EPIDEMIOLOGY

CHAPTER 9

THIS POWERPOINT WAS CREATED

BY

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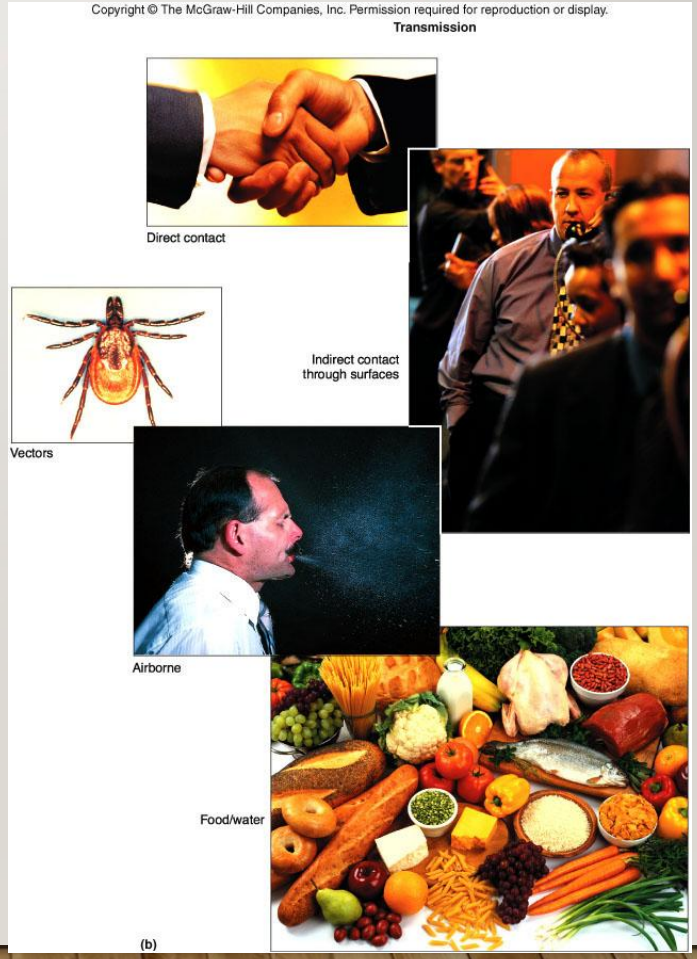
PRINCIPLES OF EPIDEMIOLOGY

- **Reservoirs** (natural habitat) of infectious disease
  - Reservoir of pathogen affects extent and distribution of disease
    - Recognizing reservoir can help protect population from disease
  - Reservoirs can be
    - Human
    - Non-human animal
    - Environmental



PRINCIPLES OF EPIDEMIOLOGY

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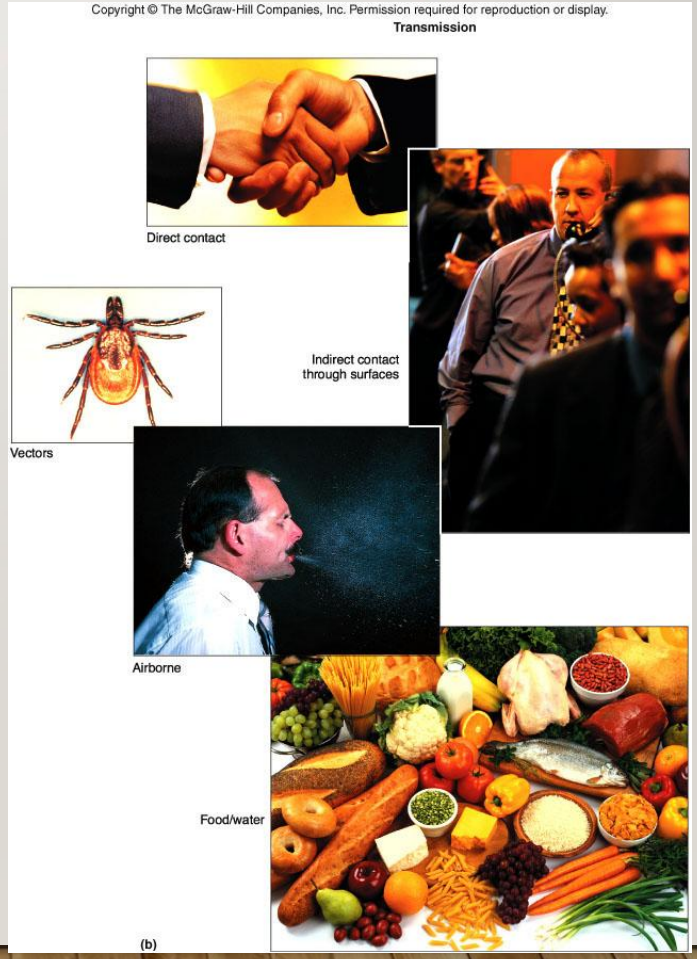

