Plagues to Pandemics
Lecture Series Notes

• The notes to accompany the lecture series "Plagues and Pandemics" are provided for the educational use of the course participants. It is believed that images may be used for educational purposes and are sighted where necessary. Full lecture notes have been provided due to limited sight lines in the classroom.

• **Please note:** These notes provide the background material. The actual lectures will include content and explanations which may or may not represent in detail the notes provided. Expect the material to evolve throughout the course based on interests of the participants.

• Alan Mortimer PhD
The Struggle to Understand and Control Infectious Disease

Alan Mortimer PhD
Course Objectives

• Investigate the causes of infectious diseases and how they are spread
• Examine impacts of infectious diseases on society
• Trace the development of preventative measures
• Use this knowledge to analyse recent outbreaks
• Look at what may be expected in the future
About Me
About You
Course Outline

**Lecture 1: Introduction**
What is an infectious disease?
Infectious agents
Factors influencing the spread of infectious disease
Early history of disease
The plague

**Lecture 2: Acquired immunity and vaccination**
Smallpox: its role in history
How we develop immunity
Discovery of vaccination
Worldwide eradication of smallpox
Course Outline

**Lecture 3: Discovery of germs, cholera and epidemiology**
Our understanding of germs and infectious agents
Epidemiology: discovering infectious agents
Cholera: its discovery, its impacts and transmission
Typhoid

**Lecture 4: Polio and the role of disease specific charities**
Polio: a disease of the rich
Polio vaccine an American and a Canadian story
The foundation of vaccine safety
The role of disease specific foundations
Lecture 5: Influenza and pandemics
Influenza and the 1918 epidemic
The influenza virus and how viruses make us ill
Seasonal influenza and pandemic influenza
Anti-viral treatment
How vaccines are made

Lecture 6: Current issues
Neglected Diseases: diseases of the developing world: including dysentery/rotavirus & malaria
Ebola & Zika
HIV and AIDS
Course Format

• Lecture and Discussion
  – Please hold questions until there is a natural break (write them down)
  – Time will be set aside for answering questions and for discussion

• Break at mid point
  – May vary slightly depending upon material

• Other topics/critical issues
  – If there are specific questions or topics related to the course material you wish to have covered please let me know today (in a note). I will try to work them in.

Questions ??
What is an Infectious Disease?

• *Disease*: a condition of the living animal or plant body or of one of its parts that impairs normal functioning and is typically manifested by distinguishing signs and symptoms (Miriam Webster)

• *Infectious Disease*: Infectious diseases are caused by pathogenic microorganisms, such as bacteria, viruses, parasites or fungi; the diseases can be spread, directly or indirectly, from one person to another. (WHO)
Infectious Agents

• Primary types:
  – Virus
    • Smallpox, influenza
  – Bacteria
    • Tuberculosis, cholera
  – Parasite
    • Malaria
Bacteria

- Generally single cell organism
- Do not contain a nucleus
- Can reproduce
- May have several different forms throughout their life cycle
- Most can live outside the body
- Antibiotics generally prevent reproduction

Cholera Bacteria
Virus

• 10 to 100 times smaller than a bacteria
• No cell nucleus
• Must enter another cell to reproduce
• Infective agent (viron) contains only RNA or DNA (sometimes a few enzymes)
• Surrounded by a virus membrane
Virus

- Examples:
  - DNA Virus: Influenza (lecture 5)
  - RNA Virus: HIV (lecture 6)
- Antibiotics are ineffective
Parasites

- Single or multicellular
- Multiply either within a cell (malaria) or within tissue (shistosomiasis)
- Some can be treated with antibiotics
Historical Perspective

- Infectious disease became prevalent when people started living in close proximity.
- Sort of equilibrium was developed until mass movements of people began.
Historical Perspective

- Plagues were reported in biblical times, however our best early records are from Europe in the middle ages.
- Europe suffered major depopulation as the result of bubonic plagues.
- Up to one third of the population was estimated to have died as a result of the 1300’s epidemic.
Historical Perspective

- In fact plague kept the population at a somewhat constant level throughout more than a century
Plagues and Conquest

• Spanish conquest of Central (Aztec) and South (Inca) America
• Spanish were carriers of smallpox due to endemic nature in Europe
• Cultures were completely wiped out in 50 years
Plagues and Conquest

- In exchange syphilis and gonorrhea were carried back from the new world to a naive population
- Persisted as a significant public health issues well into the 20th century
Plagues and Cities

- Yellow fever has led to depopulation of entire sections of populated areas.
- The most exclusive part of Buenos Aries was abandoned as a result of yellow fever and remained vacant for more than 50 years.
IN MEMORIAM

A LAS VICTIMAS DE LA FIEBRE AMARILLA DEL AÑO 1871 Y A LOS HEROICOS VECINOS DE SAN TELMO QUE COMBATIERON LOS CON TORNOSS DANTESCOS DE ESA EPIDEMIA.

