence factor** is any trait that a microbe has that gives it the ability to cause disease; e.g. mechanisms of adhesion (such as fimbria, capsules, flagella), exotoxins, endotoxins, and exoenzymes.

Avirulent – microorganisms that are avirulent do not cause disease.

13.1 We Are Not Alone

Human-microbe interactions can vary from a stable interaction to one where microbes can cause disease. There are locations on the body where microbes are normally present and offer a level of protection for humans, and there are locations on the body where microbes are absent.

Contact, Colonization, Infection, Disease

When microbes have a mutual or commensal relationship with humans, the microbes are called **normal resident microbiota**. When microbes penetrate the host defense systems an **infection** can occur, and the microbe is considered a **pathogen** that causes an **infectious disease** (Fig. 13.1).

Resident Microbiota: The Human as a Habitat

There are locations in the body that are colonized by microbes (table 13.1), and there are locations in the body that are microbe-free (table 13.2). Most microbes that come into contact with the human body for short periods of time, and usually can be easily removed are called **transients**. Microbes that are normally part of the body are called **residents**. When “good” microbes on the body help prevent other microbes from colonizing, this is called **microbial antagonism**. Normal microbial residents are very beneficial to the host as long as the host has a healthy functioning immune system.

Initial Colonization of the Newborn

The womb is generally sterile, and the infant begins colonization upon the physical act of birth. During the first few hours and days of life infants are colonized through various exposure events (Fig. 13.2). Breast-fed babies establish a more supportive microbial colonization as opposed to bottle-fed babies.

¹ The Center for Disease Control and Prevention (CDC) categorizes microorganisms based on their degree of pathogenicity (class 1 = not considered to cause disease through class 4 = high risk microbes).and the relative danger involved in handling them – for which labs are rated based on their biosafety level. (Table 13.B, pg. 392):

Indigenous Microbiota of Specific Regions

There are a variety of microbes, such as bacteria, fungi, and viruses that normally colonize the human hosts (table 13.3).

Colonizers of the Human Skin

Skin is a complex tissue (fig. 13.3a).

1. **epidermis** – outermost layers of mostly dead epithelial cells continuously sloughs off to be replaced by new living epithelial cells immediately below.
2. **dermis** - second layer of skin cells; penetrated by nerves, blood vessels and lymphatic vessels.
3. **subcutaneous tissue** - layer of connective tissue and adipose tissue found beneath the skin.

Found throughout the dermis are **sweat glands** and **hair follicles** surrounded by the oil producing **sebaceous glands**. These openings are a potential portal through which bacteria might reach deeper tissues.

There are two cutaneous populations on the skin: **transients**, that are picked up throughout the day, and can be easily washed off; and residents, that are deeply embedded in the folds of the skin and are not easily removed (Fig. 13.3b). See also **13.1 Secret World of Microbes**.

The secretions of the sweat glands and sebaceous glands supply water and nutrients to microorganisms colonizing the skin. A HUGE normal flora population colonizes the entire surface of the body. The thriving normal flora occupies niches that might otherwise be inhabited by more pathogenic strains. The predominant organisms are bacteria and fungi: *Staphylococcus*, *Corynebacterium*; *Candida*. Which organisms are where depends on the anatomical site. *Staphylococcus* on skin surface; enteric bacteria on the perineum (the skin area between the anus and genitals). Numbers also vary: **$10^2/\text{cm}^2$ of dry skin to $10^7/\text{cm}^2$ in moist areas.**

Microbial Residents of the Gastrointestinal Tract

The Gastrointestinal Tract (Fig 13.4)

The gastrointestinal tract is sterile at birth, but microbial flora become established shortly thereafter.

Microbiota of the Mouth

The oral cavity contains streptococci, veillonellae, actinomycetes, spirochetes, fungi and protozoa. The microorganisms survive on food particles that adhere to teeth and gums and soluble materials in saliva. There are approximately 5×10^9 bacteria per milliliter of saliva; for this reason a bite from a human is considered an emergency. Anaerobes can colonize the space between teeth and gums where oxygen is relatively absent. The pharynx (throat) also has a normal flora population.

Microbiota of the Large Intestine

The upper GI (stomach², esophagus) contains few bacteria, generally whatever is on the food just eaten. The stomach contains 0.2% HCl and pepsin (protein-digesting enzyme). Potential pathogens in food or drink are normally digested away. Failure to produce stomach acid or neutralization of acid (e.g. antacids: Roloids, milk) can decrease defense mechanisms.

