



Introduction to Pathology of Disease NCA&T Biol 342, NCCU Special Course

Module 3: The Basics of Pathology

Infectious Disease



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Agenda

- Introduction
 - » Most Common Infectious Diseases to Cause Death
- Agent-Host-Environment Factors
 - » That Lead to Disease
- Transmission Basics
- Infectious Diseases Throughout History
 - » Some Types of Microbes
 - » Diagnosis
 - » Prevention
 - » Control



Introduction

Infectious diseases can be caused by several different classes of pathogenic organisms (commonly called germs). These are viruses, bacteria, protozoa, and fungi. Almost all of these organisms are microscopic in size and are often referred to as **microbes** or **microorganisms**.

Infectious diseases also include *emerging infectious diseases*; diseases that have newly appeared (e.g., Middle East Respiratory Syndrome) or have existed but are rapidly increasing in incidence or geographic range (e.g., drug-resistant tuberculosis (XDR TB) and COVID-19)

Most often, illness is directly caused by the infectious agent or its toxic product, which arises through transmission from an infected person, an infected animal, or a contaminated inanimate object to a susceptible host.

Infectious disease control and prevention relies on a thorough understanding of the factors determining transmission

Shifting Trends in Cause of Death in the United States

Table. Number of Deaths for Leading Causes of Death, US, 2015-2020^a

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Cause of death	No. of deaths by year					
	2015	2016	2017	2018	2019	2020
Total deaths	2 712 630	2 744 248	2 813 503	2 839 205	2 854 838	3 358 814
Heart disease	633 842	635 260	647 457	655 381	659 041	690 882
Cancer	595 930	598 038	599 108	599 274	599 601	598 932
COVID-19 ^b						345 323
Unintentional injuries	146 571	161 374	169 936	167 127	173 040	192 176
Stroke	140 323	142 142	146 383	147 810	150 005	159 050
Chronic lower respiratory diseases	155 041	154 596	160 201	159 486	156 979	151 637
Alzheimer disease	110 561	116 103	121 404	122 019	121 499	133 382
Diabetes	79 535	80 058	83 564	84 946	87 647	101 106
Influenza and pneumonia	57 062	51 537	55 672	59 120	49 783	53 495
Kidney disease	49 959	50 046	50 633	51 386	51 565	52 260
Suicide	44 193	44 965	47 173	48 344	47 511	44 834

^a Leading causes are classified according to underlying cause and presented according to the number of deaths among US residents. For more information, see the article by Heron.⁴ Source: National Center for Health Statistics. National Vital Statistics System: mortality statistics (<http://www.cdc.gov/nchs/deaths.htm>). Data for 2015-2019 are final; data for 2020 are provisional.

^b Deaths with confirmed or presumed COVID-19, coded to *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* code U071 as the underlying cause of death.

Shifting Trends in Cause of Death in the

World in 2020

Top Five Causes of Death Globally

You're viewing total deaths. View [reported deaths](#) instead

Rank	Cause	Estimated Deaths Since the Start of 2020	Estimated Percent of All Deaths Since the Start of 2020	Estimated Deaths per 100,000
1	Ischemic heart disease	15,220,000	14.8%	196.7
2	Stroke	10,920,000	10.6%	141.1
3	COVID-19	10,000,000	9.6%	129.3
4	Chronic obstructive pulmonary disease	5,465,000	5.2%	70.6
5	Lower respiratory infections	4,150,000	4.0%	53.7

Note: Based on data from the Institute for Health Metrics and Evaluation, reported COVID-19 is the fourth leading cause of death globally and total COVID-19 deaths make it the third leading cause of death. Total deaths include excess deaths—the number of deaths estimated as attributed to COVID-19, including unreported deaths—as well as reported deaths. Deaths reflect counts or estimates through August 31, 2021.

Table: IHME/Christopher Troeger • Source: IHME
01/14/2026

Think Global Health

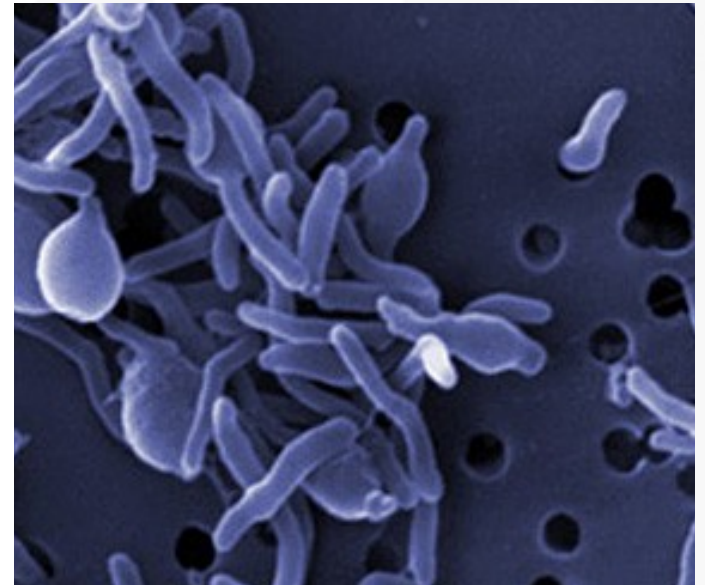


Transmission of Infectious Diseases

There are a number of different routes by which a person can become infected with an infectious agent. For some agents, humans must come in direct contact with a source of infection, such as contaminated food, water, fecal material, body fluids or animal products. With other agents, infection can be transmitted through the air.

The route of transmission of infectious agents is an important factor in how quickly an infectious agent can spread through a population.

An agent that can spread through the air has greater potential for infecting a larger number of individuals than an agent that is spread through direct contact.



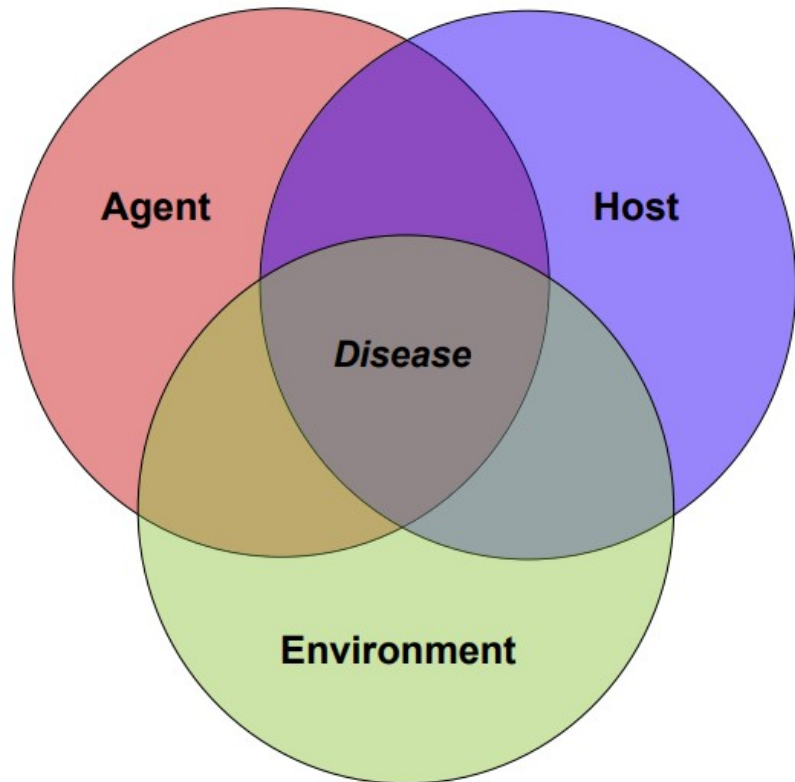


The Epidemiological Triad: Agent-Host-Environment

A classic model of infectious disease causation, the epidemiological triad, envisions that an infectious disease results from a combination of agent (pathogen), host, and environmental factors.

Infectious agents may be living parasites (helminths or protozoa), fungi, or bacteria, or nonliving viruses or prions.