1871 - 1971

JUNTA DE ESTUDIOS HISTORICOS DE SAN TELMO
Geographic Population Distribution

- Parts of Mali in sub-Saharan Africa are not populated due to prevalence of malaria
- The area is approximately equal to the province of New Brunswick
Geographic Population Distribution

- HIV/AIDS has infected up to 40% of the population in central Africa
HISTORIC DEVELOPMENT OF INFECTIOUS DISEASES
Early Stages

• Human life is believed to have started in the warm, moist environments of the African Rift Valley and most probably similar environments in Asia
  – Requires little protection for the human (e.g. clothes, fire etc.)
  – Also very suitable for other species:
Early Stages

• Parasites do not need protection, many species can survive well without human or animal host
• Here warm blooded hosts become an opportunity rather than a necessity
• Led to populations that were chronically infected by a wide variety of infectious agents

It was warmer and wetter in the rift valley
Early Stages

- As humans moved into temperate climate zones general level of infection became less
- Infectious agents needed more complex life cycles and structures to survive
Early Migration
• As agriculture took over new means of transmission were possible

• Probable source of ‘Plagues of Egypt’

• Similar events in Asia
• However it was the development of cities that provided to opportunity for direct transmission from person to person.

• Start of epidemics as we know them now.

Medieval London
Case Study: Black Death

- Black Death or Bubonic Plague is caused by the bacteria *yersinia pestis*
  - Very high fatality rate: 2/3 within 4 days
  - Primary transmission is via rats and a rat louse
  - Secondary transmission via droplets after lung infection.
    - Much more contagious
    - Much more virulent
Case Study: Black Death

Sylvatic Cycle

Bubonic Plague

Pneumonic Plague Epidemic

Urban Cycle

Pathways

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<td>Usual</td>
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Black Death

• Bacteria congregate in the lymph nodes and multiply rapidly leading to grossly enlarged node in groin or neck

• When bacteria multiply in the blood stream it leads to vascular damage
  – Gangrene
  – Black fingernails and toes
  – General vascular breakdown
Case Study: Black Death

- Humans can develop lung infection and spread by coughing
- This is much more rapid that waiting for animal life cycles and probably led to the rapid transmission of plagues

- Crowded environment and no known cause or prevention measure led to incredible death rates
Not the first and not the last

- First major occurrence during the Byzantine Empire 541-542 AD
  - Developed cities
  - Extensive trade routes
- Black Death 1347-51
  - Originated in Asia and followed Silk Road
  - Cities and first instance of extensive inter-city trade in Europe
Case Study: Black Death

- After the initial outbreaks a cyclic pattern developed
- Outbreaks in England 1498, 1535, 1543, 1563, 1589, 1603, 1625, and 1636, and ended with the Great Plague in 1665.

Plague Riot in Moscow, Wikipedia
Incredible Death Rates

- Half the population of China
- One third of the population of Europe
- One eighth of the population of Africa
- 25% of the entire population of the world
- In less than 4 years
Case Study: Black Death

“Lord! how empty the streets are and melancholy, so many poor sick people in the streets full of sores; and so many sad stories overheard as I walk, everybody talking of this dead, and that man sick, and so many in this place, and so many in that.”

Samuel Pepys, Journal of the Plague Year, 1665
Not the first and not the last

- ‘Third Pandemic’ started in 1855 in China
  - Killed more than 12 million in China and India
- Reached North America in 1900 San Francisco
- Current reservoir primarily in sub-Saharan Africa
- Outbreak in Surat, India in 1994 caused 54 deaths
  - Over 300,000 fled the area
Plague Today

• Bacteria is relatively easy to treat with several standard antibiotics
  – Some concern with disease resistance (one case)

• Remains present, but is not a primary concern
  – 500 – 2000 cases/year
Dozens placed in quarantine after China plague death

Plague affects wild rodents and is then spread by fleas.

Part of a city in north-west China has been sealed off and dozens of people placed in quarantine after a man died of bubonic plague, state media say.

The man died in Yumen city, Gansu province, on 16 July.

A total of 151 people have been placed under observation, Xinhua news agency says. Authorities have isolated a part of the city centre and three sections of Chijn town which is an hour away.

The man was believed to have caught the infection after contact with a marmot.

Marmots are large, squirrel-type rodents that live in mountainous areas.

The victim is reported to be a 35-year-old man who had fed a dead marmot to his dog.

The deputy head of the hospital where the man died told reporters that the victim had arrived with an increased heart rate and seemed to be slipping into shock. The hospital has since been quarantined.
What Did We Learn

• Change in the living environment
• Change in travel patterns
• Person to person transfer is fastest

• Impacted progress of development; certainly in Europe: political, social, economic
Concept of the Day

- Infectious Disease in an Ecological and Evolutionary Context
Concept of the Day

• Infectious diseases are all caused by an organism:
  – Sub- cellular e.g. virus
  – single celled e.g. bacteria
  – multicellular e.g. parasite

• In order to survive they need to adapt to their environment
In Other Words

• They must not kill off their host before they can reproduce.
• They must be able to spread from one host to another
• They must be able to adapt to changing circumstances
• In most cases epidemics and plagues are caused by an infectious agent entering (finding?) a new ecological niche
In Other Words ...

- They will take advantage of an ecological niche
- Particularly where defences are limited
- They have the evolutionary advantage of a very short life span
Plagues and Pandemics

• Plagues, epidemics and pandemics are usually caused when an existing infectious agent finds a niche where there is limited immunity within the population

• Most commonly by:
  – Transforming or mutating sufficiently
  – Arriving in a location where it has not been seen before