Chapter 7

Infectious diseases and their prevention and protection

Learning objectives

You will be able to gain proper understanding and explain:

- The three major factors for the establishment of infection and the definition of infectious diseases.
- Common infectious diseases in Cambodia and their causes, symptoms, and treatment.
- Common infectious diseases in Cambodia and workable preventive measures by taking into account the three major factors for the establishment of infection.
- Discrimination and prejudices that may occur with an infectious disease, and then develop ways to prevent them.
- The functions of how the skin and mucous membranes as well as perspiration, tears, and saliva work to prevent foreign substances from invading the body from outside.
- The types of defense mechanisms your body has to eliminate foreign substances that have invaded the body.

This chapter illustrates infectious diseases, which represent important disease control issues in countries around the world. Specifically, we will consider basic knowledge of the pathogenic mechanisms of infection, how biological defenses and immune systems protect our health against infection with pathogens, characteristics of major infectious diseases, and measures to prevent infectious diseases. Sexually transmitted diseases will be discussed in Chapter 11.

1. Definition of infectious diseases and three major factors for the establishment of infection

1) Definition of infectious diseases[1]

Infection refers to the invasion and growth of a pathogen inside or on the surface of the body of a host. A **pathogen** is a cause of infectious diseases, such as bacteria, viruses, and parasites that can produce diseases. A **host** is an entity such as a person or animal that is infected by bacteria or viruses. A disorder in vital functions of a host that results from infection is called a **symptom**, while the **manifestation of symptoms** or **onset of disease** refers to a state in which symptoms are present. Diseases that are caused in this manner are collectively referred to as **infectious diseases**.

How infection occurs can vary depending on the **time**, **place**, and **individual characteristics**. Infection requires three factors to be established, namely, **pathogens, infection routes**, and **host susceptibility** (**Figure 7.1**).

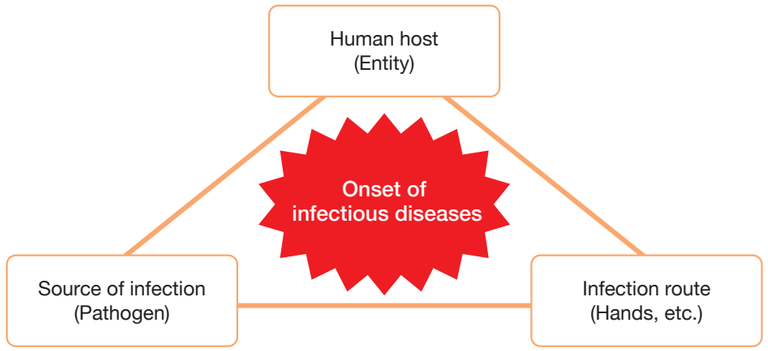

Figure 7.1 Three major factors for establishment of infection: agent, infection route, and host

2) Pathogens[2,3]

Pathogens in general are small organisms that cause diseases. As shown in **Table 7.1**, pathogens may be divided into different categories depending on their size and structure, including **viruses**, **bacteria**, **fungi**, and **parasites**, each with different characteristics and causing different infectious diseases. Other transmissible diseases include **prion diseases**, which are caused by abnormal proteins called prions.

Table 7.1 Major pathogen categories and their characteristics[3–5]

Pathogen categories	Biological classification	Characteristics	Examples
Viruses	Nonliving things Measure approx. 1–10 nm	A virus consists of nucleic acid (DNA or RNA) and protein. Viruses are incapable of self-replication; They bind to living cells and get taken up, then use those to copy themselves.	Influenza virus, Ebola virus, coronavirus, human immunodeficiency virus, hepatitis virus, rabies virus, measles virus, rubella virus, chickenpox virus, rotavirus, norovirus, adenovirus
Bacteria	Prokaryotic Approx. 1–10 μm	Bacteria do not have a nuclear membrane but do have a cell membrane.	*Staphylococci*, *Streptococcus viridans*, *Clostridium tetani*, *Klebsiella pneumoniae*, *Chlamydia psittaci*, *Legionella pneumophila*, *Clostridium botulinum*, *campylobacter*, *Escherichia coli*, *Vibrio cholerae*, *Shigella dysenteriae*, *Salmonella enterica*, *Vibrio parahaemolyticus*
Fungi	Eukaryotic Approx. 10–100 μm	Fungi include yeasts, molds, and mushrooms.	*Candida*, *aspergillus*
Parasites (protozoa)	Eukaryotic	Protozoa are a type of parasite that are single-celled.	Malaria parasite, liver fluke, schistosome, *Trichomonas vaginalis*, *Toxoplasma gondii*

Note 1: The pathogens underlined are major causes of food poisoning.
Note 2: Units: 1 nm (nanometer) = 10^{-9} m; 1 μm (micrometer) = 10^{-6} m.
Note 3: The Pathogens in italics are academic names.

Those that affect cows include bovine spongiform degenerative encephalopathy (also known as Mad Cow Disease), while human prion diseases include Creutzfeldt-Jakob disease (CJD).

3) Infection routes: vertical and horizontal transmissions

There are roughly two **routes of infection**, or ways through which a pathogen can enter a living organism: **vertical transmission** and **horizontal transmission**. Vertical transmission is the transmission of pathogens to a fetus or newborn that occurs during pregnancy or childbirth. It is commonly known as **mother-to-child transmission**. This can occur across the placenta, through the birth canal, or by breast milk.

Horizontal transmission is the spread of pathogens from the source of infection, such as people or objects, to others. It may take forms of **contagious transmission (oral, mucosal, or sexual transmission)**, **droplet transmission**, **airborne transmission**, and **fomite (vector) transmission**. Fomite transmission includes infection through blood, secretions, ingestion, and vectors. According to WHO[6], over a million people die every year from infection via vectors such as mosquitoes, freshwater aquatic snails, ticks, and fleas. **Waterborne transmission** is a form of oral transmission and is a leading cause of diarrhea due to infection to the digestive tract, which can cause explosive outbreaks regardless of age and sex, particularly in developing countries[7]. It is responsible for 2.2 million deaths globally every year, and most of the victims are children in developing countries[7].