Environmental factors determine if a host will become exposed to one of these agents, and subsequent interactions between the agent and host will determine the exposure

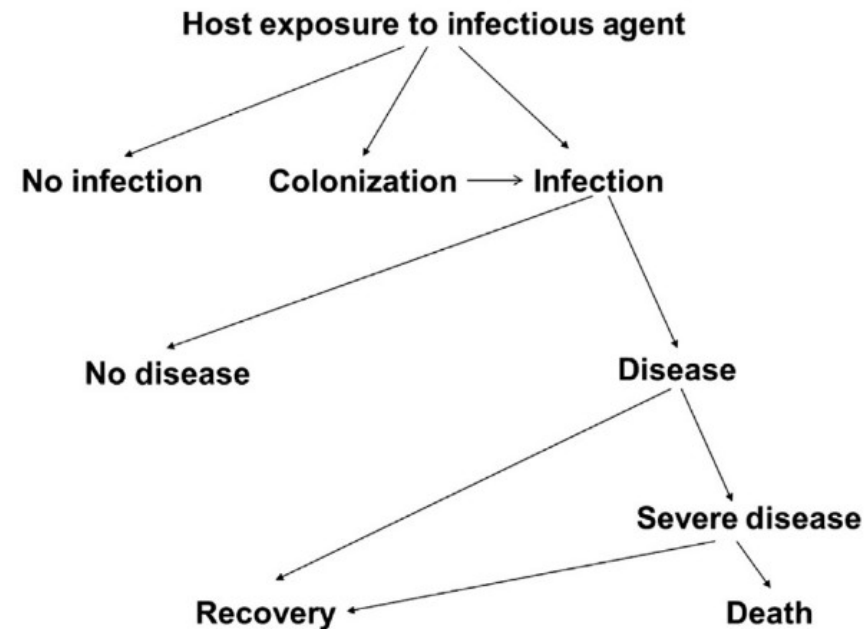


Potential outcomes of host exposure to an infectious agent

Agent and host interactions occur in a cascade of stages that include infection, disease, and recovery or death.

Following exposure:

- 1) The first step is often **colonization**, the adherence initial multiplication of a disease agent at a portal of entry such as the skin or the mucous membranes of the respiratory, digestive, or urogenital tract.
- 2) **Infection** will always cause some disruption within a host, but it does not always result in **disease**.
- 3) Disease indicates a level of disruption and damage to a host that results in subjective **symptoms** and objective **signs** of illness.
- 4) Disease indicates a level of disruption and damage to a host that results in subjective symptoms and objective signs



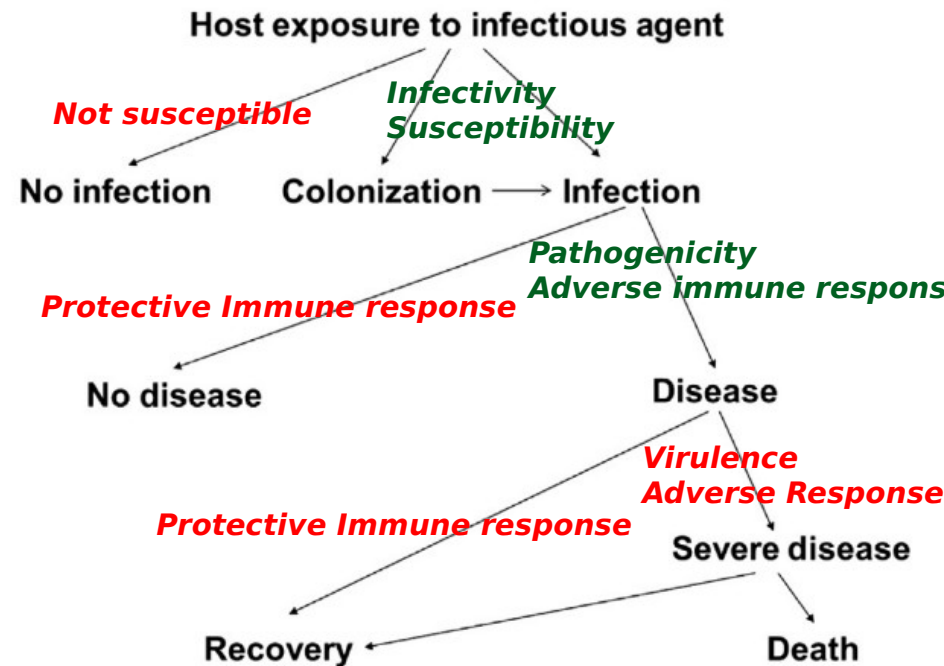


Host Factors vs. Infectious Agent Factors

The outcome of exposure to an infectious agent depends upon multiple host and infectious agent factors that determine individual susceptibility to infection and disease

Susceptibility refers to the ability of an exposed individual to resist infection or limit disease as a result of their biological makeup.

- **Factors:** innate, genetic factors, acquired immunity, vaccine
- **Immunity** is affected by extremes of age, stress, pregnancy, nutritional status, and underlying diseases
- **Barriers:** healthy intact skin, the flushing action of tears, and the trapping action of mucus are





Environmental factors facilitating emergence and/or spread of specific infectious diseases

	Environmental factor	Mechanism	Disease
<i>Climate & weather</i>	Above-normal rainfall	Incr. rodent reservoir	Hantavirus
<i>Natural disaster</i>	Tornado	Environmental disruption	Mucormycosis
<i>Infrastructure</i>	No Water treatment plant	Lack of microbial barriers	cryptosporidiosis
<i>Change in land use</i>	Deforestation	Creation of vector breeding sites	Malaria
<i>Industry & technology</i>	Medical technology	Inappropriate use of antibiotics driving genetic change	Antibiotic-resistant infections
<i>Travel & commerce</i>	Visiting friends and family	Import of virus	COVID-19
<i>Politics</i>	Government response	Denial of viral etiology epidemic	HIV/AIDS or COVID-19
<i>economics</i>	Low income	Lack of protection against vector	Dengue
<i>War and conflict</i>	Displaced persons camps	Inadequate WASH	Cholera
<i>Social/behavioral</i>	Sexual practices	High-risk sexual behavior	HIV-1 infection

Host Factors vs. Infectious Agent Factors (continued)

Infectivity is the likelihood that an agent will infect a host, given that the host is exposed to the agent.

Pathogenicity refers to the ability of an agent to cause disease, given infection, and **virulence** is the likelihood of causing severe disease among those with disease.

- Virulence reflects structural and/or biochemical properties of the agent.

Comparison of innate and adaptive immunity

Immune Response:

<i>Innate Immune Response</i>	<i>Adaptive Immune Response</i>
Immediate response; initiated within seconds	Gradual response; initially generated over 3–4 days (primary response)
Targets groups of pathogens	Targets-specific pathogens
No memory	Memory



Infection Transmission

Direct Contact

Agent transferred from reservoir or host

- Person-to-Person
- Direct spread of droplets
- Animal to Person (e.g., bite)
- Mother to Unborn Child
 - In utero, perinatal



Indirect Contact

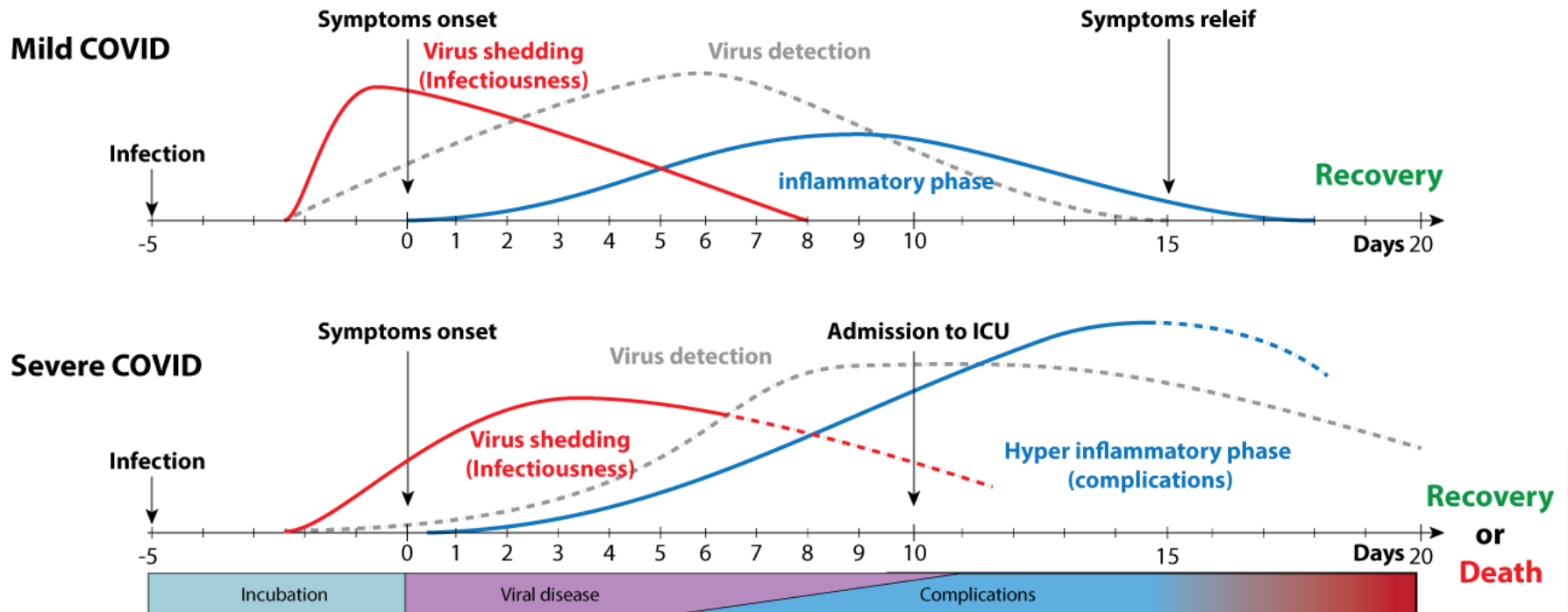
Agent transferred indirectly from reservoir or infected host

- Mechanical
 - Touching an infected inanimate object then yourself without thoroughly washing.
- Biological
 - Biological Vector
 - Intermediate Vector (e.g., flea, tick)
- Airborne (sneeze, cough)



Transmission Basics

A unique characteristic of many infectious diseases is that exposure to certain infectious agents can have consequences for other individuals, because an infected person can act as a source of exposure.