PRINCIPLES OF EPIDEMIOLOGY

- Human reservoirs
  - Infected humans most significant reservoirs
    - Primarily of communicable diseases
    - In some cases humans are only reservoir
      - In this case disease is easier to control
  - Human reservoirs as
    - Symptomatic infections
      - Obvious source of infectious agents
      - Ideally infected individuals understand the importance of precautions such as hand washing to inhibit transmission
    - Asymptomatic carriers
      - Individual harbors pathogen with no ill effects
      - They may shed organisms intermittently for long periods of time
      - Some have asymptomatic infection
        - More likely to move about spreading pathogen

PRINCIPLES OF EPIDEMIOLOGY

- Non-human animal reservoirs
  - Source of some pathogens
  - Disease transmitted by non-human animal reservoirs are termed **zoonotic**
    - Disease often more severe in humans than in normal animal
      - Infection in humans is accidental

PRINCIPLES OF EPIDEMIOLOGY

- Environmental reservoirs
  - Some pathogens have environmental reservoirs, which can include
    - Water
    - Soil
  - These pathogens difficult or nearly impossible to eliminate


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PRINCIPLES OF EPIDEMIOLOGY

- Portals of exit
  - How Microbes must leave one host in order to be transmitted to another
    - Organisms inhabiting intestinal tract are shed in feces
    - Organisms inhabiting respiratory tract are expelled in respiratory droplets of saliva
    - Organisms of the skin are shed with skin cells as they slough off

PRINCIPLES OF EPIDEMIOLOGY

- Transmission
  - Successful pathogen must be passed from reservoir to next susceptible host
  - Transmission of pathogen via contact with food, water, or living agent (vector) is termed horizontal transmission
  - Transmission via transfer of pathogen from mother to fetus or child through breast feeding is termed vertical transmission

PRINCIPLES OF EPIDEMIOLOGY

- **Contact**
  - Direct contact
    - Occurs when one person physically touches another
      - Can range from simple contact to intimate contact
    - In some cases direct contact is primary route of transmission
    - Hands are main vehicle of contact transmission
    - Handwashing physically removes organisms
      - Important in preventing direct contact transmission
    - Pathogens that do not survive for extended periods in the environment usually spread by direct contact

PRINCIPLES OF EPIDEMIOLOGY

- Contact
  - Indirect contact
    - Involves transmission of pathogens via inanimate objects or fomites
      - Usually clothing, tabletops, doorknobs, and drinking glasses
    - Organisms on hands or fingers of carrier can be transferred to objects and picked up by another individual
    - Handwashing important control measure

PRINCIPLES OF EPIDEMIOLOGY

- Contact
  - Droplet transmission
    - Microbe-laden respiratory droplets generally fall to the ground within three feet of release
    - People in close proximity can inhale infected droplets, spreading disease via droplet transmission
    - Droplet transmission considered direct transmission because of the close range required for transmission

PRINCIPLES OF EPIDEMIOLOGY

- Food and water
  - Pathogens can be transmitted through contaminated food and water
  - Food can become contaminated in number of different ways
    - Organisms can originate with animal
    - Organisms can be inadvertently added during food preparation
    - Cross-contamination occurs when organisms from one food are transferred to another from an improperly cleaned work surface
      - Cutting boards and knives
    - Sound food handling practices can prevent foodborne transmission and disease