4) Host susceptibility

When the same pathogens enter into living organisms, they may or may not develop symptoms. This is due to the differences in the amounts of invading pathogens and **host resistance**, or **activities of the immune system**. When a host is susceptible to pathogens, the activities of their immune system are compromised, and the host may develop symptoms if infected. On the other hand, when the host is not susceptible to the pathogens, which means that he/she has strong immune resistance, the immune system eliminates the pathogens that have invaded his/her body and prevents him/her from developing symptoms.

2. Biological defense mechanisms[8]

Living organisms have **biological defense mechanisms**, which help them protect themselves against pathogens and other foreign substances (i.e. substances that are not normal constituents of the body) (**Figure 7.2**).

1) Physical defense

A living body is in contact with the outside world through the **skin and mucous membranes**. The skin and mucous membranes have **physical defense systems** that prevent foreign substances from invading the body.

The **stratum corneum**, which is found on the side of the skin that comes in contact with the outside world (i.e. the outermost layer), functions as a barrier. The stratum corneum barrier consists of corneocytes and stratum corneum intercellular lipids that fill the space between the cells. It functions to protect the body against the invasion of foreign substances and plays the role of retaining water in the body.

The digestive system, including the mouth, esophagus, and digestive tract, and the respiratory system, including the trachea, are separated from the outside world by **membranes**. The lumen of the digestive system is covered with membranes, which work to protect against the invasion of pathogens and other foreign substances. Living organisms have approximately 60–70% of their immune system in the digestive system, which protects the living organisms against infection with pathogens.

The respiratory tract is lined with hair-like projections called **cilia**, which move the mucous layer upward to eliminate foreign substances. The mucous layer captures foreign substances so as not to allow any pathogens or atmospheric particles to reach the lungs during breathing.

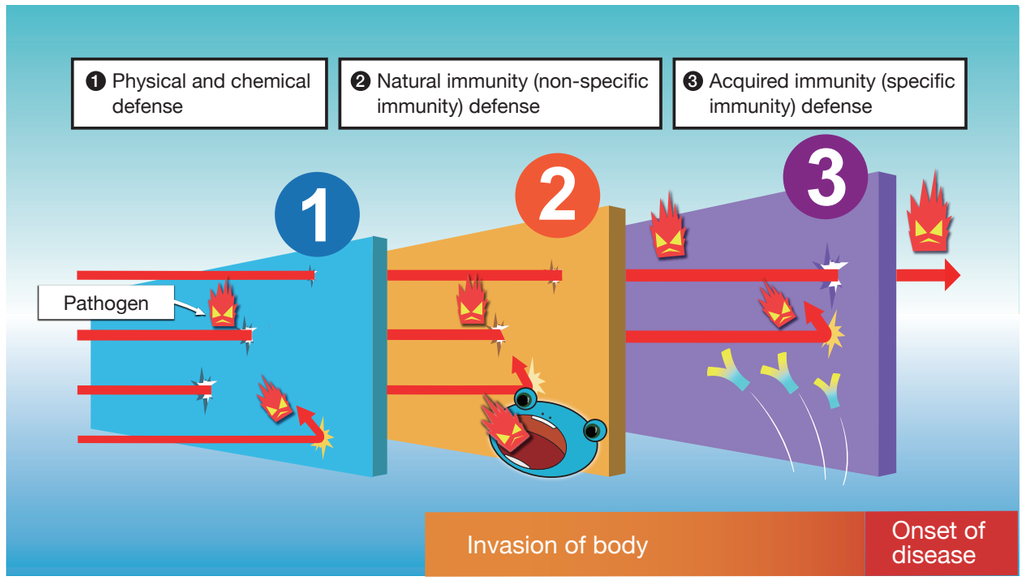

Figure 7.2 Three defense mechanisms to protect the body

2) Chemical defense

Chemical defense is included as a part of the physical defense mechanism. Perspiration, tears, and saliva contain an enzyme called **lysozyme**, which breaks down cells of pathogens ("**bacteriolytic activity**"). Sebum and gastric acid have acidic pH conditions. This helps suppress the growth of pathogenic bacteria, which are not highly resistant to acids.

3) Immune system

If foreign substances such as pathogens have broken through the physical and chemical defense systems (the "first line of defense"), they are inside the living organism. The system that eliminates invading pathogens that have entered the body is called the immune system. The immune system consists of the **natural immune system** (the "second line of defense") and **the acquired immune system** (the "third line of defense"; also called the **adaptive immune system**). They work in stages: first the natural immune system, followed by the acquired immune system. The natural immune system represents primitive defense mechanisms that humans are born with, and it works to eliminate invading pathogens through **phagocytosis**. The defense provided by the natural immune system has limits, however, which is why the acquired immune system plays an important role.

Table 7.2 Types and functions of key white blood cells involved in the immune system

Type of white blood cell		Major roles	Type of immunity
White blood cells	Neutrophils	Phagocytic and bactericidal; cause inflammation.	Natural
	Dendritic cells (differentiated from monocytes migrating from the bloodstream to the tissues)	Phagocytic; communicate antigen information ("antigen presentation").	
	Macrophages (differentiated from monocytes migrating from the bloodstream to the tissues)	Phagocytic and highly bactericidal; cause inflammation; present antigen.	
	Lymphocytes: Helper T cells (differentiated from T cells which mature in the thymus gland)	Receive antigen information from dendritic cells and become activated, promoting proliferation and activation of B cells, which have the same antigen information; some become memory cells to prepare for invasion of the same antigen.	Acquired
	Lymphocytes: Killer T cells (differentiated from T cells which mature in the thymus gland)	Receive antigen information from dendritic cells, and attack and eliminate infected cells; some become memory cells to prepare for invasion of the same antigen.	
	Lymphocytes: B cells (differentiate and mature in the spleen)	Proliferate, become activated, and differentiate into antibody-producing cells (plasma cells) to produce antibodies that are specific to the antigen; present antigen; become memory cells to prepare for invasion of the same antigen.	
	Natural killer (NK) cells	A potent killer; directly attack and eliminate virus-infected cells and autologous cancer cells.	Natural