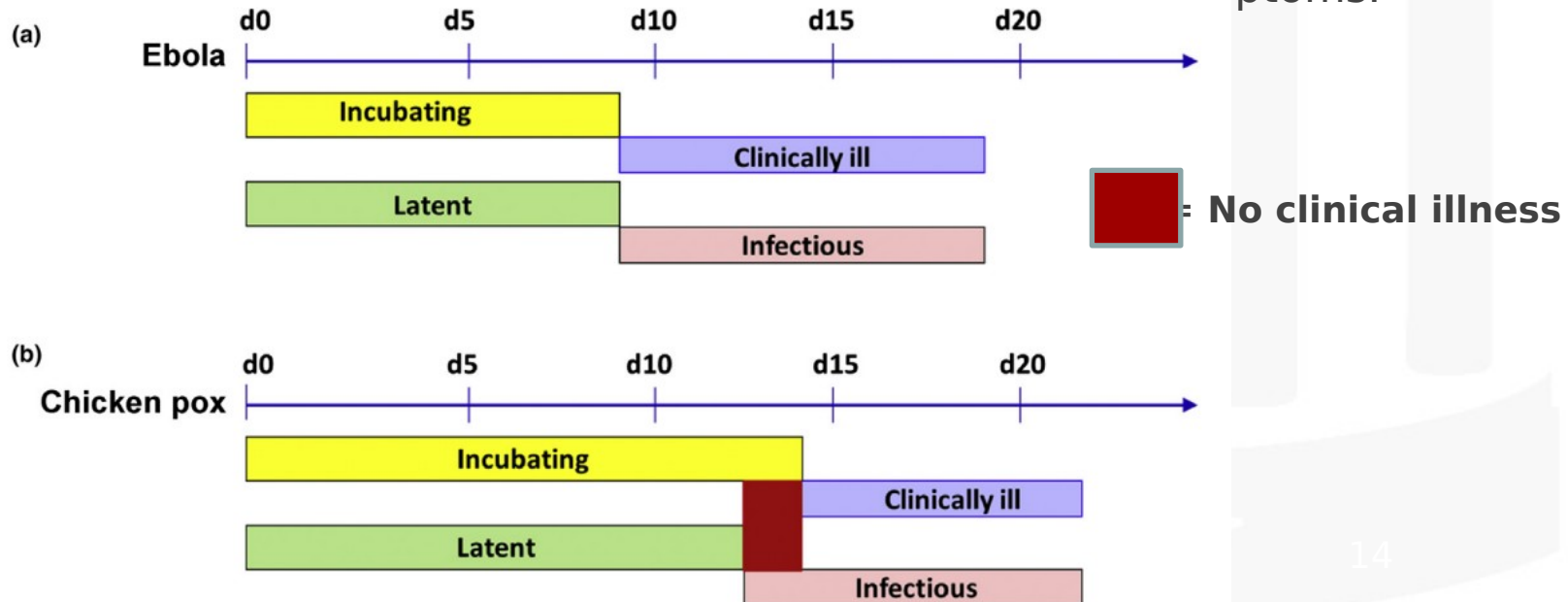


Transmission Basics

With respect to disease, the incubation period is defined as the time from exposure to an infectious agent until the time of first signs or symptoms of disease.

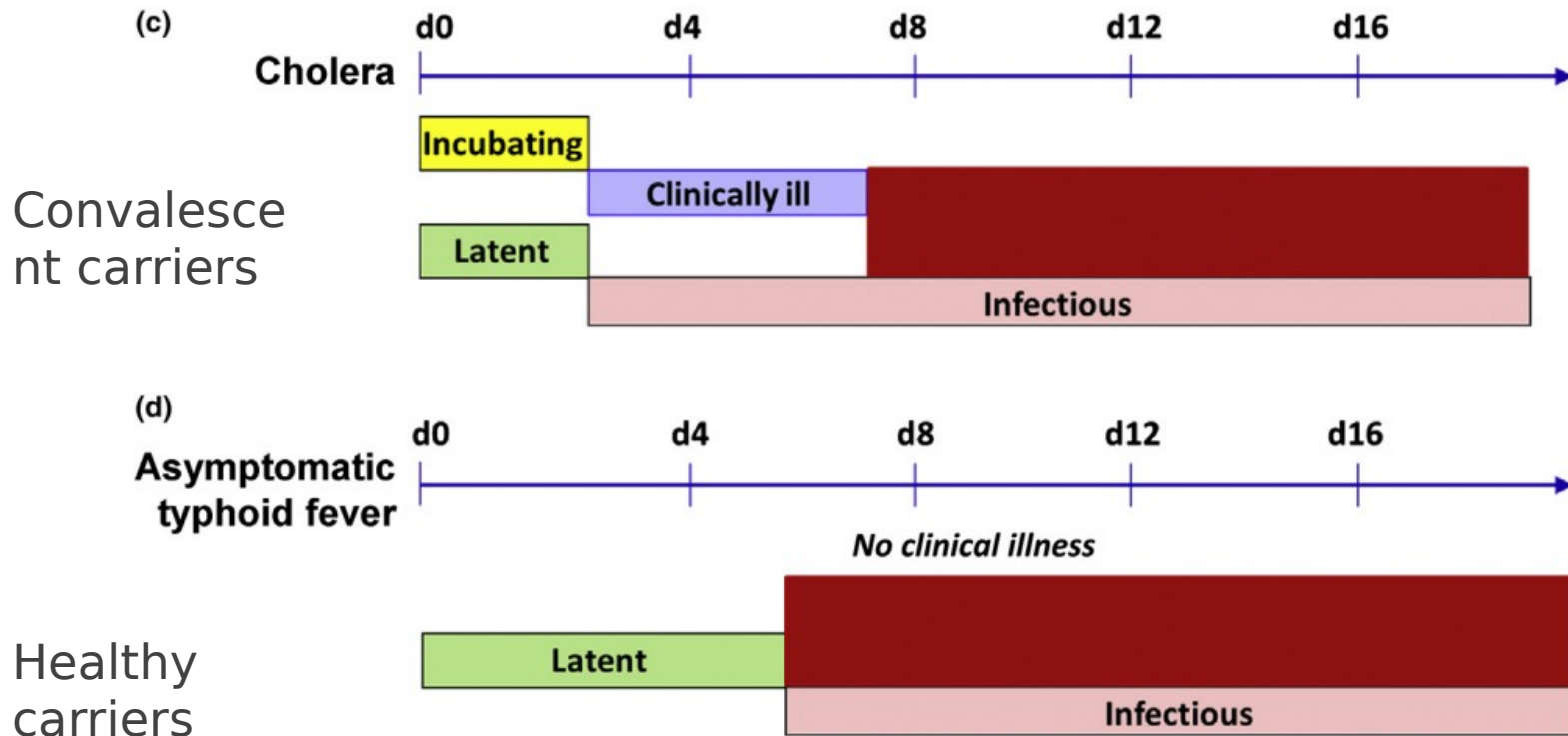
The efforts to control an outbreak through contact tracing and quarantine require knowledge of the latent, latent, and infectious period.

Most often, incubation period is followed by the period of clinical illness which is the duration between first and last disease signs or symptoms.





Transmission Basics (continued)



A **carrier** is, by definition, an infectious individual who is not showing clinical evidence of disease and, thus, might unknowingly facilitate the spread of an infectious agent through a population.

Dynamics of Infectious Diseases within Populations

Endemic: Constant presence of a disease or infectious agent within a given geographic area. The usually prevalence of a given disease within such an area (HIV, MERS, malaria).

Epidemic: Occurrence in a community or region of cases of an illness or outbreak clearly in excess of expectancy (Hep A, salmonella).