PRINCIPLES OF EPIDEMIOLOGY

- Food and water
  - Waterborne disease outbreaks can involve large numbers of people
    - Due to the fact that municipal water is distributed to large areas
  - Prevention of waterborne diseases requires chlorination and filtration of public water sources and proper disposal of sewage

PRINCIPLES OF EPIDEMIOLOGY

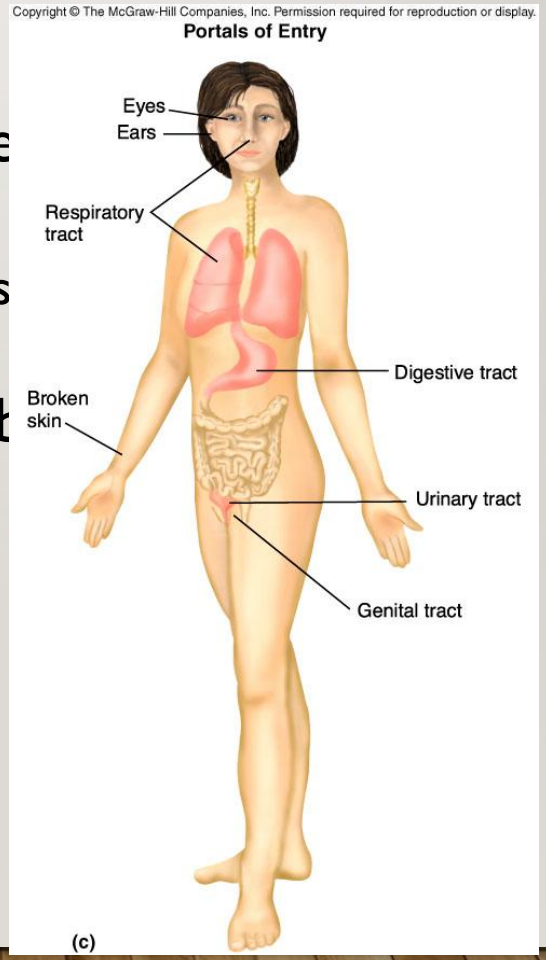
- **Air**
  - Respiratory droplets can be transmitted through the air
    - Smaller droplets dry in the air leaving one or two organisms attached to dry material
      - Creates droplet nuclei
    - Droplet nuclei can remain suspended indefinitely in presence of light air currents
  - Airborne transmission is difficult to control
    - Ventilation systems aimed at circulating air in buildings
      - HEPA (High Efficiency Particluate Air) filters effective at removing airborne organisms

PRINCIPLES OF EPIDEMIOLOGY

- **Vectors**
  - Any living organism that can carry a disease-causing microbe
    - Most common are arthropods
    - Vector may carry organism internally or externally
  - Control of vector-borne disease directed at controlling arthropod population

PRINCIPLES OF EPIDEMIOLOGY

- Portals of entry
  - Pathogen must enter and colonize host
    - Colonization is prerequisite for caus disease
  - Route by which pathogen enters b termed portal of entry
  - Major portals of entry include
    - Eyes
    - Ears
    - Respiratory tract
    - Broken skin
    - Digestive tract
    - Genitourinary tract



Infectious Disease

Transmission:
How disease causing microbe is getting from reservoir to new host

Reservoir:	Portals of exit:		Portals of entry:	host:
Where it normally lives = Natural habitat of pathogen	Route of exit of pathogen	Fomites (inanimate object) Air Food Water Vector (living organism, arthropod) Direct contact (touch, body fluids, STD) Indirect contact	Route of entry of pathogen	target of pathogen/ New reservoir of pathogen

Infectious Disease

Transmission:
How pathogen is getting from reservoir to new host

Reservoir:

Water
Air
Food
Soil
Humans
Non-human animal (zoonosis)

Portals of exit:

Mouth
Nose
Anus
Urogenital tract
Wounds
Eyes
Respiratory tract
Digestive tract
urogenital tract

Fomites (inanimate object)
Air
Food
Water
Vector (ticks Lyme disease, lice Rickettsia)
Direct contact
(touch warts,
body fluids feces, semen,
Mucus,
HIV
, STD)
Indirect contact