The duodenum of small intestine contains mostly lactobacilli and enterococci. Jejunum contains coliforms³ and anaerobic bacteria. The ileum contains predominantly G- bacteria, plus yeasts and anaerobic bacteria (coliforms, *Bacteroides*, *Eubacterium* and *Bifidobacteria*).

The large intestine contains the largest numbers of bacteria. Bacteria actually make up 20-60% of the mass of feces. Flora includes *Bacteroides*, *Bifidobacteria*, lactobacilli, coliforms, clostridia, streptococci, and yeasts.

Bacterial count = 10^{11} cells/gm of feces.

Typically, the normal flora is considered as beneficial for humans since these “good bacteria” protect the host by competing with pathogens for space and nutrients. Furthermore, the normal flora of the large intestine produce several important vitamins (vitamin K, B₁₂, riboflavin (B₂), pyridoxine (B₆), and thiamine) by metabolizing waste materials in feces.

Inhabitants of the Respiratory Tract

Respiratory Tract & Eyes (fig.13.5)

Tears contain an enzyme called **lysozyme** which digests peptidoglycan (bacteria cell walls).

The sinuses and the eustachian tube drain into the back of the nose. The tonsils and adenoids are located in nasopharynx (where the nose joins the throat). Tonsils and adenoids are important in the production of immunity, but can also be a site of infection. Continuously beating cilia line the nasal cavity, the middle ear, and the sinus cavity. These and a film of mucus produced by mucous membranes propel organisms out of the nose and throat. Mucous membranes also secrete antibodies in the mucus.

The upper respiratory tract (trachea) also has ciliated cells and mucus secretions that sweep upward from the bronchioles and bronchi. Phlegm is usually swallowed and enters the acidic stomach.

Normal microbial flora consists mainly of bacteria: staphylococci, streptococci, diphtheroids, actinomycetes, G- cocci, coccobacilli, and fungi: aspergilli, yeasts and zygomycetes. The normal flora keeps potential pathogens from colonizing a region. Certain indigenous streptococci inhibit the growth of Group A streptococci and protect the host from pharyngotonsillitis.

The lower respiratory tract (below the level of the trachea) is considered free of microbial flora. If any microbes were to colonize and grow in the bronchioles or alveoli, pneumonia would result.

² One notable exception is the presence of *Helicobacter pylori* in the stomach of some individuals.

³ **coliform** – Gram negative, facultative anaerobic, and lactose-fermenting microbes.

Microbiota of the Genitourinary Tract

The Urogenital Tract (fig.13.6)

Urination keeps the urinary tract cleared of pathogens in most cases, but not always in women (the urethra is much shorter). Urine is essentially sterile. Bacteria that colonize the anterior urethra (staphylococci, diphtheroids, gamma hemolytic streptococci, and lactobacilli) may reach the bladder and cause a **urinary tract infection (UTI)**. From there the infection may spread. Diagnosis is generally based on numbers of bacteria in urine (100,000 or 10^5 or more bacteria/ml). **50-80% of all UTI infections are caused by *E. coli***, but mixed infections have been reported.

Lactobacilli colonize the vagina and cervix shortly after birth because the mother's progesterone production (hormone which maintains pregnancy) promotes the multiplication of the bacteria in the daughter. After birth, lactobacilli numbers decrease and the pH in the vagina becomes alkaline. During this time, diphtheroids, enterococci and anaerobes predominate. Hormonal changes at puberty cause lactobacilli to reappear and become the predominant organism. They consume nutrients from vaginal secretions (e.g. glycogen) and release acids, maintaining a low pH. This inhibits other bacteria and keeps pathogens under control (e.g. yeast = *Candida albicans*). Reduced lactobacilli counts can result from overuse of antibiotics and lead to *Candida* superinfection (i.e. a yeast infection).

Many microorganisms are transmitted between people during sexual intercourse. Table 13.5 lists the major types of sexually transmitted diseases (STDs) and the estimated number of new cases per year in the U.S.

Maintenance of the Normal Microbiota

Lifestyle, medications and diseases can change the normal microbiota of a person. A growing trend is to use **probiotics** to maintain a normal gut-microbe balance.