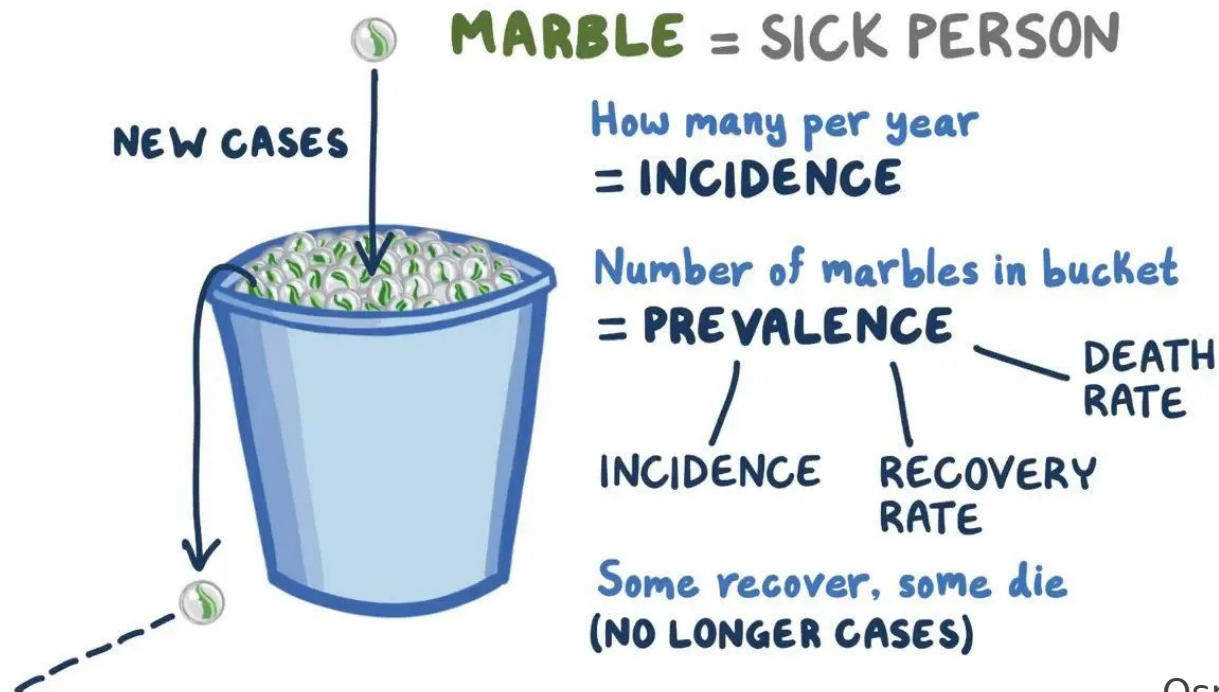
Pandemic: Occurring over a wide geographic area and affecting an exceptionally high proportion of the population (Covid-19).

Epidemics and pandemics have always had major social and economic impacts on affected populations, but in our current interconnected world, the impacts are truly global. This has been clearly demonstrated by the COVID-19 pandemic that began in 2020. Infections in one region can easily spread to another.



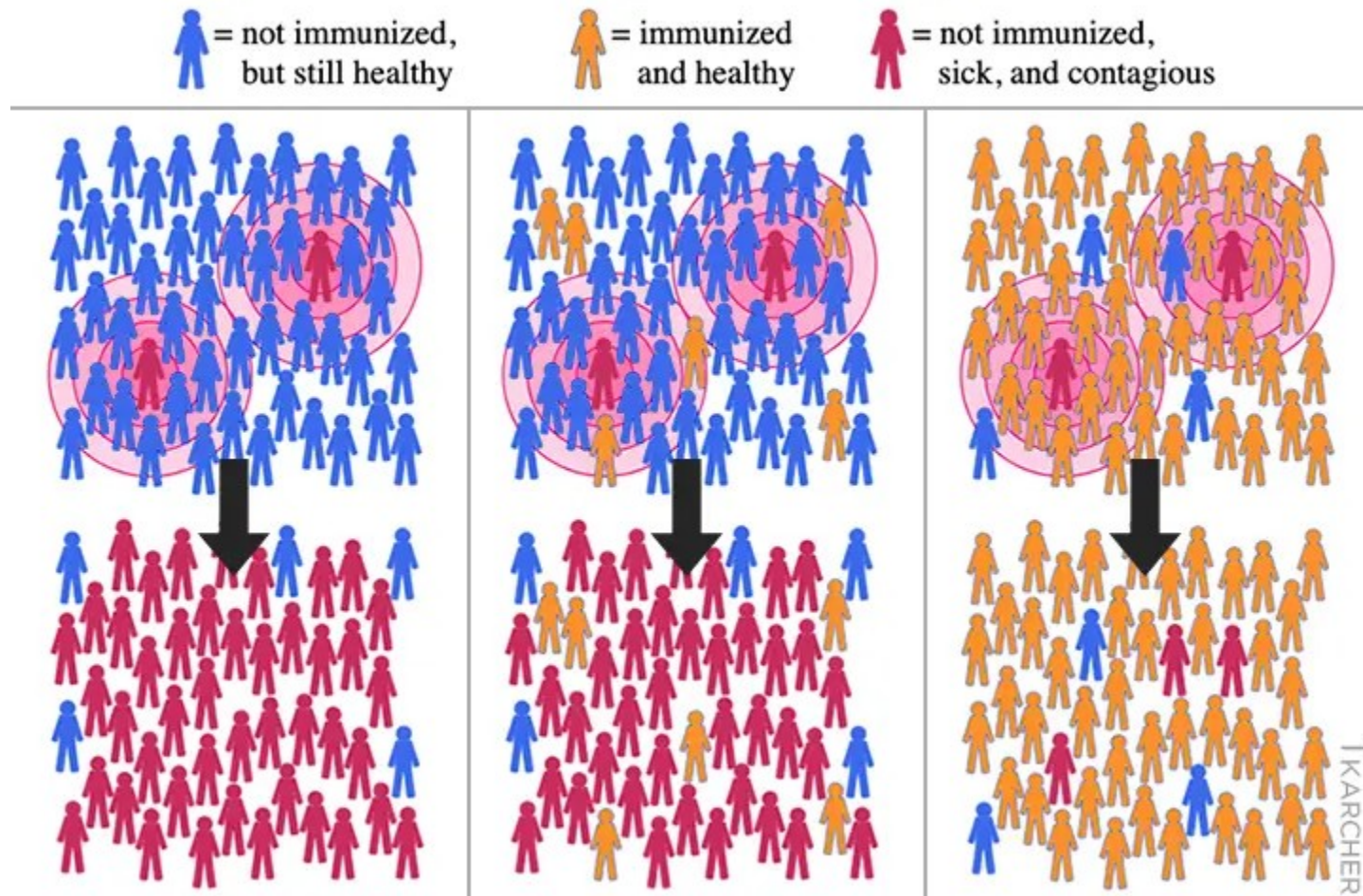
Dynamics of Infectious Diseases within Populations

Two fundamental measures of disease frequency are **prevalence** and **incidence**.





Herd immunity occurs when one is protected from infection by immunization occurring in the community.



Infectivity

Infectivity is the likelihood that an agent will infect a host, given that the host is exposed to the agent.

Virulence is the likelihood of causing severe disease among those with disease. Virulence reflects structural and/or biochemical properties (e.g., receptor binding, toxins produced) of an infectious agent.

Infective doses are cited as required for the condition to affect a person.

