Epidemiology of Infectious Diseases

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Bailu Liu, Xuhua Yang, and Lili Kong

8.1 Source of Infection

Source of infection refers to both people and animals with pathogens growing and reproducing inside the body and are capable of expelling the pathogens out of the body to invade another organism. It is a cycle with the pathogens growing and reproducing within an organism, followed by being expelled out of the organism to invade another. Some intermedia, such as water, food, and others, can carry pathogens into another susceptible organism. However, these intermedia fail to serve as a place for their long-term survival and reproduction in large quantities rather function as a carrier or transfer station for their spreading. Therefore, the intermedia are not a source of infection. The source of human infectious diseases can be categorized into two groups, namely, humans and animals. It can be further divided into the following four subgroups:

8.1.1 Patients

Patient is an important source of infection. Patients with different infectious diseases show varied infectivity and infective period. Symptoms of patients with acute conditions, such as cough, vomiting, and diarrhea, play facilitating role in the spread of pathogens, while patients with chronic conditions demonstrate long-term effects on their surrounding environment. Patients with slight infectious diseases are in large quantities and tend to be misdiagnosed. Different infectious diseases have been demonstrated to have different epidemiological implications.

8.1.2 Patients with Latent Infection

For some infectious diseases, such as poliomyelitis, the patient with latent infection is an important source of infection.

8.1.3 Carriers of Pathogen

Given the fact that carriers of pathogen show no symptoms but being capable of expelling pathogens, their diagnosis and management present challenges to health-care professionals. However, these carriers play an important role in spreading pathogens. Carriers of chronic pathogens show no symptoms but with long-term discharge of pathogens, which are attached important epidemiological implications in infectious diseases such as typhoid fever and bacillary dysentery. Therefore, carriers of pathogen are also an important source of infection. The importance of pathogen carriers as source of infection is related to the pathogen they discharge, its quantity, period of carrying, vocation of the carrier, personal cleaning habit, sanitary condition the carrier lives, and the susceptibility of their surrounding populations.

8.1.4 Infected Animals

A human can be infected by many diseases found in animals such as brucellosis, rabies, plague, anthrax, and type B encephalitis. Some infectious diseases prevalent in animals such as rabies and plague can be transmitted to humans, leading to serious conditions. Some other infectious diseases

B. Liu (✉)
CT Department, The Second Affiliated Hospital, Harbin Medical University, Harbin, Heilongjiang, China
e-mail: liubailuhmu@sina.com

X. Yang
Department of Radiology, City Kangan Hospital (Former City Hospital for Infectious Diseases), Mudanjiang, Heilongjiang, China

L. Kong
Department of Radiology, City Development District Hospital, Yantai, Shandong, China

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like schistosomiasis have their animal hosts as a part of the source of infection. Yet in terms of susceptibility, process of infection, ways of transmission, epidemic process, and pathological changes towards animal pathogens, humans and animals are not in common. The epidemiological implications of the infected animals as the source of infection are different in terms of the quantity of infected animals and chances and ways of human-animal contact. The infectious diseases with animals as the source of infection are mostly zoonotic diseases or natural source diseases.

8.2 Process of Infection

After pathogens invade into the human body through different ways, the process of infection begins. The pathogenicity of the pathogen and the immunity of the human body play decisive role in the survival of the pathogen. The pathogen may be eliminated after its invasion. Otherwise, it stays leading to further tissue impairments, inflammatory reactions, and other pathological changes. In addition, the survival of pathogens is also related to some external factors, including catching a cold, fatigue, medication, and radiotherapy.

8.2.1 Elimination of Pathogen

Pathogens can be eliminated by nonspecific immunological barrier functioning as the first line of defense after they invade into the human body, such as elimination of a small amount of dysentery bacteria and *Vibrio cholerae* by gastric juice. Meanwhile, pathogens can also be eliminated by specific humoral immunity and cellular immune substances that previously exist in the human body. Specific immunity can be acquired via vaccination or natural infections for active immunity or otherwise via placental barrier from mothers or injection of immunoglobulin for passive immunity.

8.2.2 Asymptomatic Infection

Asymptomatic infection is also known as subclinical infection, which refers to infection that only produces specific immune response after invasion of pathogen, with no or slight tissue damages. Therefore, asymptomatic infection usually has no clinical symptoms, signs, and biochemical changes, which can only be detected immunologically. For most infectious diseases, asymptomatic infection is the most frequently found condition. After the whole course of asymptomatic infection, most patients acquire specific immunity of different degrees, with pathogens eliminated. In some cases, patients with asymptomatic infection develop into pathogen carriers, with the pathogen surviving in their bodies but no symptoms. Such cases are commonly found in patients infected by typhoid bacillus, Shiga bacillus, and hepatitis B virus.