Such immune responses involve a number of cells and organs, and **white blood cells** play a central role. White blood cells come from their precursor cells known as **hematopoietic stem cells** that are present in the bone marrow. When matured, they become cells such as **granulocytes** (neutrophils, eosinophils, and basophils), **monocytes** (which leave, or "migrate" from, the bloodstream into tissues that are invaded by foreign substances, and differentiate into dendritic cells and macrophages), **lymphocytes** (B cells, T cells — helper T cells and killer T cells —, and natural killer (NK) cells) (Table 7.2). Note that some other types of blood cells, such as platelets and red blood cells, also differentiate from hematopoietic stem cells. Of these types of white blood cells, those responsible for natural immunity are **neutrophils** (which account for 40–70% of white blood cells), **monocytes (dendritic cells and macrophages;** approx. 5% of white blood cells), and **NK cells**, while acquired immunity involves **T cells (helper T cells and killer T cells)** and **B cells**. These are the typical immune cells. Eosinophils are responsible for the immune function that protects the body against parasitic infection.

(1) Natural immune system

a. Phagocytosis

When bacteria have entered into a living organism, cells such as **neutrophils**, **dendritic cells**, and **macrophages** migrate from the bloodstream and gather in the invaded tissues to take these bacteria into the cells. Known as **phagocytes**, these cells recognize "autologous" or normal components of the body, and "heterologous" or other components. Phagocytes digest and break down foreign substances that have been taken up with cellular enzymes. This process is called the **phagocytic mechanism**.

In the case of virus infection, unlike bacterial infection, phagocytosis has limits on its own. This is where **NK cells** come in, directly attacking and destroying the virus-infected cells. NK cells, too, recognize autologous and heterologous components, and usually do not attack uninfected or normal cells (see *Immunological tolerance*).

b. Inflammation

When natural immunity provided by phagocytosis has caused substantial damage to the body (such as mass cell deaths), **macrophages** recognize it and gather neutrophils in the bloodstream, causing a localized inflammatory response. As the capillaries relax and dilate, the blood flow is increased locally, which in some cases causes a plasma leakage, accompanied by tumefaction and rubor. Macrophages release substances into the bloodstream that work on the hypothalamus of the brain (i.e. interleukins), thereby increasing the body temperature (i.e. fever) and activating the immune cells. In other words, an inflammatory response is proof that the immune system is given a boost.

(2) Acquired immunity

a. Communication from the natural to the acquired immune system (Figure 7.3)

The acquired immune system is characterized by its specific activity against a specific kind of foreign substance. An **antigen** is a substance that induces acquired immunity. In general, exogenous pathogens are recognized as antigens. First, **dendritic cells** and **macrophages**, which work as a part of natural immunity, digest and break down the foreign substances such as pathogens through phagocytosis. Then they take up the foreign substances (antigens) and move to lymph nodes, where they present the antigen information on the cell surface, and deliver the antigen information to T cells (helper T cells and killer T cells), which work as a part of acquired immunity that follows. The mechanism in which antigen information is transferred from the natural to the acquired immune system is called **antigen presentation**.

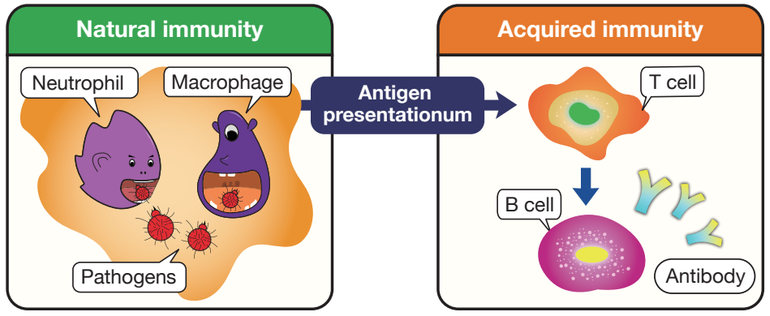

Figure 7.3 Antigen presentation from natural to acquired immune system

b. Cell-mediated and humoral immunity

The acquired immune system has two mechanisms, namely **cell-mediated immunity** and **humoral immunity**. In cell-mediated immunity, upon recognizing antigen presentation by dendritic cells and macrophages, helper T cells and killer T cells proliferate and become activated, and move to the infected site. There, **killer T cells** capture and destroy the infected cells in a specific manner. At the same time, proliferated **helper T cells** activate neutrophils, macrophages, and **B cells**. Even after the elimination of the antigen, helper T cells and killer T cells promote the differentiation of the activated B cells into **memory cells (i.e. memory B cells)**, which remain in the body for a long time to prepare for any subsequent infection. Meanwhile, some of the T cells become **memory T cells** (memory helper T cells and memory killer T cells) to prepare for any subsequent infection.

In humoral immunity, first proliferated helper T cells activate the B cells that have recognized the same antigen. Then the **B cells** differentiate into **the antibody-producing cell (plasma cells)**, and produce **antibodies**. Antibodies are made up of proteins called **immunoglobulin**, and they deactivate the invading antigen by binding specifically to it ("**antigen-antibody reaction**"). The deactivated antigen is eliminated through phagocytosis by neutrophils and macrophages. Once the antigen has attenuated in the living body, normally the antibodies also disappear in two to three weeks, but as described above, some of them remain in the body as memory cells to prepare for any subsequent infection.

c. Secondary immune response

In acquired immunity, upon invasion by the pathogens or other foreign substances that have the same information as that is stored in **memory cells**, B cells promptly differentiate into **antibody-producing cells** (plasma cells) to produce antibodies. In general, they produce antibodies in a larger amount and more quickly than when the first infection occurred and eliminated the pathogens. As a result, an individual may have relatively mild symptoms or may not manifest symptoms at all in a second or subsequent infection.