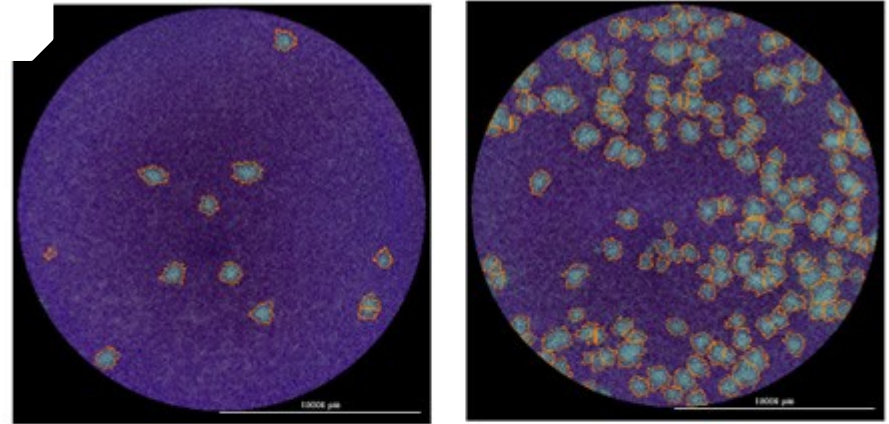
Disease

Inhalation Anthrax
Pneumonic Plague
Ebola

Infective Dose

8,000 to 10,000 spores
<100 organisms
1-10 plaque forming

Infective dose is



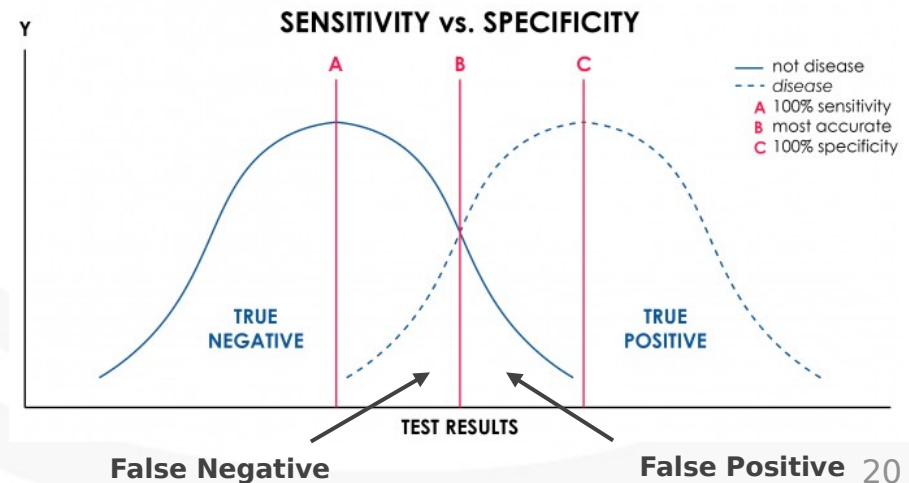
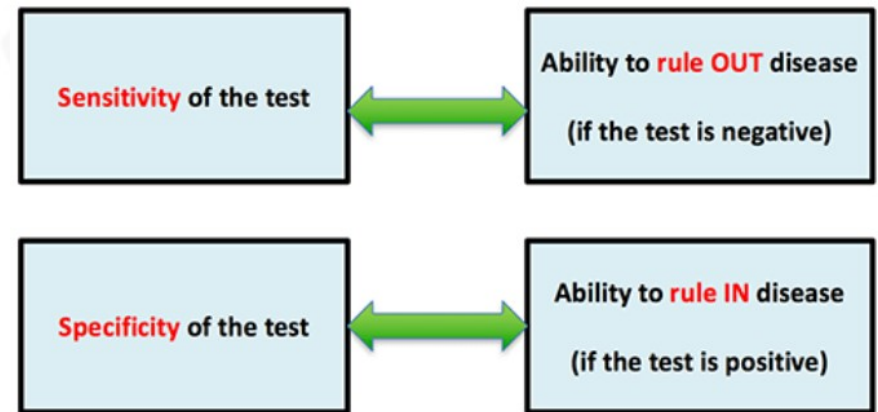
Metric	Sample 1	Sample 2
Plaque Count	12	165
AVG Plaque Area (μm^2)	7.43E+05	6.15E+05
Total Plaque Area (μm^2)	8.91E+06	1.02E+08

Plaque assays are a common type of infectivity assay, used to count discrete “infectious centers.”



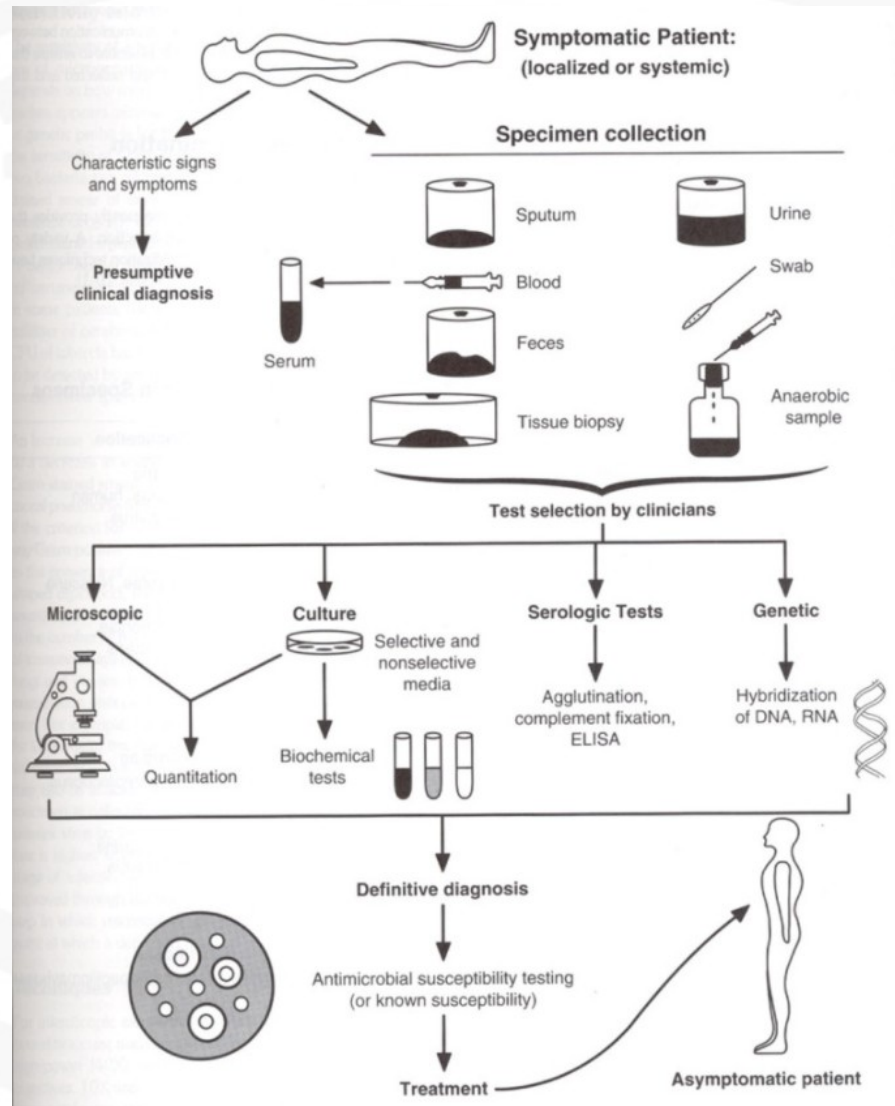
Infectious Disease Diagnosis

- Proper diagnosis of infectious illnesses is essential for both appropriate treatment of patients and carrying out prevention and control surveillance activities.
- Two important properties that should be considered for any diagnostic test utilized are sensitivity and specificity.
- **Sensitivity** refers to the ability of the test to correctly identify individuals infected with an agent ('positive in disease').
- **Specificity** is the ability of the test to correctly identify individuals not infected by a particular agent
- Often, screening tests are highly sensitive (to capture any possible cases), and confirmatory tests are more specific (to rule out false-positive screening tests).



Infectious Disease Diagnosis

- Direct Examination and Molecular Techniques:** Direct examination of specimens reveals gross pathology. Microscopy may identify microorganisms in specimens or with specific probes to identify genus- or species-specific DNA or RNA sequences. PCR is the most widely used method for microbial nucleic acid detection
- Culture:** Isolation of infectious agents frequently requires specialized media. Nonselective (noninhibitory) media permit the growth of many microorganisms. Selective media contain inhibitory substances that permit the isolation of specific types of microorganisms to identify.
- Microbial Identification:** Colony and cellular morphology may permit preliminary identification. Growth characteristics under various conditions, utilization of carbohydrates and other substrates, enzymatic activity, immunoassays, and genetic probes are also used.
- Serologic diagnosis:** A high or rising titer of specific antibodies to an agent may suggest or confirm a diagnosis.



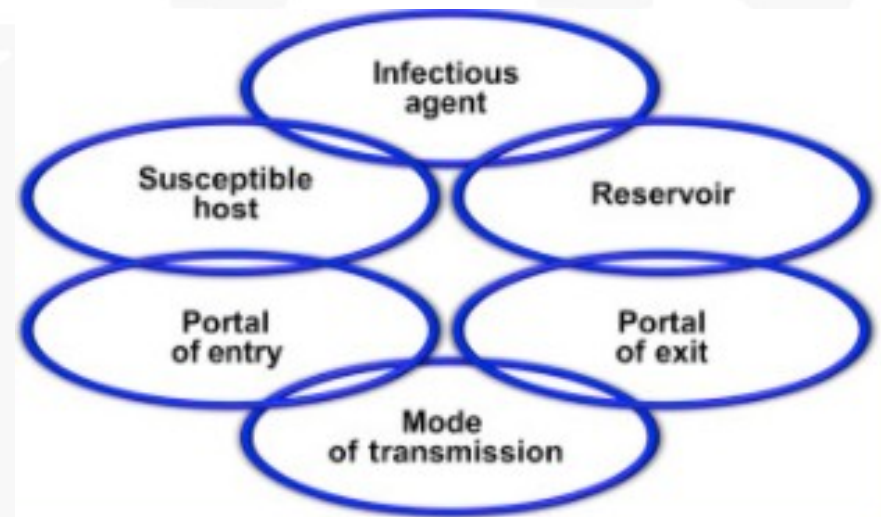


The Infectious Agent and Its Reservoir

The Chain of Infection (or transmission)

One way to visualize the transmission of an infectious agent through a population is through the interconnectedness of six elements linked in a chain.

The chain starts with the infectious agent residing and multiplying in some natural reservoir; a human, animal, or part of the environment such as soil or water that supports the existence of the infectious agent in nature.