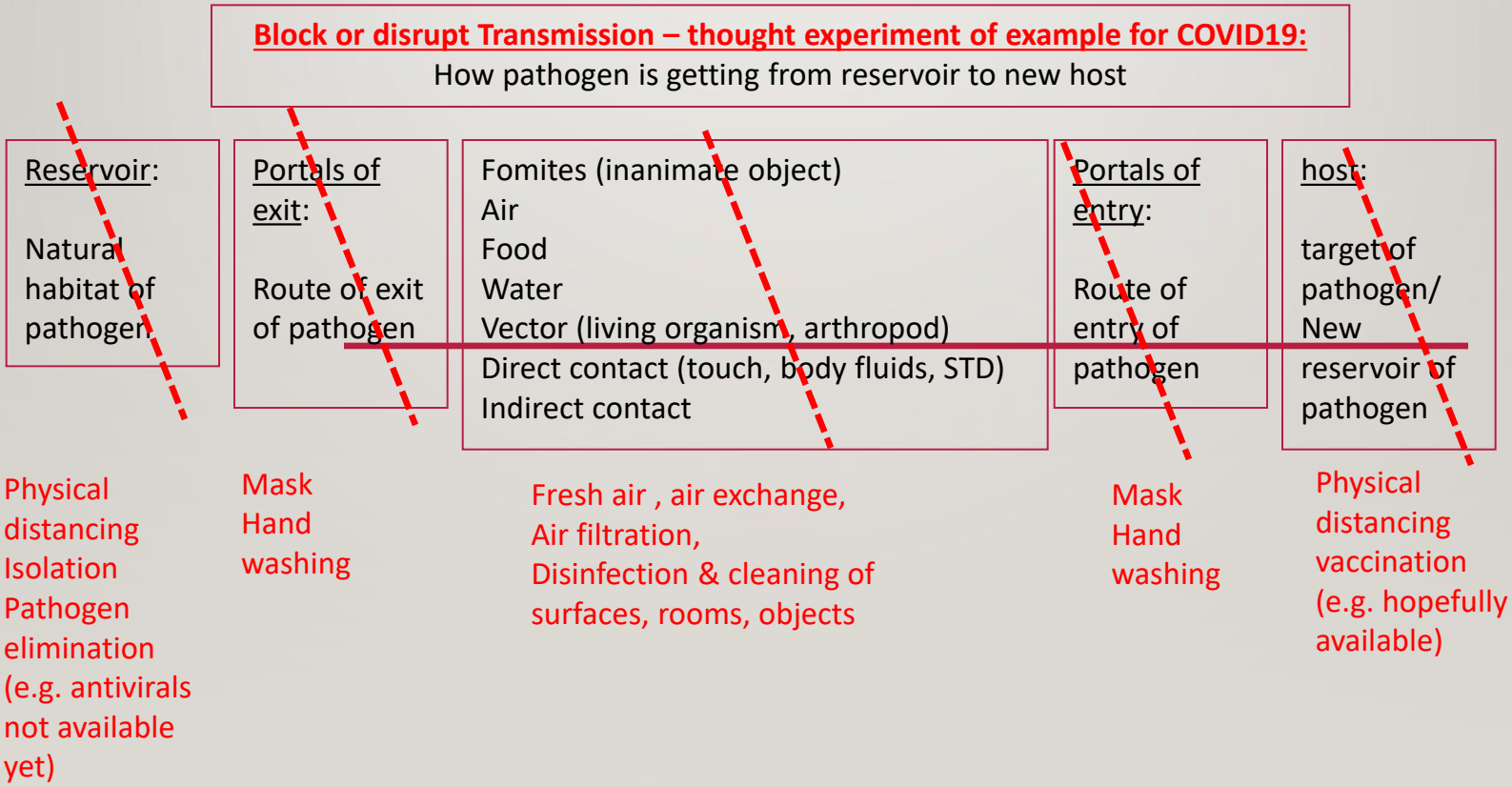
Portals of entry:

Mouth
Nose
Anus
Urogenital tract
Wounds
Eyes
Respiratory tract
Digestive tract
urogenital tract

host:

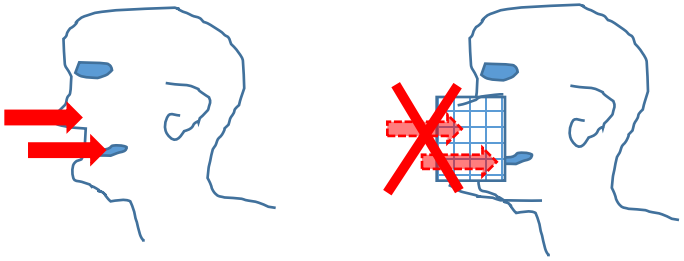
e.g. humans

MITIGATION OF INFECTIOUS DISEASE



Why to wear a face mask ?

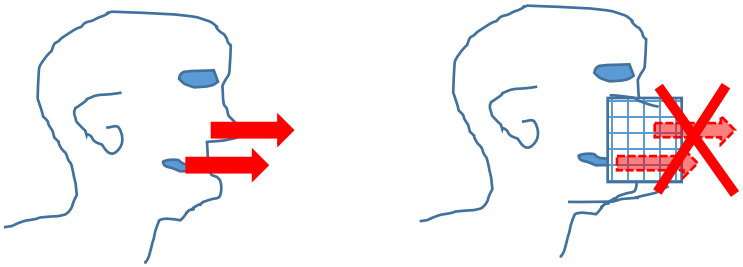
- Stop virus from entering your body



Portals of entry:

Route of entry of pathogen

- Stop virus from leaving your body



Portals of exit:

Route of exit of pathogen

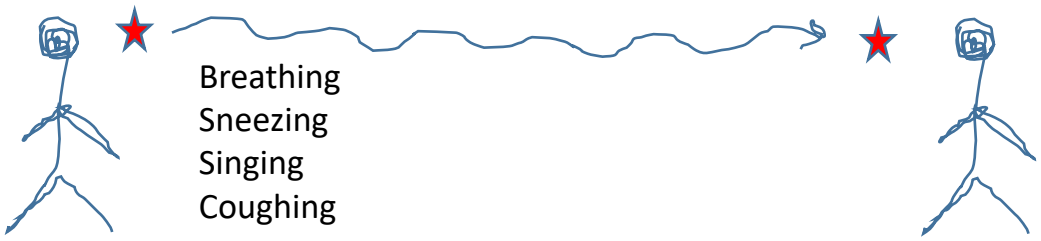
Why social distance/ six feet distance?

- Virus floats in the air (in droplets) from person to person

Transmission:
How pathogen is getting from reservoir to new host

- Airborne transmission
- Droplet transmission

Air-borne transmission/ droplet transmission



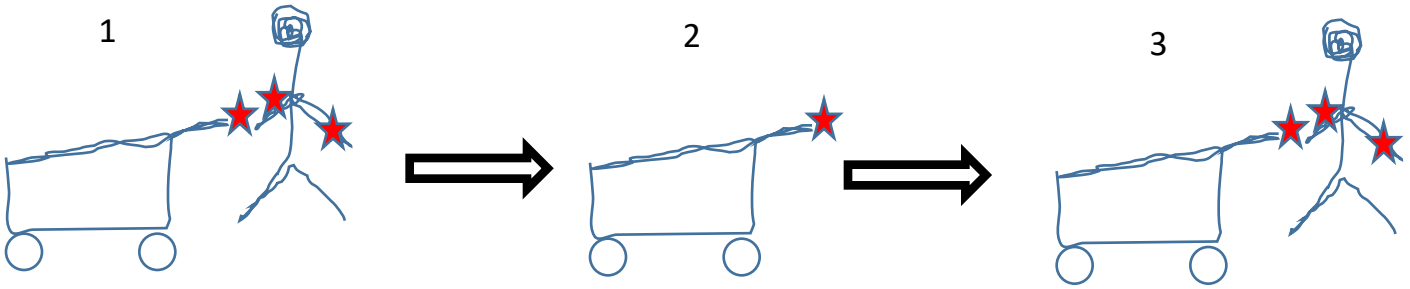
Breathing
Sneezing
Singing
Coughing

Why handwashing?