(3) Immunological tolerance

Immunological tolerance is the body's mechanism that prevents the immune system from wrongly recognizing normal autologous cells and tissues as antigens and attacking them. On rare occasions, this immunological mechanism fails to work properly, resulting in the immune system wrongly recognizing normal autologous cells and tissues as antigens and attacking them. This is called **autoimmune diseases**, which include type 1 diabetes and rheumatoid arthritis.

3. Prevention of infectious diseases

To prevent infectious diseases, it is necessary to cut off the chain of **three major factors for the establishment of infection** described earlier in 1. Specifically, it is necessary to eliminate pathogens (**source control**), block the routes of infection (**control of infection routes**), and boost the host resistance to diminish susceptibility to pathogens (**susceptibility control**) (**Figure 7.4**). By cutting off one of the factors of the three principles, an epidemic of infectious disease may be prevented after an outbreak. In addition, the practice of preventive behavior by individuals and improvements in the social system are required for the prevention of infectious diseases.

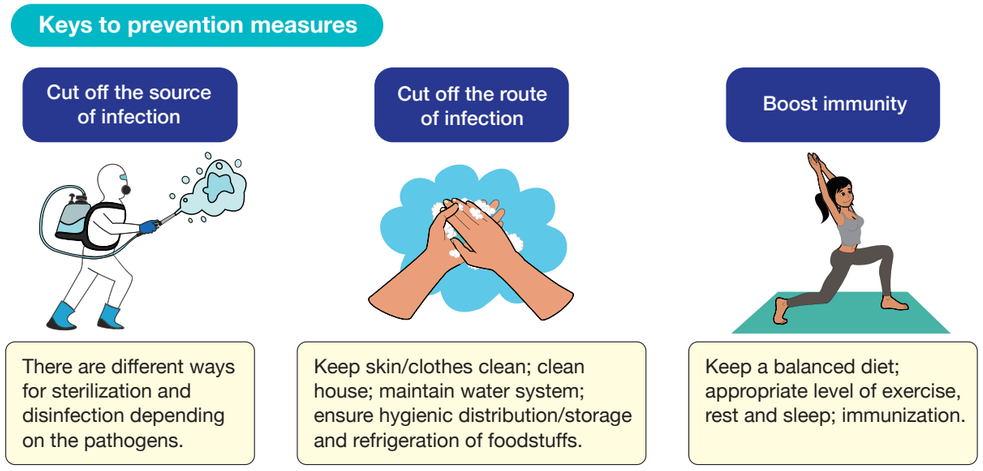

Figure 7.4 Keys to prevention measures to cut off the three major factors for establishment of infection

1) What can individuals do?

We will discuss measures an individual can take that are based on the three principles of infection. Source control measures may include proper management of food to prevent pathogens from growing, and **disinfection** and **sterilization** of pathogens. An important measure for the control of infection routes is **hand washing**. While the routes of infection vary among different pathogens, many of the pathogens that affect humans tend to adhere first to a hand; as the hand touches mucosal membranes of the nose, mouth, and eyes, the pathogens can be introduced into the body. Moreover, as a person's hands carrying pathogens touch many objects and other people touch such objects with their hands, the infection spreads. Washing hands thoroughly with soap is an effective way to prevent infection that anyone can do. For infectious diseases that are caused through **droplets** produced by coughing and sneezing, it is effective in reducing droplets by having infected individuals wear masks and maintain cough etiquette (e.g. cover your mouth and nose with a handkerchief or sleeve when you don't have a mask), and ventilating indoor spaces as well (see Chapter 4). As a susceptibility control measure, one can boost their immunity. For people to protect themselves from developing an infectious disease, and to keep it from becoming serious if they do develop one, it is important for them to boost their immunity. Specifically, they should form a healthy lifestyle based on a balanced diet, adequate sleep, and an appropriate level of exercise (see Chapter 5). **Vaccination (immunization)** is another effective measure for preventing infectious diseases.

From the standpoint of preventing waterborne infectious diseases, changing from open urination and defecation to the use of toilet facilities can prevent contamination of water lines, and thus help in the prevention of infectious diseases.

Column: Vaccines and immunization

Infectious diseases are caused by pathogens such as bacteria and viruses. However, the human body memorizes pathogens that once invaded and maintains a defense system that prevents the onset of diseases or alleviates symptoms caused by the second infection and thereafter. That is the immune system. Vaccination is a medical application of this mechanism. Vaccines contain weakened or detoxifyed pathogens. Vaccination helps not only to protect you from infectious diseases, but also helps prevent infections to those around you. However, vaccines are attenuated or detoxified pathogens, and the possibility of side reactions cannot be eliminated.

Column: Fighting smallpox

Humanity has fought many infectious diseases. The first infectious disease that humanity eradicated was smallpox. Extremely contagious, smallpox was feared as a fatal disease since pre-Christian times. At the end of the 18th century, noticing that milkmaids did not catch smallpox while they did catch cowpox, which is not fatal, an English physician named Edward Jenner developed immunization (the smallpox vaccine). Although the introduction of the smallpox vaccine dramatically decreased smallpox deaths, the vaccine was potent only for a few days at room temperature and could not be delivered to all corners of the world. In 1967, an initiative to eradicate smallpox was launched under the leadership of the WHO. For the purpose of ensuring the quality of the vaccine, a manual on vaccine production was created and guidance given on its production, while a simplified technique for vaccination was developed. As a result, following the case of a young Somali man in 1977, no cases of smallpox have been reported. In 1980, the WHO announced the global eradication of the disease. The eradication of smallpox demonstrates that it is essential for countries to work together across national boundaries to control infectious diseases.

2) What are schools expected to do?

Since schools are where children learn in large groups, they are prone to the prevalence of **droplet transmission** and **contagious transmission**. For this reason, it is necessary to implement infectious disease control measures based on the three principles of infection prevention. Source control measures include improvement of the school environment. Drinking water stations and toilets, in particular, should be kept clean. It is preferable to inspect drinking water routinely to ensure that it meets safety standards (See Chapter 4 for drinking water standards).