13.2 Major Factors in the Development of an Infection

The sequence of an infection is diagrammed in Figure 13.7. Pathogenic organisms have the opportunity to cause disease. A **true pathogen** can cause disease in healthy people, and an **opportunistic pathogen** can cause disease in an immune-compromised person (Fig. 13.4 and Table 13.4). The severity of a microbe is dependent on its **virulence**, its degree of pathogenicity, which is its ability to invade the host and cause damage. Any characteristic or structure of the microbe that damages the host's tissues is called a **virulence factor**.

Becoming Established Phase One – Portals of Entry

Resistance to disease involves a broad range of factors including: immune system health, nutrition, fatigue, age, sex, and even climate. Before a parasite can cause a disease, it must gain entry to the host in sufficient numbers to establish a population (fig. 13.1). Mechanical and Chemical Barriers: Skin, respiratory, digestive and urogenital tracts are all external barriers to bacterial invasion.

Portal of entry refers to the site at which the parasite enters the host (Fig. 13.8). *Clostridium tetani* spores can cause tetanus when introduced into anaerobic tissue in a wound but won't cause an infection in the intestine should you ingest them. Certain parasites have multiple portals of entry (*M. tuberculosis* may enter the body by respiratory droplets, contaminated food and milk, and skin wounds.).

The source of the infectious agent can be **exogenous**, from outside the host's normal flora, and/or **endogenous**, from the host's own normal flora.

Infectious Agents That Enter the Skin

Infectious agents can enter the skin through cuts, nicks, wounds, and burns, such as *Staphylococcus aureus*. Other infectious agents can create their own entry through the skin by the use of digestive enzymes. Some enter through bites of insects and other animals, through the use of needles, and the eyes.

The Gastrointestinal Tract as Portal

Pathogens usually enter through ingestion of food and drinks. Enteric pathogens can survive digestive enzymes and pH changes. Bacteria such as *Salmonella*, *Shigella*, and *Vibrio*; Viruses; and enteric protozoans, such as *Giardia*, can be enteric pathogens.

The Respiratory Portal of Entry

The oral and nasal cavities are the most likely sites of entry for the respiratory system. These anatomical locations are lined by mucous membranes which can carry microbes deeper into the respiratory system. Infectious agents can infect the upper respiratory and lower respiratory tracts.

Urogenital Portals of Entry

This is a portal of entry for infectious agents that are transmitted by sexual contact. These diseases are called **sexually transmitted infections (STI) or sexually transmitted diseases (STD)**. See table 13.5.

Pathogens That Infect During Pregnancy and Birth

Ordinarily, the placenta is an effective barrier against microorganisms in the maternal circulation (fig. 13.9). However, some bacteria such as *Treponema pallidum* (syphilis) and the protozoan *Toxoplasma gondii* (toxoplasmosis) can cross. Many viruses are also capable of crossing the placenta. Perinatal infections (caused when the child is contaminated by the birth canal) and infections of the fetus *in utero* are grouped together in a cluster known as **STORCH**. STORCH is an acronym for: **s**yphilis, **t**oxoplasmosis, **o**ther diseases (hepatitis B, HIV, and chlamydia), **r**ubella, **c**ytomegalovirus, and **h**erpes simplex virus.

The Requirement for an Infectious Dose

Infectious dose (ID) refers to the number of parasites that must be taken into the body in order for disease to be established. (Table 13.6). Examples: Ingesting 100 million cholera bacilli in contaminated water will probably lead to disease, but only 10,000 typhoid bacilli need be ingested. Approximately 1000 *N. gonorrhoeae* cells can lead to gonorrhea, but only 10 *Mycobacterium tuberculosis* cells can lead to tuberculosis; even worse, only 1 bacterium of *Coxiella burnetii* can lead to Q fever, and for certain viruses (measles) only 1 virion can lead to infection. Low doses of a parasite can result in the person developing an immunity rather than the disease.

Attaching to the Host: Phase Two

How Pathogens Attach

Adhesion is a process by which microbes gain a more stable foothold at the portal of entry. The ability of a microorganism to adhere to host tissues can determine the specificity of a pathogen for its host.

Mechanisms of adhesion include (fig. 13.10; Table 13.7):

- a. fimbria
- b. capsules
- c. “spikes” – specialized viral receptors
- d. hooks (spirochetes)
- e. flagella

Invading the Host and Becoming Established: Phase Three

The ability of a parasite to penetrate tissues and cause structural damage is called **invasiveness**. This constitutes one of the major **virulence factors** by which a parasite may cause disease. For some organisms (e.g. *B. pertussis*), penetration is not critical to disease, but the production of a toxin is.