- Virus can be spread through (commonly touched) surfaces
- (elevator buttons, shopping cart)

Indirect Transmission through fomites:

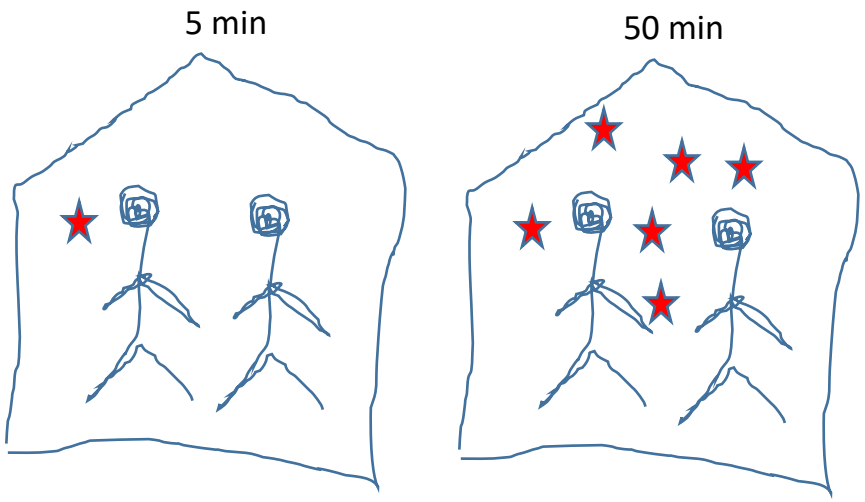
- ct
- Airborne transmission
- Droplet transmission



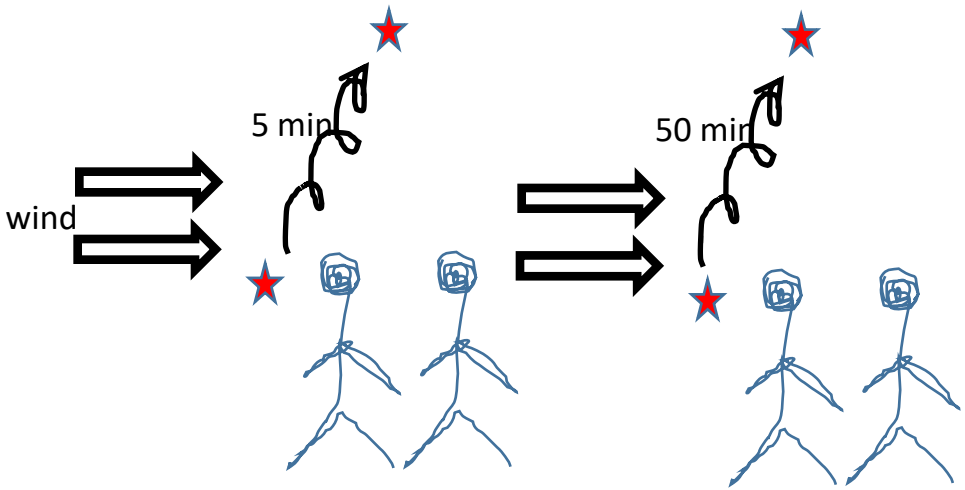
Shopping cart

Why is indoors different than outdoor?

