THE BASICS

A PRIMER TO INFECTIOUS DISEASE EPIDEMIOLOGY

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Infectious diseases, like the 'novel' coronavirus pandemic, are amongst the leading causes of death across the world. What are infectious diseases? Where do such diseases come from? How do they spread? How do we study them? And how do human societies combat or limit their spread?

All of us have suffered from disease at some point in our lives. Diseases, like the common cold and cholera, that spread from one person to another are referred to as **infectious diseases**. In contrast, heart disease, diabetes, and cataract are **non-infectious**. Whether infectious or not, we know that any disease can affect many people in a population. But how do we know what causes the disease, how often it occurs, how common it is in a population? Or if it can spread from one person to another, and who is more likely to get the disease? These are the kind of questions that **epidemiologists** engage with.

Who are epidemiologists?

You can think of epidemiologists as disease detectives. These detectives investigate the 5W's of a disease — the diagnosis or health event (what), the person (who), the place (where), the time (when), as well as the causes, risk factors, and modes of transmission (why/how). For example, epidemiologists study how many members of a population suffer from heart attacks, or how many people who live close to a dirty river suffer from cholera. They do this by applying principles of epidemiology.

The term 'epidemiology' comes from three Greek words — *epi,* meaning on or upon, *demos,* meaning people, and *logos,* meaning the study of. It is a branch of science that studies the distribution and spread of a disease in a population, and applies this understanding towards control of public health problems. Take the example of the ongoing COVID-19 pandemic (see **Box 1**). Epidemiologists have helped identify the origins of the disease (possibly from a wild animal), how it spreads among people (through contact with respiratory droplets), and what measures and strategies can help reduce

its spread (wearing masks, better hand hygiene, and physical distancing). It is this growing body of knowledge that enables public health officials to plan adequate and appropriate responses to the pandemic. Understanding epidemiology is particularly relevant in preventing the spread of infectious diseases, which are amongst the leading causes of premature death across the world, especially in poor and developing countries. This may explain why epidemiology has often been described as the science of preventive medicine.

In the past 30 years, many infectious diseases have emerged, leading to a high number of deaths. Unlike non-infectious diseases, infectious diseases can spread quickly through a population due to person-to-person transmission. Over the years, studying infectious diseases has allowed us to control or eliminate many diseases (like polio and smallpox), find cures for others (like for bacterial pneumonia), and help prevent the spread of many more. Today, as epidemiologists race to understand COVID-19, it is useful to look at where such diseases come from, and how we can deal with them.

Understanding infectious diseases

For as long as we know, humans have suffered from infectious diseases. But it was only with the invention of the microscope that we were able to peer into the blood and tissue of infected people, and discover that they were caused by certain microorganisms and parasitic nematodes.

While there are millions of species of microorganisms, only a handful are known to cause infectious diseases in humans. In fact, many microorganisms are beneficial to us, and are essential for a healthy life. Microorganisms (bacteria, fungi, viruses, or protists) that cause disease in humans are called **human pathogens**. Examples of diseases they cause include malaria (caused by *Plasmodium* parasites that are transmitted through mosquitoes), rabies (caused by a virus that is transmitted by dog bites), dengue (caused by a virus that is transmitted by mosquitoes), and tuberculosis (caused by *Mycobacterium* bacteria). Similarly, the ongoing COVID-19 pandemic is caused by a virus that belongs to the coronavirus family (SARS-CoV-2).

Where do these human pathogens come from? We encounter many of them through our physical environment. For example, *Vibrio cholerae,* the bacteria that causes cholera, is found in contaminated water. Many others reside in wild or domesticated animals. In fact, a majority (> 60%) of the infectious diseases seen in humans are believed to have animal origins. We may encounter such pathogens on contact with an infected animal, its blood, or other tissues. Such an encounter leads to disease only if the pathogen is able to enter and replicate within a human host. An infectious disease that is caused when a pathogen 'jumps' from an animal host to a human population is called a **zoonotic disease** or **zoonosis**, and the event is called a **zoonotic spillover**. For example, the current consensus is that the COVID-19 infection emerged from a spillover from a wild animal into the human population.

