Chapter 1
Epidemiology Models

ABSTRACT

Epidemic infectious diseases are occurring more often and spreading faster and farther than ever in many different regions of the world. The scientific community, in addition to its accelerated efforts to develop an effective treatment and a vaccination, is also playing an important role in advising policymakers of possible non-pharmacological approaches to limit the catastrophic impact of the pandemic. This chapter briefly describes the history of epidemic diseases and illustrates the classification of mathematical epidemic models, essentially various compartment models in the early days of the development of this subject.

INTRODUCTION

Communicable diseases have been an important part of human history. From the beginning of the recorded history, epidemics afflicted populations, causing many deaths, before gradually fading away and emerging again years after, possibly diminishing in severity as populations developed some immunity in course of time. An epidemic is a disease that affects a large number of people within a community or region. An endemic is a disease that affects a particular community or a country. A pandemic is an endemic that is spread across multiple countries all over the world. The outset of the pandemic goes back many centuries though Covid-19 is not the first pandemic of this century. SARS and Swine Flu were pandemics before Covid-19.

DOI: 10.4018/978-1-7998-8343-2.ch001

The first pandemic reported is the Athenian plague which occurred in 430-426 B.C during the war fought between Athens and Sparta. The cause of the plague was not known but it spread quickly because of the war which led to the overcrowding of the cities. Another outbreak was recorded a couple of centuries later called The Antonine Plague of 165-180 AD. It occurred in the Roman Empire and spread across Asia Minor, Egypt, Greece, and Italy. It inflicted a huge number of deaths in the Roman Military diminishing their global supremacy.

The Plague of Justinian or real plague is another prominent pandemic that originated in 541 AD in Ethiopia, moved to Egypt, and spread from Asia Minor to Africa and Italy and further to western Europe. The first symptoms were fever and fatigue. Later enlarged lymph nodes appeared in the groin area or armpits or beside ears. After this, the disease progressed rapidly causing death within days. It is estimated 30 to 50 million people, perhaps half the global population died from either disease or starvation. The Black Deaths (probably bubonic plague) originating from Asia spread all across Europe in several waves and is estimated to have consumed one-third of the population of Europe between 1346 and 1350. The disease recurred regularly in different parts of Europe for more than 300 years, notably the Great Plague of London of 1665-1666 before it disappeared gradually. This is the pandemic when the idea of quarantines emerged to avoid further spreading of the disease (Brauer, 2017).

In the early twentieth century, the Spanish flu epidemic played havoc, causing 50,000,000 deaths worldwide, and still, there are annual influenza seasonal epidemics that cause deaths up to 35000 globally. Some diseases have become endemic in some populations, especially in developing countries with the poor health care system. The most dreadful diseases that have inflicted a significant number of deaths are illustrated below.

A Brief History of Epidemiological Mathematical Models

The work of John Graunt in his 1662 book "Natural and Political Observations made upon the Bills of Mortality" initiated the study of infectious disease data. The Bills of Mortality were the weekly records of a number of deaths and causes in London parishes. He analyzed the various causes of death and gave a method of estimating comparative risks of dying from various diseases.

However, what is considered to be the first model in Mathematical epidemiology is given by Daniel Bernouilli (1700-1782) while he worked

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Humaira Nisar, Muhammad Burhan Khan, Wong Ting Yi, Yeap Kim Hoand Lai Koon Chun (2016). *International Journal of Disease Control and Containment for Sustainability (pp. 1-11).*

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