Health education of pupils and students is important for the implementation of control measures for infection routes and susceptibility. Children should not only be given knowledge in class, but also learn to be mindful of preventive behaviors against infection in their school life, such as those concerning the use of toilets, hand washing after using the toilet, and cough etiquette. In Cambodia, prevention of infectious diseases represents an important challenge. For Cambodians to learn basic knowledge on infectious diseases and prevention skills at school helps them protect not only their own growth and health, but the health of their families and communities, as well.

3) What is society expected to do?

Because infectious diseases spread from person to person, it is necessary to ensure not only the practice of preventive behaviors by individuals but also the improvement of social systems. Specifically, this means improving public health systems such as water and sawage systems in order to prevent infectious diseases, implementing **quarantine** in order to prevent infectious diseases from getting into the country, and promoting immunization to give the population acquired immunity as prophylaxis. It is also important to develop a monitoring system to check on infection in the country, communicate appropriate information to the people, and make use of the information gathered in studies for future measures to be implemented.

Column: A new lifestyle

In the wake of the outbreaks of the novel coronavirus infectious disease (COVID-19) in 2020, a shift is called for to a new lifestyle, represented by mask wearing and maintaining a distance of at least 1 m between one another. These measures not only change the way we live our daily lives, but will lead

to changing how we work and how we live. We all feel reluctant to change the lifestyles we are familiar with. It is not all a bad thing, however. As we have gained the habit of washing hands to prevent COVID-19, morbidity due to influenza and food poisoning has also declined. As long as we are part of nature, there will always be infectious diseases caused by viruses. What we should aim for is not to overcome viruses but to co-exist with them while minimizing the damage they cause.

4. Common infectious diseases in Cambodia

An outline of infectious diseases commonly seen in Cambodia is given below.

1) Dengue fever

According to a WHO report[9], a total of 9,108 dengue cases with 14 deaths had been reported in Cambodia by September 2020. This number of cases is only 15% of the 61,198 cases in the same period last year. Dengue fever is still one of the most serious infectious diseases in Cambodia, which has a tropical climate.

Dengue fever is an **infectious disease caused by the dengue virus** and spread by the **yellow fever mosquito** (*Aedes aegypti*) and the **tiger mosquito** (*Aedes albopictus*). The dengue virus is of the family *Flaviviridae*, and has four serotypes (DENV 1–4). The dengue virus forms a human-mosquito-human **transmission cycle** (**Figure 7.5**). It is believed that most of the cases of dengue virus infection end up being inapparent or subclinical.

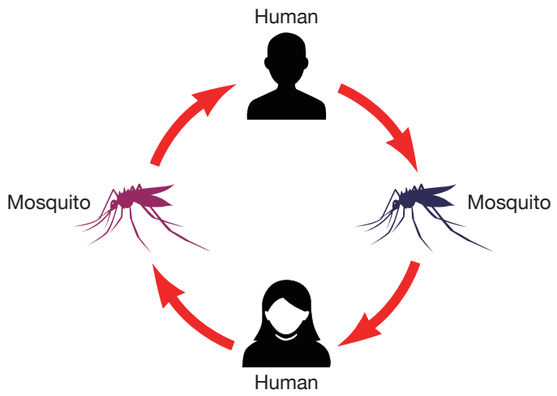

Figure 7.5 Transmission cycle of dengue virus

For those who do manifest symptoms, there are two types: a relatively mild form of dengue fever and dengue hemorrhagic fever, which is a severe form. Dengue fever manifests as a sudden onset of fever 3–7 days into infection, often accompanied by a headache (especially orbital pain), muscle pain, and joint pain. It may also be accompanied by a loss of appetite, stomachache, or constipation. Three to four days into infection, a red rash appears on the chest and trunk and then spreads to the limbs and face.

These symptoms disappear in about a week, and patients usually recover without sequelae. The severe form of dengue fever, namely dengue hemorrhagic fever, causes a patient to experience a sequence of dengue fever symptoms, but before recovery, they experience bleeding, hypotensive shock, and multiple organ failure. It is noteworthy that severe symptoms tend to appear when a fever recedes and the temperature begins to return to normal. Pleural effusion and ascites occur at very high rates. Patients may also experience enlargement of the liver, activation of **complements**, platelet depletion, and/or prolonged blood clotting. In addition, as the name "hemorrhagic fever" implies, 10–20% of the patients experience nasal and/or gastrointestinal bleeding. Treatment for dengue fever is symptomatical.

For the prevention of infection, it is important to take measures to avoid mosquito bites. Specifically, one shoud wear long-sleeved shirts and long pants, apply an insect deterrent, and sleep under a mosquito net. It is also important for the purpose of prevention to make community-wide efforts to exterminate mosquitoes and suppress breeding of mosquitoes (e.g. eliminating puddles, cutting grasses).

Column: What are complements?

Complements are a collective term for proteins that mediate immune response to eliminate antigens such as pathogens invading a living organism. They are so named because they complement the function of antibodies.

2) Malaria

Malaria is an infectious disease that results from the transmission of a **malaria parasite** into the human body via **female anopheles mosquitoes**. After 1–4 weeks of incubation, a malaria parasite proliferates in the hepatic cells and red blood cells, and causes symptoms such as fever (which has cyclicity of repeating febrile periods followed by afebrile ones), headache, joint pain, nausea, anemia, and spleen enlargement. Few patients develop all of the symptoms from the beginning; many follow atypical courses. There are four types of malaria that affect humans depending on the species of the parasites: *Plasmodium falciparum* (*P. falciparum*), *Plasmodium vivax* (*P. vivax*), *Plasmodium ovale* (*P. ovale*), and *Plasmodium malariae* (*P. malariae*). Incubation periods, fever cycles, and treatment methods vary depending on the type of the parasites. Treatment is provided by antimalarial drugs; the choice of drug depends on the type of the parasites. There is no immunization for malaria. For prevention, it is important to take measures to avoid mosquito bites (see *Dengue fever*).