Antiphagocytic Factors

When microbes invade the host, the host’s **phagocytes** will engulf and destroy the pathogens. Some microbes produce **antiphagocytic factors**. Species of *Streptococcus* and *Staphylococcus* make **leukocidins**, a substance that is toxic to white blood cells. Other types of antiphagocytic factors are slime layer/ capsule, and survival in the host’s cells.

Extracellular Enzymes

Many bacteria produce and secrete **exoenzymes** that break down host tissues, aiding in deeper penetration of the microbe. Exoenzymes are enzymes released by the bacteria into their surrounding environment (fig.

13.11a). These enzymes break down tissues and allow the bacteria to infiltrate deeper into the body. Examples: hyaluronidase digests hyaluronic acid, a compound that glues cells together and collagenase, which digests collagen, an important protein in connective tissue.

Bacterial Toxins: Poisonous Products

Toxins are microbial poisons that affect the establishment and course of a disease (Table 13.8, and fig. 13.12). There are 2 types: **exotoxins** and **endotoxins**.

(i) **Exotoxins** are produced primarily by G⁺ bacteria. They are protein molecules, manufactured during the metabolism of bacteria. Released by the bacteria, they dissolve in blood plasma and circulate in the blood stream until they reach some site of activity. The most lethal exotoxin known is botulinum produced by *Clostridium botulinum* (this is the “Botox” that is used in cosmetic treatments!). **Neurotoxins** interfere with the nervous system, and **enterotoxins** function on the gastrointestinal tract.

(ii) **Endotoxins** are part of the *outer cell membrane* of Gram negative bacteria and are released only upon death and disintegration of the bacteria. They are composed of **lipopolysaccharide-protein** (LPS) complexes. They produce an increase in body temperature, body weakness and aches, and general malaise. They may damage the circulatory system and cause shock. (See notes for chapter 20.)

Endotoxin shock may accompany antibiotic treatment of disease when G⁻ bacilli die and are released into the system as the bacilli disintegrate. Potentially fatal.

An **antitoxin** is an antibody produced by the body in response to the toxin. When toxin and antitoxin molecules combine with each other, the toxin is neutralized. This becomes important therapy for conditions such as botulism, tetanus or diphtheria.

A **toxoid** is an altered toxin used for immunization (DTaP vaccine contains toxoids for diphtheria and tetanus). The toxoid will not cause us harm, rather it stimulates the immune system to produce antibodies (antitoxins) that will neutralize active toxin should a person be exposed.

Effects of Infection on Organs and Body Systems

As a result of the enzymes, toxins, and other virulence factors by infectious agents, these can lead to damage and destruction of host tissue called **necrosis**. Viruses destroy their host cell by using it for their multiplication.

13.3 The Outcomes of Infection and Disease

The Stages of Clinical Infections

A disease is really a series of events that occurs during the competition between parasite and host (fig. 13.14).

1. **Period of incubation** is the time that elapses between entry of the parasite to the host and the appearance of symptoms. Incubation periods may be short (1-3 days for cholera), moderate (2 weeks for chickenpox) or long (3-6 years for leprosy). *It depends on generation time and virulence and the level of host resistance.* Location of entry may also be a determining factor (e.g. rabies: 1-2 months typically, but shorter if the bite was near the face).
2. **Period of prodromal symptoms** is the period characterized by general signs⁴ and symptoms such as nausea, fever, headache, and malaise (Table 13.9, signs and symptoms of disease).
3. **Period of invasion** is the acute stage of the disease. This is when the specific symptoms appear. Examples: the rash of scarlet fever, jaundice in hepatitis, swollen lymph nodes in bubonic plague. Symptoms include high fever and chills, dry skin and pale expression as the result of constriction of the skin's blood vessels to conserve heat.
4. **Period of decline** (fastigium) - This period may be preceded by a crisis period after which recovery is often rapid. Sweating is common and the body releases excessive amounts of heat, normal skin color returns.
5. **Period of convalescence** is the period during which the body systems return to "normal."

Patterns of Infection

Acute disease is one that develops *rapidly*, is accompanied by severe symptoms, comes to a climax and then fades rather quickly (cholera, yellow fever).

Chronic diseases linger for long periods of time. The symptoms are slower to develop, a climax is rarely reached, and convalescence may continue for several months (mononucleosis, chronic fatigue syndrome). Sometimes an acute disease becomes chronic if the person has trouble clearing the parasite from the body (amebiasis).