The classic example of a human reservoir is the cook Mary Mallon (Typhoid Mary); an asymptomatic chronic carrier of *Salmonella enterica* serovar Typhi who was linked to at least 53 cases of typhoid fever.

Hierarchy of public health efforts targeting infectious diseases

Public health interventions targeting infectious diseases:

1. **control**, the reduction of disease incidence, prevalence, morbidity or mortality to a locally acceptable level; continued intervention measures are required to maintain the reduction (e.g. diarrheal diseases)
2. **elimination of disease**, reduction to zero of the incidence of a specified disease in a defined geographical area (e.g. neonatal tetanus)
3. **elimination of infections**, reduction to zero of the incidence of infection caused by a specific agent in a defined geographical area as a result of deliberate efforts; continued measures to prevent re-establishment of transmission are required (e.g. poliomyelitis)
4. **eradication**, permanent reduction to zero of the worldwide incidence of infection caused by a specific



Infectious Diseases in History

1346, during a plague outbreak, Mongols catapulted victims into a city.

1520, Narvaez expedition to Aztec empire spread smallpox.

1763, during French and Indian War (Pontiac's Rebellion), blankets and handkerchiefs were given to Native Americans.





Bacterial Infections



A single-celled organism.

- ☐ Under certain circumstances some can transform into spores.
- ☐ Bacteria are larger than viruses and are capable of reproducing on their own.
- ☐ Beneficial bacteria live in the human gastrointestinal (GI) tract and play an important role in digestion and immunity.

Bacteria can infect any area of the body. The disease-causing method can occur in one of two ways:

- ☐ Invading host tissues, and
- ☐ Producing poisons (toxins)

Pneumonia, dermatitis, meningitis, and food poisoning are few examples.

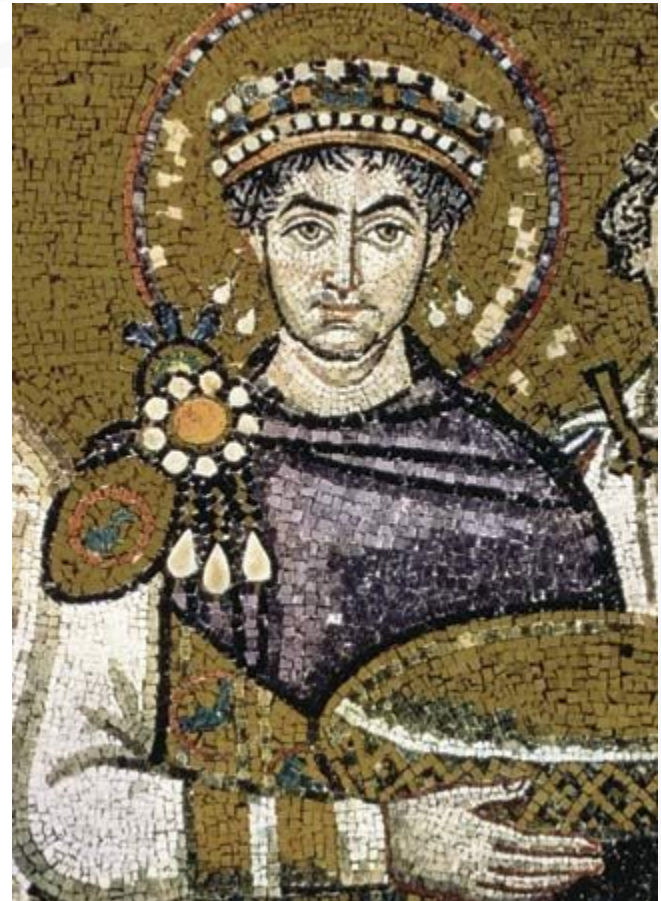
- ☐ Certain gram-negative bacterium, like *E. coli* and *Salmonella* can be present in uncooked foods.
- ☐ Bacterial skin infections are usually caused by gram-positive strains of *Staphylococcus* and *Streptococcus* or other organisms.
- ☐ Many sexually transmitted diseases (STDs) are caused by harmful bacteria (*Chlamydia*, *Gonorrhea*, *Syphilis*, *Bacterial vaginosis*).

Bubonic Plague in History

Bubonic plague is a bacterial infection spread mostly to humans by infected fleas that travel on rodents. Called the Black Death, it killed millions of Europeans during the Middle Ages.

The first recorded bubonic plague epidemic ravaged the Byzantine Empire during the sixth century. It was named the Plague of Justinian after emperor Justinian I, who was infected but survived through extensive treatment.

It gets its name from the swollen lymph nodes (buboes) caused by the disease. The nodes in the



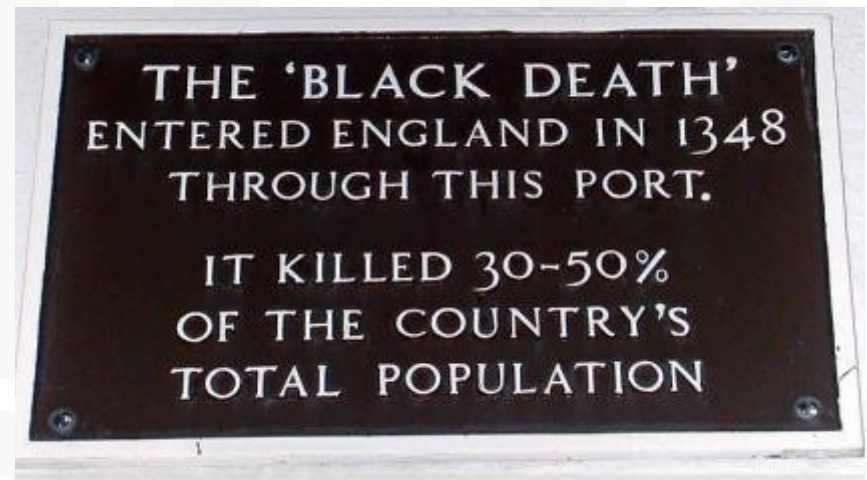


Bubonic Plague in History

Plague is an infectious disease caused by a specific type of bacterium called *Yersinia pestis*. *Y. pestis* can affect humans and animals and is spread mainly by fleas (black rat flea).



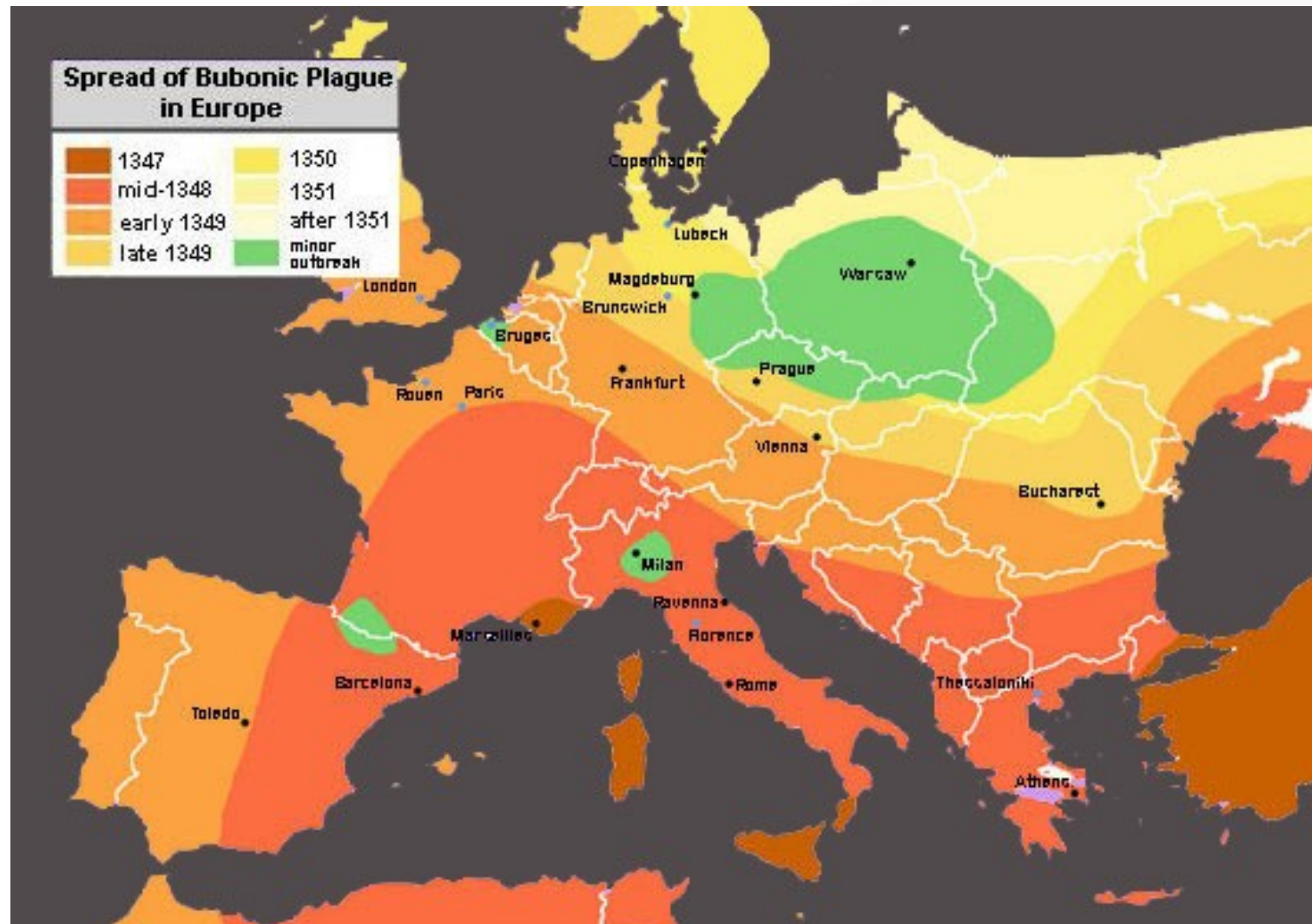
In the late Middle Ages (1340–1400) Europe experienced the most deadly disease outbreak in history when the **Black Death**, the infamous pandemic of bubonic plague, hit in 1348, killing a third of the human population.