8.2.3 Symptomatic Infection

Symptomatic infection is also known as clinical infection, which refers to the infection that produces both specific immune response and tissue damage due to pathogenicity of the pathogen or allergic reactions of the human body after the invasion of the pathogen. Therefore, such infections are demonstrated by pathological changes and clinical manifestations. For most infectious diseases, symptomatic infection only accounts for a small fraction of all the cases with infectious diseases. However, for some infectious diseases, such as measles and varicella, most patients present symptomatic infection. After the whole course of the symptomatic infection, the pathogens are eliminated and the affected patients acquire a relatively stable immunity against these infectious diseases like measles, hepatitis A, and typhoid fever. These patients are no longer susceptible to such infections. In addition, for the cases of some infectious diseases, such as bacillary dysentery and amebic dysentery, the acquired immunity is weak after the symptomatic infection. These patients are still susceptible to the infections. A small fraction of patients with symptomatic infection may develop into chronic pathogen carriers.

8.2.4 Pathogen Carrying Condition

Based on the types of pathogens, pathogen carriers are accordingly categorized into three types, namely, virus carriers, bacteria carriers, and parasite carriers. Based on the state the patient is in, the carriers can be grouped into carriers in latency, carriers in recovery, and chronic carriers. Generally, carriers with less than 3 months carrying period are referred to as acute carriers; those with more than 3 months carrying period are chronic carriers. Specifically for viral infection of hepatitis B, those with more than 6 months carrying period are referred to as chronic carriers.

8.2.5 Latent Infection

After invading into the human body, some pathogens might survive at certain part of the body. The immunity of the human body can successfully suppress and localize their further progress to cause symptomatic infections while being not strong enough to eliminate the pathogens. In such cases,

the pathogens may survive a long period of time and cause symptomatic infection when the immunity is compromised. The commonly found latent infections include infections caused by herpes simplex virus, varicella virus, plasmodium, and *Mycobacterium tuberculosis*.

In addition to elimination of pathogens, the above five types of infection have different occurrence in different infectious diseases. Generally, asymptomatic infection is the most common, followed by pathogen carrying condition. Latent infection is the least common but can be identified at its occurrence. Furthermore, the above five infections fail to keep a persistent condition but are interchangeable at certain conditions.

8.3 Route of Transmission

Route of transmission refers to the path that begins from the departure of pathogen away from the source of infection to its arrival of another susceptible human body. It includes the whole course during which the expelled pathogens arrive at another susceptible human body via certain transmitting factors. Each infectious disease spreads via certain transmitting factors. The route of transmission for some infectious diseases is singular, while some other infectious diseases are transmitted via a combination of transmitting factors. The combination of various environmental transmitting factors ranges from simple to complex.

8.3.1 Airborne Transmission and Droplet Transmission

Airborne transmission and droplet transmission are common routes of transmission for respiratory infectious diseases, such as measles and diphtheria. After the pathogens are expelled along with breathing, talking, coughing, and sneezing of the infected person, they distribute in the air surrounding the person. Those pathogens capable of surviving in dry condition, such as *Mycobacterium tuberculosis* and anthrax bacillus, spread via different types of dusts. After the small droplets stay in the air for a while, the water on their surface evaporate to leave over particles composed by protein and pathogen, which is known as droplet nucleus. It floats in the air as a colloid. Since a human keeps breathing, those susceptible persons can be infected after inhaling the droplet nuclei containing pathogens. Infectious diseases, such as diphtheria and tuberculosis, can spread via droplet nucleus. Airborne diseases are epidemiologically characterized by concentrated and consecutive cases, outbreak or prevalence of diseases with a short latency, periodic and seasonal increase of cases that are more common in springs and winters, and more pediatric cases, the prevalent intensity being highly related to immunity, living standard, and housing conditions of the population.

8.3.2 Water-Borne Transmission

Water-borne transmission is common in gastrointestinal infectious diseases. After the drinking water is contaminated by pathogens and keeps on being unsterilized, it can result in prevalence of infectious diseases, such as cholera and typhoid fever. Some infectious diseases spread via contact to the contaminated water, such as leptospirosis and schistosomiasis. The water-borne diseases are epidemiologically characterized by a history of drinking contaminated water of the same water source for infectious diseases that spread via drinking contaminated water, with possible occurrence of outbreak; a history of contact to contaminated water of the same water source for the infectious diseases that spread via contact to contaminated water, with regional and seasonal occurrence; occupational variance, with more cases in susceptible population exposed to the contaminated water; and possible occurrence of outbreak after access of large susceptible population to the area with contaminated water.