Localized infections are those restricted to a single area of the body while **systemic infections** are those that disseminate to deeper organs and systems. For example a local *Staphylococcus* boil can develop into bacteremia. Bacteria growing in the circulatory system is called **bacteremia**. **Septicemia** is often synonymous with bacteremia, but is technically a more general term for any organism growing in the circulatory system. Fungemia, viremia and parasitemia refer to fungal, viral and parasite infections respectively. Initial **primary infections** can sometimes lead to **secondary infections** by a different microbe (e.g. chickenpox may lead to *Staphylococcus* infections of open pustules) (fig.13.15).

⁴ A **sign** is something that can be seen (like a rash) or measured objectively (like temperature). **Symptom** refers to something the person reports subjectively, like they feel tired, or dizzy.

Table 13.9 and the section of the chapter called “Signs and Symptoms of Inflammation” define many of terms used in describing infections and their results.

Signs and Symptoms: Warning Signals of Disease

When patients have a disease, it is prudent to look for **signs** and ask about **symptoms**. A sign can be observed by visual, tactile, and/or medical devices, like thermometers. Symptoms are experienced by the patient. The combination of signs and symptoms can help diagnose a disease, a **syndrome** table 13.9.

Signs and Symptoms of Inflammation

One of the first sign and symptom of a disease is **inflammation**, which is a non-specific defense response. Signs of inflammation are: **edema**, **abscesses**, and **lymphadenitis**.

Signs of Infection in the Blood

1. Changes in the normal level of white blood cells: **leukocytosis**, an increase in the number of white blood cells, and **leucopenia**, a decrease in white bold cells.
2. Presence and growth of microbes in the blood: **septicemia**, **bacteremia**, and **viremia**.
3. Presence of antibodies produced against an infectious agent.

Infections That Go Unnoticed

When a person has no obvious symptoms associated with an infectious agent, it is called **asymptomatic**, or **subclinical**. But, there may be a few signs that are associated with the infection.

The Portal of Exit: Vacating the Host

A parasite that kills its host before it can move on will die with the host; likewise, a parasite that does not have a means to move from host to host will not be successful. The portal of exit is the exit route taken by the infectious agent and varies depending on the microorganism.

Major exit portals include (fig. 13.16):

- a. respiratory expulsion – coughing and sneezing
- b. skin cell shedding
- c. urine
- d. feces
- e. blood loss via needles, wounds, or insect bites.

The Persistence of Microbes and Pathogenic Conditions

Just because the obvious signs and symptoms of a disease may subside over time, infectious agents can become “quite” and move to a condition called **persistence**, or **latency**. Some diseases leave **sequelae**, permanent trauma as a result of the infection, like arthritis as a result of Lyme disease.

13.4 Epidemiology: The Study of Disease in Populations

Epidemiology is the study of the transmission of infectious agents in human populations.

Origins and Transmission Patterns of Infectious Microbes

Reservoirs: Where Pathogens Persist

Pathogens reside in a natural habitat in the environment called its **reservoir**. Reservoirs can be humans, animals, plants, soil and water. The **source** is an individual or object from which an infection is actually acquired.

Living Reservoirs

Pathogens can be harbored and spread by **carriers**, who may or may not themselves have any signs / symptoms of the infectious agent, and thus can pass the infectious agent on to others in the population.

Types of the carrier state:

1. **Asymptomatic carrier:** are infected, but seem to be healthy (fig. 13.17a, fig. 13.17b).
 - i. *incubation carriers:* spread the infectious agent during the incubation period.
 - ii. *convalescent carriers:* recuperating patients can pass the infectious agent.
 - iii. *chronic carriers:* recovered from the infectious agent, but still harbors the pathogen.
2. **Passive carrier:** usually medical and dental personnel who must come into contact with patient body fluids. Proper hand washing and disposal of patient waste is critical to prevent passing on the infectious agent (fig. 13.17c).

ANIMALS AS RESERVOIRS AND SOURCES

Vectors are living organisms that transmit disease. **Zoonosis** (zoonotic) refers to any infection indigenous to animals that can be spread to humans (Table 13.10).