3) Tuberculosis

Tuberculosis is an infectious disease caused by inhalation of tubercle bacilli. It is the leading cause of death linked to a single pathogen worldwide, followed by AIDS[10]. According to WHO statistics[10], approximately 10 million (range: 9–11 million) patients contracted tuberculosis in 2018; the numbers have remained constant for the last few years. While tuberculosis affects people regardless of sex and

age, it was most prevalent in men aged ≥15 years, accounting for 57% of all the patients. It was estimated that women accounted for 32% and children of age <15 years, 11%. Geographically, most tuberculosis cases were found in India (27%), China (9%), Indonesia (8%), the Philippines (6%), Pakistan (6%), Nigeria (4%), Bangladesh (4%), and South Africa (3%); these eight countries accounted for 67% of the world's patients. Cambodia is among the 30 countries with the highest tuberculosis burden, with 49,000 patients and an incidence of active tuberculosis of 302 patients per 100,000 population[11]. This is approximately 2.3 times the average among the WHO Member States of 132 patients per 100,000 population, which warrants tuberculosis control measures[12].

While tuberculosis is a systemic infectious disease, **pulmonary tuberculosis**, which causes lung lesions, accounts for as much as approximately 80% of the cases. As the tubercle bacilli start to move hematogenously in the body, lesions form in a number of organs, including the pleura, lymph nodes, kidneys, and bones, and symptoms appear at each site. If the tubercle bacilli enter the lungs through the respiratory tract and cause a small initial focus of infection, it is regarded that initial infection is established (first infection). However, many such patients do not manifest symptoms and become **carriers**. They may spend years as **carriers** with the tubercle bacilli being established in the lung alveoli and may manifest symptoms only after several years to decades when they become seniors or become ill and have weaker immunity (second infection). Children often become infected through household transmission, in which most cases are primary tuberculosis (first infection). Common treatment for tuberculosis is a combination of anti-tuberculosis drugs. There are concerns over the emergence of multi-drug-resistant tuberculosis, however, and WHO[13] recommends Directly Observed Treatment, Short-Course Chemotherapy (DOTS), where healthcare professionals, health nurses, and family members directly check on patients' compliance to help them avoid missing doses. Immunization is effective, and Cambodia recommends immunization of infants within the first 12 months after birth[14].

Column: Carriers (asymptomatic carriers)

Some people may be infected with a virus and carry it inside their bodies, but do not manifest symptoms. This is a state where the strength of the pathogens and the person's immunity are well balanced, and which suppresses manifestation of symptoms. Even though they do not show any symptoms, such people still shed bacteria and viruses, and thus risk infecting others around them. Such people are called bacterial or virus carriers for bacterial or virus infection, respectively, and those who do not show particular symptoms are called asymptomatic carriers. In the spread of a new coronavirus, tuberculosis, and HIV, such carriers play a significant role, and it is important for people to exercise preventive measures and get tested even if they are not aware of any symptoms.

4) Rabies

Rabies develops when a person is bitten or scratched by a dog, cat, bat or other wild animal that is infected with the **rabies virus**, and the virus invades the body through the wound. The duration of incubation after infection, while it may vary depending on the site of the bite, is usually 1–2 months. Symptoms of a common cold may develop, including fever, headache, lethargy, muscle pain, tiredness, poor appetite, nausea/vomiting, sore throat, and dry cough. It may be accompanied by pain at the bite site and loss of sensation or muscle spasms around the site. Symptoms of encephalitis appear, starting with excitement, anxiety, and mania, followed by delirium, hallucination, aggressiveness, and muscle spasms such as hydrophobic fits. Patients eventually progress to coma and die of respiratory arrest. Rabies, once developed, has a mortality rate of almost 100%. Due to its long incubation period, its onset can be averted by continuous vaccination starting immediately after any events that may cause infection to happen. Since rabies is a **zoonosis**, wild dog management and immunization of domestic dogs are important for prevention.

Column: Zoonosis

A zoonosis is a disease that can be transmitted from animals to humans and vice versa. Zoonotic diseases make up for approximately 50% of all infectious diseases, and include a number of diseases other than rabies, such as avian influenza, SARS, clonorchiasis, and plague. For this reason, the concept of One Health, which means that human health and animal health are interdependent, is advocated primarily among veterinarians.

5) Parasitic infections

There are many parasitic infectious diseases found in Cambodia. Of these, those that are particularly common, namely trematode and nematode infections, are discussed in this chapter.

(1) Trematode infections

Trematodes bear two suckers, one at the end of the body and the other on the ventral surface, and are flat and symmetric. For them to grow, trematodes always require **intermediate hosts**, in which larvae multiply by division. They grow inside a first and second intermediate hosts, and eventually become adult in the **definitive host**. Common trematodes include **schistosomes**, which are transmitted via a percutaneous route and live in the host's blood vessels, and trematodes that settle in organs through oral transmission. Depending on the type of trematode, various symptoms develop. Particularly problematic in Asia are four species of foodborne trematodiases (**Table 7.3**).

Trematodes infect freshwater aquatic snails as a first intermediate host. A second intermediate host may vary depending on the type of trematode; freshwater fish for **clonorchiasis** and **opisthorchiasis**, and crustaceans for **paragonimiasis**, while **fascioliasis** does not require a second intermediate host. The definitive hosts are always mammals. Humans become infected by trematodes by eating raw fish,

Table 7.3 Epidemiological characteristics of foodborne trematodiases

Disease	Infectious agent	Acquired through consumption of	Natural definitive hosts of the infection
Clonorchiasis	*Clonorchis sinensis*	Fish	Dogs and other fish-eating carnivores
Opisthorchiasis	*Opisthorchis viverrini, O. felineus*	Fish	Cats and other fish-eating carnivores
Fascioliasis	*Fasciola hepatica, F. gigantica*	Aquatic vegetables	Sheep, cattle and other herbivores
Paragonimiasis	*Paragonimus spp.*	Crustaceans (crabs and crayfish)	Cats, dogs and other crustacean-eating carnivores

Note: Infectious agents in italics are academic name. Source: World Health Organization[15]

crustaceans, or vegetables contaminated with larvae. According to estimations by the WHO Foodborne Disease Burden Epidemiology Reference Group (FERG) (2015)[15], the leading four species of foodborne trematodes cause physical disorders in an estimated total of 200,000 people and more than 7,000 deaths per year. For treatment, patients take an **anthelminthic** (such as praziquantel) orally.