Bubonic plague still occurs throughout the world and in the



Movement of the Black Plague





Bubonic Plague in History

In 1665-1666, the Plague hit London killing an estimated 100,000 people; 20% of London's population



The bubonic plague can be treated and cured with antibiotics now. If you are diagnosed with bubonic plague, you'll be hospitalized and given antibiotics. In some cases, you may be put into an isolation unit



Plague

- **Bubonic:** From rats by the bite of an infected fleas.
- **Septicemic:** When plague bacteria multiplies in the blood stream.
 - Spreads rapidly until hemorrhagic pneumonia involves entire lung area.
- **Pneumonic:** May result from septicemic form or from inhalation of the organism.
 - Pneumonic affects the lungs and is spread person to person by way of cough droplets.



Plague

Type

- Bubonic:
- Septicemic:
- Pneumonic:

Infection of:

Lymph nodes
The blood
Lungs





Bubonic Plague

- From the bite of the black rat flea.
- “Black Death” transmittable by bite of an infected flea or person to person by respiratory route.
- This can include domesticated animals, i.e., cats to wild animals, i.e., rabbits, rats, squirrels.
- Characterized by buboes which appear.





Septicemic Plague

This form of the disease occurs when the bacteria multiply in the blood, causing bacteremia and severe sepsis.

Primary septicemic plague results from direct inoculation of the bacteria into the bloodstream, typically via the bite of an infected animal or flea or direct contact with infected tissues.

Secondary septicemic plague occurs when there is progression of disease and dissemination of bacteria following bubonic presentation.



Septicemic Plague

Septicemic plague is rarely transmissible human to human but may become transmissible if the disease reaches the pneumonic stage.

Septicemic plague, either primary or secondary, has approximately 40% mortality when treated, and in untreated cases, the mortality is 100%.





Pneumonic Plague Symptoms

Spread person to person by way of cough droplets.

- Cough with bloody sputum
- Difficulty breathing
- High fever
- Nausea/vomiting
- Weakness

Progresses quickly leading to respiratory failure and shock in 2 days of infection.

Initiate antibiotics within a day of signs and symptoms or it is likely to be fatal. May result from septicemic form or from inhalation of organism.



Plague Symptoms

Symptoms: High fever, headache, general aches, extreme weakness, glandular swelling, pneumonia, hemorrhages in skin and mucous membranes possible, extreme lymph node pain.

Incubates: Bubonic, 2-6 days; unvaccinated: few days longer if vaccinated. Pneumonic: 1 to 6 days.

Fatal: Bubonic if untreated; Pneumonic if untreated.

Treatment: Tetracycline with streptomycin.



Plague Complications

Death

Gangrene

Meningitis





Plague Risk Factors

Where you're located



Your occupation

Hobbies





Pneumonic Plague Prevention

Affects lungs, least common form but most deadly.

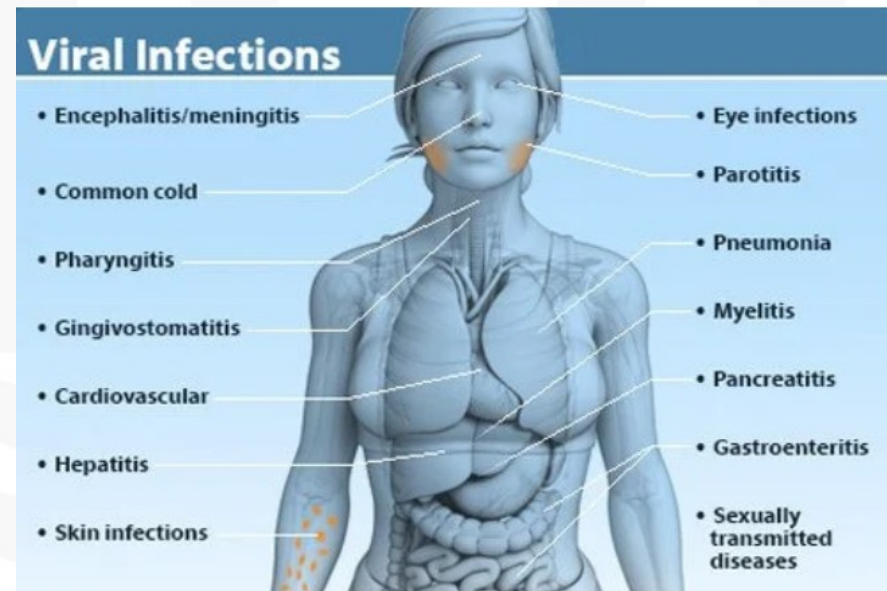
- Spread person to person through cough droplets (aerosolized).
- Rodent-proof your home
- Use insect repellent to kill fleas





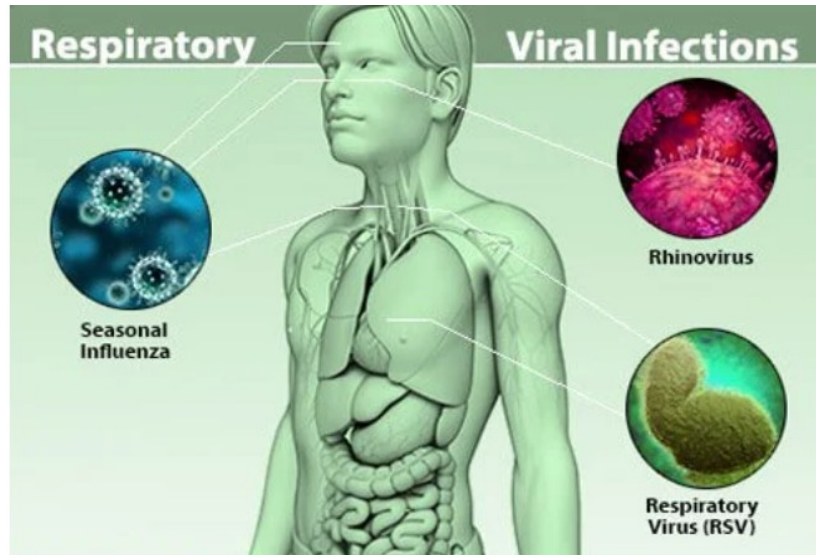
Viruses

- ❑ Smaller than bacteria, a virus is able to cause diseases ranging from the common cold, HIV/AIDS, Influenza, chickenpox, cold sores, COVID-19.
- ❑ Usually consist of a protein coat with genetic material (either RNA or DNA).
- ❑ These are intracellular parasites and lack a system for their own metabolism; they are dependent on the synthetic machinery of their host cells.
 - ❑ Every virus requires its own special type of host cell for multiplication.
 - ❑ Viruses can affect many areas in the body, including the reproductive, respiratory, and gastrointestinal systems. They can also affect the liver, brain, and skin.
 - ❑ Can cause cancer as well (HPV-cervical, throat, and penile cancer)





Viruses



- ❑ A viral infection is a proliferation of a harmful virus inside your body.
- ❑ Viruses cannot reproduce without the assistance of a host. Viruses infect a host by introducing their genetic material into the cells and hijacking the cell's internal machinery to make more virus particles.
- ❑ With an active viral infection, a virus makes copies of itself and bursts the host cell (killing it) to set the newly-formed virus particles free.
- ❑ In other cases, virus particles "bud" off the host cell over a period of time before killing the host cell.
- ❑ Certain viruses -- like the ones that cause chickenpox and cold sores -- may be inactive or "latent" after the initial infection.