How do infectious diseases spread from one human to another? An uninfected person can contract an infectious disease by direct contact with an infected person (touching, hugging), or indirect contact with their bodily fluids such as blood, mucus, or respiratory droplets. Such infectious diseases are also called **contagious diseases**. For example, respiratory diseases such as the common cold and COVID-19 spread through droplets produced when an infected person speaks, sings, coughs or sneezes. But not all infectious diseases are contagious. Some are transmitted through other animals (called **vectors**). For example, people get malaria when

Box 1. Do you know these terms?

These terms are common in discussions on infectious diseases:

- **Population:** the total number of people inhabiting a given region or geographic area. It can also refer to a group of people who share a common characteristic, like gender, age, or ethnicity.
- **Pathogen:** an organism that causes disease.
- **Outbreak:** a sudden increase in the number of cases of an infectious disease in an area. It can occur in a small town, or at the scale of a continent.
- **Prevalence:** the number of cases of a disease, or the number of people with the disease in a population at a given time.
- **Incidence:** the number of new cases of a disease in a population during a given time period.
- **Epidemic:** a disease that shows rapid and widespread prevalence (or an increase in number of cases) in an area. This increase can occur sporadically or seasonally. For example, some epidemics are triggered by sporadic changes in disease susceptibility of the host, increased virulence of the pathogen, or perhaps the introduction of the pathogen into a new setting. In contrast, seasonal epidemics of chikungunya are caused by an increase in mosquito numbers during the monsoons.
- **Pandemic:** an epidemic that spreads to many countries or regions versus being limited to a specific area. In the ongoing COVID-19 pandemic, more than 180 countries have reported cases of the disease.
- **Endemic disease:** a disease whose prevalence is maintained at a baseline number in the population without any external inputs. In other words, an endemic disease shows a constant presence in a given location. For example, chikungunya is endemic to India.

they are bitten by a female *Anopheles* mosquito that has just fed on the blood of a person with malaria. Other diseases spread through the physical environment. For example, cholera spreads through the consumption of water contaminated with *Vibrio cholerae*. Also, the prevalence of infectious diseases can vary over time, across seasons, and across regions.

Controlling the spread of infectious diseases

An understanding of the epidemiology of an infectious disease allows public health officials to plan a variety of strategies to control its spread. In an ongoing pandemic, many of these strategies will often need to be used at the same time.

When a new infectious disease emerges, the first priority of public health efforts is to **prevent** its incidence. Strategies to do this are based on a recognition of the causes of the disease, and the origins of the pathogen causing it. One strategy involves the control of conditions favouring the survival and multiplication of the pathogen outside its human hosts. For example, minimizing the chances of mixing sewage and other effluents with drinking water can help prevent cholera. Another strategy is to facilitate a change in patterns of human behaviour. For example, encouraging the use of mosquito nets in places that show a high burden of mosquito-borne diseases such as malaria and dengue can help reduce their incidence. A third strategy is to provide vaccination, if available, to susceptible populations. Vaccines help prevent the incidence of a disease by strengthening our immune response to the pathogen causing it.

The next priority of public health officials is to limit person-to-person spread of the disease in a population. Strategies to do this are based on an understanding of all the ways in which the infectious agent can spread among people. For example, COVID-19 spreads via respiratory droplets that can travel up to 2 m (or 6 feet) from the infected person, and can cause disease in those who come into contact with them. Hence, spread of COVID-19 can be controlled by minimizing the possibility of people making contact with these droplets (see **Fig. 1**). One strategy that public health officials rely on is to identify people who are (or are likely to be) infected, as well as those they may have come into contact with, as quickly as possible. These people are encouraged to physically isolate themselves at home (if mild), or in a hospital to reduce the risk of spreading the infection to others. A second strategy is to encourage people to use masks to cover their nose and mouth, maintain physical distance, and avoid crowded areas. Many countries have relied on lockdowns to keep people inside their homes, and away from public gatherings. A third strategy is to encourage research into drug development to treat the infection. These drugs could include antibiotics for bacterial infections, or antivirals to treat viral infections. Most containment measures during this pandemic are aimed at slowing the spread of infection enough to give a head-start to the public healthcare system. This is needed to identify clinical symptoms of the infection, and develop corresponding treatment and management regimens. In the meanwhile, the medical research community has continued working on testing and developing existing and new medicines for use against this infection.