(2) Nematode infections

Nematodes have a cylindrical body. There are approximately 500,000 species known, of which some 50 parasitize human bodies. They do not always require an intermediate host, and some may repeat cycles of growth and reproduction inside the definitive host. Many nematodes are transmitted orally, but some are transmitted via a percutaneous route. In this chapter, we discuss the **roundworm** (*Ascaris lumbricoides*) and the **human pinworm** (*Enterobius vermicularis*). With ascariasis, a person becomes infected through ingestion of the worm's eggs with food. They typically show digestive symptoms, and may cause acute abdominal conditions in the case of erratic parasitism in the biliary tree. Enterobiasis is caused when a person happens to take stools or food contaminated with stools in the mouth, or eats with a hand that has touched a person or object contaminated with stools. It is particularly prevalent in children. The worms lay eggs around the anus, which causes itchiness around the area. Infection can also be transmitted orally via fingers that have scratched the area around the anus. It may lead to urethritis, vaginitis, or hepatitis. For treatment, patients take **anthelminthic** (e.g., pyrantel pamoate) orally for both the roundworm and human pinworm.

6) Enteric infections

Enteric infections refer to a group of diseases characterized by the manifestation of symptoms such as diarrhea, vomiting, and stomachache caused by bacteria, viruses, and protozoans. Since there are a large number of causative pathogens and their symptoms are similar, their diagnoses are challenging. It is however important to identify the cause as precisely as possible because the treatment varies depending on the type of pathogen. In this chapter, we discuss the most important type of enteric infection, namely **food poisoning**.

Food poisoning is a foodborne illness caused by intake of naturally occurring toxins, chemical substances, or pathogen found in food. Adverse health effects of exposure to naturally occurring toxins may be caused by an intake of wild mushrooms or plants, poisonous fish such as pufferfish, or molds.

Food poisoning is commonly caused by pathogens. Other causes include chemicals, such as metal poisoning caused by copper pots or dishes for eating or lead in canned food, and histamine poisoning caused by raw fish or processed fish.

(1) Food poisoning caused by pathogens

A common form of food poisoning is that caused by pathogens, which can be roughly divided into **bacterial food poisoning** and **viral food poisoning**. In general, bacterial food poisoning is common in an environment suitable for bacterial growth, namely when it is warm and humid. Viral food poisoning, on the other hand, tends to be more common when it is cold with low humidity.

a. Bacterial food poisoning

Common forms of bacterial food poisoning include cholera and dysentery, as well as infection with campylobacter living in the intestines of poultry. While many types of food poisoning occur as a result of infection with 100,000 to 1,000,000 viable bacteria, dysentery and Campylobacteriosis require a much smaller number of bacteria for infection. In many cases, predominant symptoms of food poisoning are vomiting, diarrhea, and fever, but some may be accompanied by a headache or neurological symptoms. Particular caution is required with infection with verotoxin-producing **Enterohemorrhagic *Escherichia coli*** (EHEC), O-157, O-26, O-111, and O-128. In addition to a high fever and severe diarrhea, they may cause hemorrhagic enteritis and hemolytic uremic syndrome, which may progress to kidney failure or encephalopathy resulting in death.

b. Viral food poisoning

Viral food poisoning occurs as a result of intake of a virus carried by shellfish or virus-contaminated water or food. Common forms include **norovirus** and **rotavirus** infections. While bacterial food poisoning is caused by bacteria that are attached to the surface of foodstuff and grow in the food, viruses do not grow in food but inside the body or cells of a host.

(2) Prevention of food poisoning

A key to the prevention of food poisoning is the exercise of the "**three principles of food poisoning prevention**," which ensures that we "**do not allow pathogens to come in contact with food**," "**do not allow pathogens to multiple**," and "**destroy all pathogens**." Heat kills many of the bacteria responsible for food poisoning. Bacteria such as campylobacter die when the contaminated food is heated at a center temperature of 75°C for 3 minutes or longer. Meanwhile, toxin-producing bacteria are more heat resistant. A toxin from *Staphylococcus aureus* will not die even after heating at 100°C for 30 minutes, but will be killed at 200°C for 30 minutes or longer. It is therefore common to use antibacterial agents.

Many pathogenic bacteria multiply by binary fission every 20–30 minutes. One *E. coli* bacterium, for instance, becomes eight after an hour, and 10^{22} after 24 hours. When food contaminated with pathogenic bacteria is left at room temperature, the bacteria multiply in a short period of time. They do

not die even in the refrigerator; they simply multiply at a slower rate. While antibacterial agents are effective against bacterial growth, they are not against viruses. Vaccines are effective against viruses, yet not all viruses have vaccines, and everyday exercise of preventive measures is important.

It is possible to prevent food poisoning by means of disinfection with 70–80% alcohol and invert soap. In the case of **norovirus**, however, alcohol is not highly effective, and disinfection with sodium hypochlorite is necessary.

Even when causative bacteria or viruses for food poisoning find their way into the body, how symptoms manifest can vary depending on the immune strength of the person infected. Because even asymptomatic carriers can spread infection through their hands or bodily waste, hand washing is extremely important.

Column: What is invert soap?