8.3.3 Food-Borne Transmission

Intestinal infectious diseases can be spread via pathogen-carrying food. The food capable of carrying pathogen can be categorized into two types: mechanical carrier such as fruits and vegetables and reproducible carrier such as meat, dairy products, and eggs. When the food that is not thoroughly cooked or sterilized is consumed by people, it can lead to occurrence and prevalence of intestinal infectious diseases.

8.3.4 Contact Transmission

Contact transmission can be divided into direct and indirect contact transmission.

8.3.4.1 Direct Contact Transmission

It refers to the direct contact by a susceptible person to the source of infection without the involvement of external factors, including sexual contact; transfusion of pathogen-carrying blood, blood products, or medication; use of contaminated medical instruments; and organ transplantation. The diseases that spread via direct contact are epidemiologically characterized by an intensive occurrence of the disease, circulation within family members or roommates, and more common occurrence in persons with unfavorable personal hygiene habits.

8.3.4.2 Indirect Contact Transmission

It refers to the transmission via contact to contaminated tools or daily-life necessities and thus is also known as daily-life contact transmission. It can be found in some

intestinal infectious diseases such as dysentery, hepatitis A, and typhoid fever. The infectious diseases that spread via indirect contact transmission are epidemiologically characterized by sporadic occurrence, rarely found prevalence, circulation within family members or roommates, more common occurrence in populations with unfavorable personal hygiene habits and in regions with poor sanitary conditions, and slow spreading without obvious seasonal peak of prevalence.

8.3.5 Soil-Borne Transmission

The soil can be the carrier of a pathogen to spread diseases such as tetanus and anthrax after being contaminated by the spores of the pathogen. It can also be contaminated by the larva of the pathogen causing ascariasis and by the eggs of the pathogen such as ascaris to spread the diseases. Many infectious diseases can spread via pathogen-carrying soil since it is most likely to be contaminated directly or indirectly by feces and secretions of pathogens. Improper bury of deceased human or animal body with infectious diseases may contaminate the soil, whose carried pathogen may invade susceptible persons via different routes of transmission. It is especially common for children to be infected by parasites carried in the soil. In addition, pathogens that can produce spores in the cases of tetanus and anthrax can survive in soil for a long period of time, which have stronger spreading potential.

8.3.6 Arthropod-Borne Transmission

Arthropod-borne transmission is commonly found in the spreading of infectious diseases such as malaria and exanthematous typhus with blood-sucking arthropods like mosquito, flea, sand fly, and tsutsugamushi as intermediary host. The intermediary insects as transmitting factors spread diseases via biological and/or mechanical transmission. The spread of pathogen via biological transmission can be found in mosquito-transmitted malaria and epidemic encephalitis B. The spread of pathogen via mechanical transmission can be found in fly-transmitted dysentery. The infectious diseases spreading via biological transmission of intermediary insects are epidemiologically characterized by rigid seasonal and regional prevalence; obvious occupational prevalence, with forest encephalitis more common in lumbermen and epidemic encephalitis B more common in workers raising pigs; age difference in prevalence, with prevalence in children and susceptible new residents in the epidemic area but less common occurrence in adults due to their well-equipped immunity; and no occurrence of human-to-human transmission.

8.4 Population Susceptibility

Susceptible population refers to persons who lack specific immunity against a certain infectious disease. The percentage of susceptible population in a certain group of people is the determinant to the susceptibility. When the percentage increases to a certain level, in combination with the source of infection and a route of transmission, prevalence of the infectious disease occurs. For some infectious diseases such as measles which produce stable immunity against them after cured, prevalence may recur after several years when the percentage increases again to the risky level. Due to the widely adopted intervention of artificial autoimmunity, the percentage of susceptible population decreases to a possibly lowest level. In such cases, the prevalence of certain infectious disease fails to recur. Multiple factors have been demonstrated to exert effects on the population susceptibility.

8.4.1 Common Factors Increasing Population Susceptibility

The factors increasing population susceptibility include enlarged susceptible population and/or reduced population with immunity against the infectious disease. Therefore, the percentage of susceptible population increases, such as the input of susceptible population.

8.4.2 Common Factors Reducing Population Susceptibility

Artificial intervention to increase immunity of target population can effectively decrease the susceptibility of targeted population. After a prevalence of infectious disease or asymptomatic infection, the population with proper immunity enlarges. Improved living conditions, improved health status, and strengthened nonspecific immunity of population facilitate the prevention against infectious diseases.