- **Mechanical vectors** transport the microbes on their legs or other body parts (example: a housefly might deposit pathogenic bacteria on food when it lands.) A mechanical vector is not infected with the pathogen; transmits the disease *indirectly*.
- **Biological vectors** are organisms that *are infected* with the pathogen, for example: a mosquito will infect a person with malaria when it draws blood. Biological vectors transmit disease *directly* by biting human hosts and exchanging blood.

Nonliving Reservoirs

Nonliving reservoirs are soil, water, air and dust. Each of these can harbor a variety of infectious agents.

The Acquisition and Transmission of Infectious Agents

Diseases associated with microbial infection are classified as communicable or non-communicable:

1. Communicable diseases are those that are transmitted among hosts. Certain communicable diseases are also described as **contagious** diseases. A contagious disease is one that passes with particular ease among hosts. By law, certain communicable diseases must be reported to the public health department (last page in book). Communicable diseases can be transferred between hosts via direct or indirect methods (fig. 13.18):

(A) Direct methods of transmission imply close or personal contact with the infected person. These include hand shaking, kissing, sexual intercourse, contact with fecal matter or body fluids, or direct contact with an infected animal. Exposure to droplets (the tiny particles of mucus expelled from the respiratory tract in a cough or sneeze) can also be a direct method.

(B) Indirect methods include consumption of contaminated food or water or contact with inanimate objects such as doorknobs, handrails, cups, etc.

2. Non-communicable diseases are singular events where the infectious agent is acquired directly from the environment and is not easily transmitted to the next host. The spores of *Clostridium tetani* cause tetanus after the person steps on an infected nail.

Patterns of Transmission in Communicable Diseases

Microbes can be transmitted along *horizontal* and *vertical* modes of transmission, direct or indirect routes (fig. 13.18).

Direct transmission: an infectious agent moves from one person to another without any interference in between.

Indirect transmission: The infectious agent is passed to an “intermediate”, then to the new host. One example of an “intermediate” is a **fomite**, an inanimate object that harbors and transmits infectious agents. Another route of transmission is the **oral-fecal route**, when food and drinks are contaminated with feces and served to the public. Air can also transmit infectious agents through sneezing and coughing (fig. 13.19).

13.5 The Work of Epidemiologists: Investigation and Surveillance

Epidemiologists track the progress of infectious agents in populations, and by law there are certain communicable diseases that must be reported called **reportable / notifiable diseases** that must be reported to the proper authorities, such as the state health department. The national government agency that is responsible for tracking infectious disease in the US is the Centers for Disease Control (CDC) headquartered in Atlanta, GA.

Epidemiological Statistics: Frequency of Cases

Prevalence – the total number of existing cases with respect to the entire population. $\text{Prevalence} = (\text{total number of cases in the population} \div \text{total number of persons in population}) \times 100 = \%$.

Incidence or Morbidity⁵ rate – is a measure of the number of new cases over a certain time period, as compared with the general healthy population. $\text{Incidence} = (\text{number of new cases} \div \text{number of healthy persons}) = \text{ratio}$. Usually reported in cases per 1000 or 100,000 people.

Example:

In a class of 50, with 5 students getting sick each week:

	Week 1	Week 2	Week 3
Number sick	0 sick	5 sick	10 sick
Prevalence	0%	$5/50 = 10\%$	$10/50 = 20\%$
Incidence	0	$5/45$ or 1 in 9	$5/40$ or 1 in 8

⁵ See Morbidity and Mortality Weekly Report: <http://www.cdc.gov/mmwr/>
published by Center for Disease Control

How disease spreads in a population is described by several terms (fig. 13.21):

Epidemic - disease that breaks out in explosive proportions in a population.

Pandemic - an epidemic that occurs worldwide (1918 influenza outbreak; AIDS).

Endemic – an disease that has a steady frequency over time in a particular geographic locale.

Sporadic – occasional cases reported at irregular intervals in random locations.

Mortality rate - total number of deaths in a population due to a certain disease.

Morbidity rate – the number of persons afflicted with infectious diseases.

Hospital Epidemiology and Nosocomial Infections

Infections acquired during a hospital stay (or during any medical procedure) is called **nosocomial infections**. Medical, surgical procedures, antibiotics, can leave a person susceptible to acquiring infectious agents (Fig. 13.22 and Table 13.11).

Universal Blood and Body Fluid Precautions

As a result of the AIDS epidemic, and other blood-borne pathogens, the CDC developed **universal precautions** to prevent the spread of HIV and other blood-borne pathogens. See Appendix B for a more detailed list of the Ups.