Although called "soap," invert soap has properties that are opposite to those of regular soap. It is not capable of removing dirt or stain but has bactericidal and sterilizing properties to destroy the cells of molds and bacteria. It is not effective against viruses, which do not have cells. It is used for sterilizing fingers and dishes for eating, laundry, and cleaning. To sterilize fingers, one should first wash hands thoroughly with regular soap to remove any dirt, then disinfect with invert soap.

5. New challenges with infectious diseases

Throughout human history, we have fought many infectious diseases, and successfully overcome some by improving healthcare standards and public health. On the other hand, we are facing new challenges. One example is **emerging infectious diseases**. WHO[16] defines emerging infectious diseases as "those due to newly identified and previously unknown infections which cause public health problems either locally or internationally." While not all emerging infectious diseases are fatal, their causes and routes of transmission are unknown at the beginning, which can cause a quick spread of infection. One of the causes behind these diseases is the increasing proximity between wild animal and human populations by such activities as forest development. As there are more opportunities for humans to enter wildlife habitats, humans may contact viruses carried by wild animals, or a virus that should originally infect only animals may undergo the mixing of other viral genomes inside the cells of the animal and mutate into a new type of virus that may prove extremely pathogenic when transmitted to humans. Because it takes time to develop a new vaccine or therapeutic drug, emerging infectious diseases can pose challenges on the prevention and treatment front.

A second example is **pandemics**. A pandemic is defined as an epidemic of an infectious disease occurring across different countries and regions. With globalization comes greater movement of people, and this can cause an infectious disease in one area to rapidly spread to multiple countries and regions, resulting in a global outbreak. WHO declared the H1N1 pandemic in 2009[17,18], and the COVID-19 pandemic in March, 2020[19]. Because it is not possible to prevent a pandemic from occurring through individual countries' efforts alone in implementing thorough infectious disease control measures, there is a growing demand for enhanced public health systems based on international cooperation, for example, supported by WHO.

Other than those mentioned above, challenges we are facing include the rise of **multidrug-resistant organisms**, which are pathogens resistant to newly developed drugs, and animal-derived infectious diseases due to increases in imported pets and changes in how people interact with them.

Furthermore, infectious disease control measures always face discrimination and prejudice. Misconception, fear, and anxieties concerning an infectious disease can give rise to discrimination. With leprosy and HIV infection (AIDS), there were cases where national governments implemented control policies such as isolation of patients, even though the risk of transmission was low in everyday settings. Preventing infectious diseases is important, yet it is necessary to take into account the human rights of the infected when implementing measures, so as not to let them become a target of discrimination.

Column: Preventing discrimination and prejudice from being induced by infectious diseases

Year 2020 saw a global outbreak of **novel coronavirus infectious disease (COVID-19).** COVID-19 is an emerging infectious disease, and we are faced with the challenge of responding to infection prevention. In the course of our tackling this crisis, prejudice against infected people occurred. This was nothing new. As the cases of AIDS and Ebola hemorrhagic fever are still fresh in our minds, infectious diseases and pandemics have historically induced prejudice and discrimination. Behind such discrimination are people's anxieties over the illness. Prejudice and discrimination pose a public health threat. They not only cause damage to physical and mental health and welfare of the people who are subjected to prejudice, but they also make it difficult to contain the infectious disease. WHO recommends that governments, citizens, media, key influencers and communities should do their part to prevent prejudice and discrimination from spreading[20]. Steps suggested to achieving this are: "Spread the facts"; "Engage social influencers"; "Amplify the voices of people with lived experience with the coronavirus"; "Portray diversity of ethnicity in public information materials"; "Promote ethical journalism"; and "Correct myths, rumors, and stereotypes that encourage purejudice"[21].

Exercises for further thought and research

[7-1] Do research on the laws and measures concerning infectious diseases and those concerning hygiene management in Cambodia and give a presentation about them.

[7-2] Choose one infectious disease that is common in Cambodia and summarize the measures against it. In doing so, list up measures by the following categories: the three principles of infectious diseases; what individuals can do; what schools can do; and what society should do.

[7-3] Create a poster promoting the prevention of food poisoning. Discuss as to where it should be posted for it to be effective, keeping your target audience in mind.

[7-4] Discuss in groups what brings about discrimination and prejudice related to an infectious disease.

Plan a lesson on the theme of infectious diseases and human rights.

[7-5] Propose a new lifestyle for a new era of people living with the novel coronavirus in Cambodia.

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Chapter 8

Eye and dental health

Learning objectives

You will be able to gain proper understanding and explain:

- How we can see an object and why refractive errors occur, and explain how we can prevent eye diseases.
- The function of a tooth, the causes of dental caries, gingivitis, and periodontal disease, and explain how we can prevent them.

This chapter explains the mechanisms of the eyes and the teeth, diseases related to them, and prevention of those diseases. Eyes and teeth, which are organs familiar to children in that they can easily observe them, provide them with opportunities to experience, for example, preventive measures in practice and make them realize the outcomes of health learning easily. Therefore, eye and dental health is one of the teaching and learning materials of school health familiar to all members of a class.

1. Eye health

1) Importance of eye health

Eye and dental diseases significantly affect our health not only during school age but also in adulthood. Loss of sight in particular is a serious issue. Cambodia implemented the national strategic plan to prevent loss of sight (2008–2015) with a focus on the **National Program for Eye Health**, and achieved the goal of making the rate of blindness 0.5% or lower.[1] Nevertheless, an estimated 28,800 people still suffer from loss of sight or visual impairment. The leading cause of loss of sight and visual impairment is cataracts (approx. 19,000 people), but they can also be caused by leaving refractive errors that occur during school age untreated. It is said that 80–90% of these causes are preventable or treatable.[2]

Meanwhile, about 20% of children have missed a class due to a toothache over the last 12 months, indicating that dental health is an issue that should be given priority for school-age children.[3] The school age is a period in which milk teeth (deciduous teeth) are replaced by permanent teeth, and leaving dental caries or periodontal disease untreated during this period can invite exacerbation later and result in loss of teeth in adulthood.

Therefore, it is very important to learn eye and dental health in school health classes during school age.