8.5 Epidemic Focus and Epidemic Course

Epidemic course refers to the whole process where an infectious disease occurs, transmits, spreads, and regresses within a population. Three basic elements give rise to an epidemic episode, including source of infection, route of transmission, and susceptibility of population, which are also known as the three basic procedures of an epidemic process. Concurrence of the three basic procedures causes the transmission and spread of an infectious disease. The

epidemic course of an infectious disease is characteristic and is affected by environmental and social factors. These factors either promote or inhibit any basic procedure to either promote or block the spread of an infectious disease within a population.

8.5.1 Regional Distribution of Epidemic Foci

8.5.1.1 Universal Distribution

The epidemic foci of infectious diseases are widely distributed. However, their distributions are not necessarily even across the world.

8.5.1.2 Regional Distribution

The epidemic foci of some infectious diseases are confined within certain areas, such as visceral leishmaniasis and schistosomiasis.

8.5.1.3 Naturally Occurring Focus

Some infectious diseases have animals that are living in the area as the source of infection and/or the carrier of pathogen and are prevailing in these animals. Under certain conditions, the infectious diseases can be transmitted to human or farm livestock.

8.5.1.4 Importability

An infectious disease that otherwise never occurs in one area before it is imported from foreign countries is known as the importability of infectious diseases.

8.5.2 Time Distribution of Epidemic Course

8.5.2.1 Seasonal

An infectious disease may occur all year round or has strict seasonal prevalence.

8.5.2.2 Periodic

An epidemic episode of an infectious disease occurs with an interval of a given period of time when the proportion of susceptible population reaches a certain level. The periodic prevalence may change in the case that the incidence of the infectious disease reduces dramatically.

8.5.3 Population Distribution of Infectious Disease

8.5.3.1 Age Distribution

Some infectious diseases, such as pertussis and scarlet fever, are more commonly found in children aged 1–5 years.

8.5.3.2 Gender Distribution

The gender difference of incidence is commonly due to the different opportunities to contact the pathogen. Such gender difference can be found in the cases of schistosomiasis, with male patients outnumbering female patients.

8.5.3.3 Occupational Distribution

Occupation is closely related to the risk of exposing to source of infection. For example, forest workers are especially susceptible to tick-borne infectious diseases due to their high risk of being bee-biten. Such tick-borne infectious diseases include forest encephalitis and Lyme disease.

8.6 Factors Influencing Epidemic Course of Infectious Diseases

Factors influencing the epidemic process of infectious diseases include social and natural factors, which exert the effect on the three basic procedures of spreading to either promote or inhibit the prevalence of infectious diseases.

8.6.1 Natural Factors

The natural factors influencing the prevalence of infectious diseases are various, including geographic, meteorological, and ecological conditions, which play an important role in the occurrence and development of epidemic course. The geographic and climate factors show especially obvious effects on the prevalence of regional and naturally occurring infectious diseases. The growth, reproduction, and activities of wild animals and arthropods, as the source of infection, are confined due to the geological and climatic conditions, namely, regionally characteristic. Natural disasters commonly cause prevalence of infectious diseases. For instance, contaminated water source may give rise to the spreading of intestinal infectious diseases. The spreading of parasite-borne and arthropod-borne infectious diseases is especially dependent on the natural factors. For instances, the spread of visceral leishmaniasis is regionally confined within northern China; the spread of schistosomiasis is regionally confined within southern China; the spread of encephalitis B is rigidly confined in summers and autumns. Such cases of prevalence are all related to natural factors. Certain natural and ecological conditions play roles in the spread of some infectious diseases within wild animals, including plague, tsutsugamushi disease, and leptospirosis. Access to such regions provides chances for their transmission to human.

8.6.2 Social Factors

Social factors influencing the epidemic course of infectious diseases include social constitution as well as demographic factors, economy, culture, education, religion, condition of housing, occupational environment, social status, health-care service, occupation, personal hygiene habits, and social stability. All these social factors play decisive roles in the epidemic course of infectious diseases. Certain social constitution enables people to achieve well-being while taking measure to control and eliminate many infectious diseases, such as schistosomiasis, cholera, and ancylostomiasis. Before the founding of the People's Republic of China (P.R. China), the prevalence of some infectious diseases including plague, cholera, and small pox was serious and out of control. After the founding of P.R. China, the well-established health-care system is so effective that the prevalence of such infectious diseases has been under control within a short period of time. Currently, due to the rush of a large quantity of peasant workers into cities for better life and their poor awareness of favorable life style in China, the incidences of intestinal infectious diseases are rising in urban areas of China. In addition, some social factors, such as customs, density of population, and the frequency of person-to-person communication, exert effects on the occurrence and prevalence of infectious diseases.