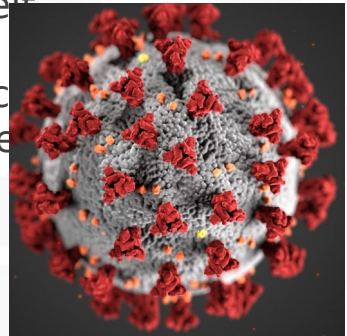


Infectious Diseases in History: Coronaviruses

The SARS outbreak of early 2003. This epidemic demonstrated that new infectious diseases are just a plane trip away. The virus, **SARS-CoV**, which caused a severe, and sometimes fatal, respiratory illness emerged in China. More than 8,000 people were infected by July 2003, and 774 died. Air travelers rapidly spread the disease to Canada, the United States, and Europe. Even though the SARS outbreak was relatively short-lived and geographically contained, the economic loss to Asian countries was estimated at \$18 billion as fear inspired by the epidemic led to travel restrictions and the closing of schools, stores, factories, and airports.

In 2013, a new SARS-like virus emerged in Saudi Arabia. Named **MERS-CoV**, the virus causes Middle East respiratory syndrome, or MERS, a severe and often fatal respiratory disease. Infection occurs through direct contact with an infected animal (camel) or person. Even though MERS did not spread easily from person to person, the virus spread to 27 countries in the Middle East, Europe, Asia, and North America, including the United States.

The most recent coronavirus to emerge is named **SARS-CoV-2**. It causes the disease known as COVID-19. The effects of COVID-19 pandemic have been felt around the worldwide, with schools and businesses closing, travel restricted, in some cases even limitations on people leaving their homes. The pandemic caused major economic hardships, stressed healthcare systems, and impacted mental health.





Smallpox in History

Over the course of millennia, these tiny infectious particles traveled the globe along trade and exploration routes, afflicting victims with high fevers and numerous raised lesions on their skin. One of history's deadliest diseases, smallpox is estimated to have killed more than 300 million people since 1900 alone.

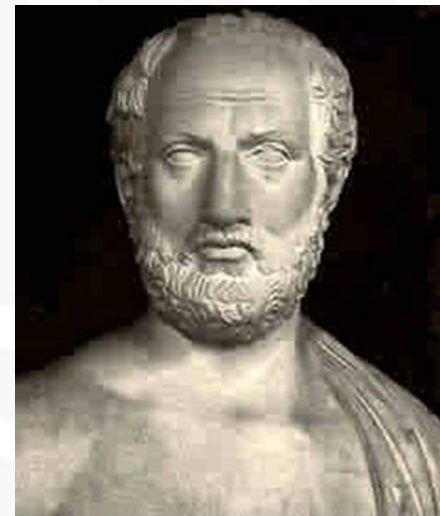
The mummified body of the Egyptian pharaoh Ramses V (died c. 1156 BC) bears evidence of pustules characteristic of smallpox.

It is possible that smallpox was behind the great plague of Athens in 430 BC, recorded by the Greek historian Thucydides, and a devastating plague carried to Italy by a Roman army returning from Mesopotamia around AD 165.

Thucydides



Ramses V





Smallpox in History

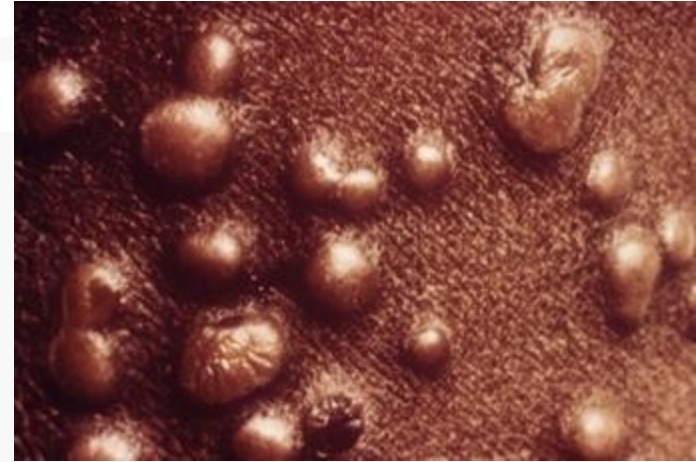
The virus that causes smallpox comes in two forms—the relatively mild *Variola minor* and its deadlier cousin, *Variola major*.

Death followed in one-third of *Variola major* cases. Even when victims survived, smallpox often left the survivors scarred for life. Although the first smallpox vaccine appeared in 1796, outbreaks continued well into the 1900s.

1949: Large-scale vaccination finally eliminated smallpox from the United States.

1967: World Health Organization (WHO) began a global vaccination program.

1980: the disease was officially declared eradicated.

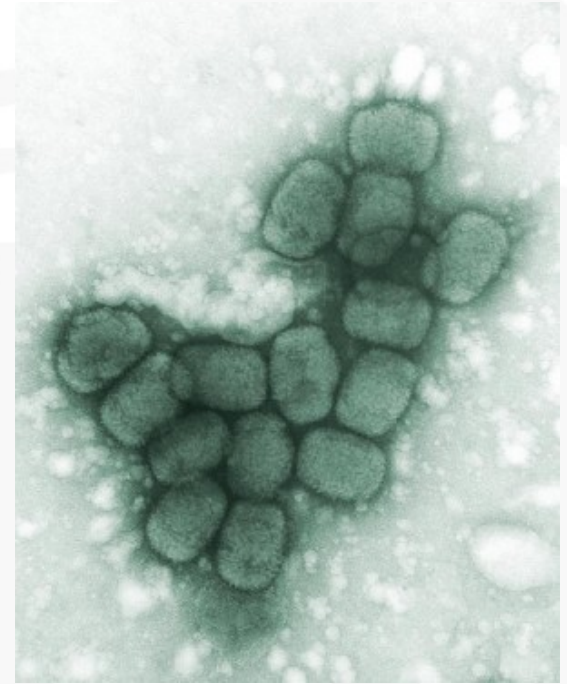


Tuareg Girl, Mali, 1967



Virus: **SMALLPOX**

- ❑ Caused by variola virus.
- ❑ Highly contagious, disfiguring and often deadly. Most people survive.
- ❑ No cure or treatment exists to this day.
- ❑ Naturally occurring smallpox was wiped out worldwide by 1980 — the result of an unprecedented global immunization campaign.
- ❑ A vaccine can prevent smallpox, but the risk of the vaccine's side effects is too high to justify routine vaccination for people at low risk of exposure to the smallpox virus.



SOURCE: CDC / JEAN ROY | ID#10657 | BANGLADESH 1974



Smallpox Contracted via:

- Direct contact person to person
- Indirectly via an airborne virus
- Contaminated items
- As a terrorist weapon (potentially)



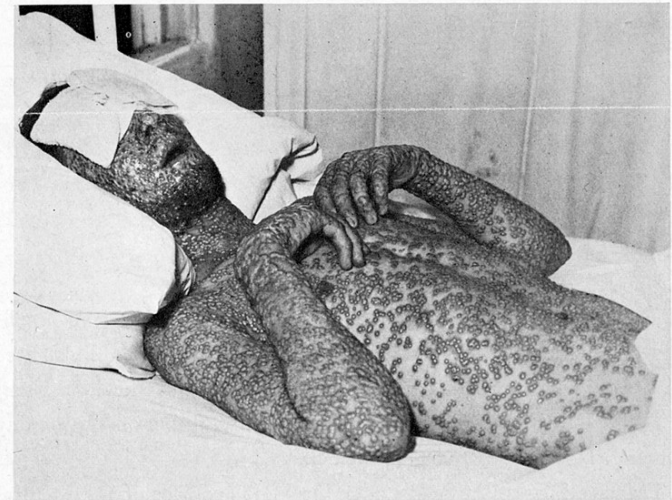


Smallpox Symptoms

Incubation period: 7 to 17 days during which time you can not infect others.

Following incubation:

- Fever
- Overall discomfort
- Headache
- Severe back pain and fatigue
- Vomiting is possible



New York State Department of Health Photograph

Smallpox Symptoms

A few days later, flat, red spots on your face, hands and forearms which then appear on your trunk.

Lesions may then turn into small blisters with clear fluid

8-9 days later scabs fall off leaving deep, pitted scars.





Smallpox Symptoms

Lesions may also form on mucus membranes of nose and mouth.

Most who contract smallpox survive. Blindness may occur in some.

More lethal smallpox affects pregnant women and those with compromised immune systems.

Lethality: High to moderate.





Smallpox Prevention

- Vaccine may lessen infection if given within 4 days of exposure.
- Childhood vaccination may provide partial immunity





Smallpox Treatment

No cure - treat symptoms.

- Rehydrate.
- Antibiotics may be used for those who have a bacterial skin or lung infection.

Treatment

Vaccine exists which is a preventative-not cure.

No specific therapy, supportive care must include prevention of secondary infections.



Questions





Module 1: Infectious Diseases

Introduction to Mechanisms of Disease

**Learning and understanding
infectious disease terminology
helps learn and understand
mechanisms of disease.**

**This was the goal of this
presentation**

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