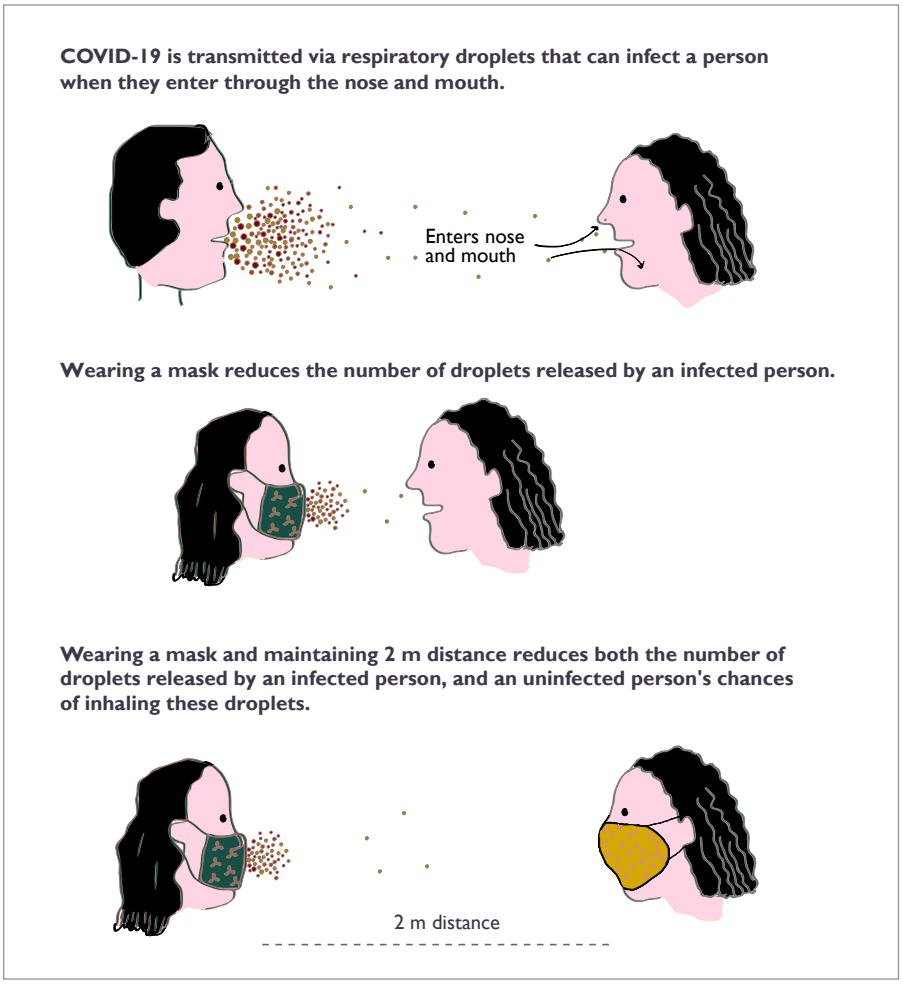

Fig. 1. Droplets released by an infected person can lead to spread of respiratory diseases like COVID-19. Wearing a mask, and maintaining physical distance limits the spread of the droplets, thus reducing risk.

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Parting thoughts

Understanding the origin and spread of infectious diseases is an important part of public health efforts. Apart from the biology of the pathogen, human behaviour can also determine how a disease spreads in a population. Therefore, the study and application of infectious disease epidemiology requires the collaboration of experts from different fields — epidemiologists, biologists, medical experts, and social scientists — as well as the cooperation and collective efforts of communities at risk.

Key takeaways

- Epidemiology is a branch of science that studies the distribution, causes, and possible control of (infectious and non-infectious) diseases in a population.
- Infectious diseases are caused by a variety of microorganisms (certain species of bacteria, viruses, fungi, and protists) and parasitic nematodes.
- Humans come in contact with a new disease-causing organism through their physical (air, water, soil) or biotic (wild or domesticated animals) environment.
- Infectious diseases can spread from one human to another through direct or indirect contact, animal vectors, or the physical environment.
- Depending on their causes, origins, and modes of transmission, public health efforts use different strategies to prevent the incidence of an infectious disease, and control its spread.
- The study and effective use of infectious disease epidemiology requires the collaboration of experts from different fields, as well as the cooperation and collective efforts of communities at risk.

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