- Amount of virus can increase over time



Wind and open space reduces virus increase over time

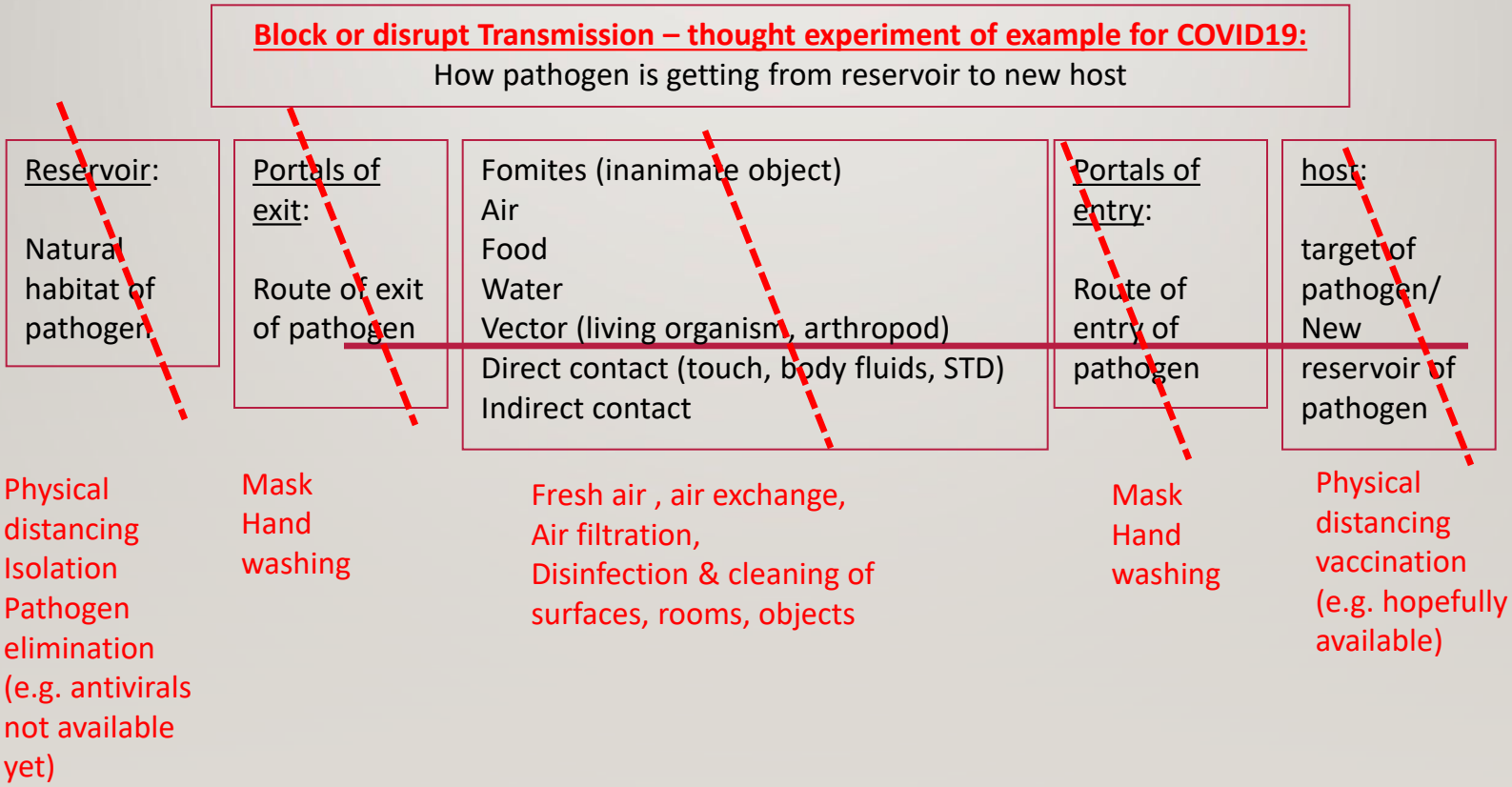


Infection Prevention and Mitigation of Infectious Disease

Block or disrupt Transmission:
How pathogen is getting from reservoir to new host

Reservoir:	Portals of exit:	Fomites (inanimate object) Air Food Water Vector (living organism, arthropod) Direct contact (touch, body fluids, STD) Indirect contact	Portals of entry:	host:
Natural habitat of pathogen	Route of exit of pathogen		Route of entry of pathogen	target of pathogen/ New reservoir of pathogen

MITIGATION OF INFECTIOUS DISEASE



OCCURRENCE OF A DISEASE

- **Endemic disease**: Disease constantly present in a population
- **Epidemic disease**: Disease acquired by many hosts in a given area in a short time, sudden increase
- **Pandemic disease**: Worldwide epidemic
- **Herd immunity**: Immunity in most of a population

REPORTED AIDS CASES IN THE UNITED STATES

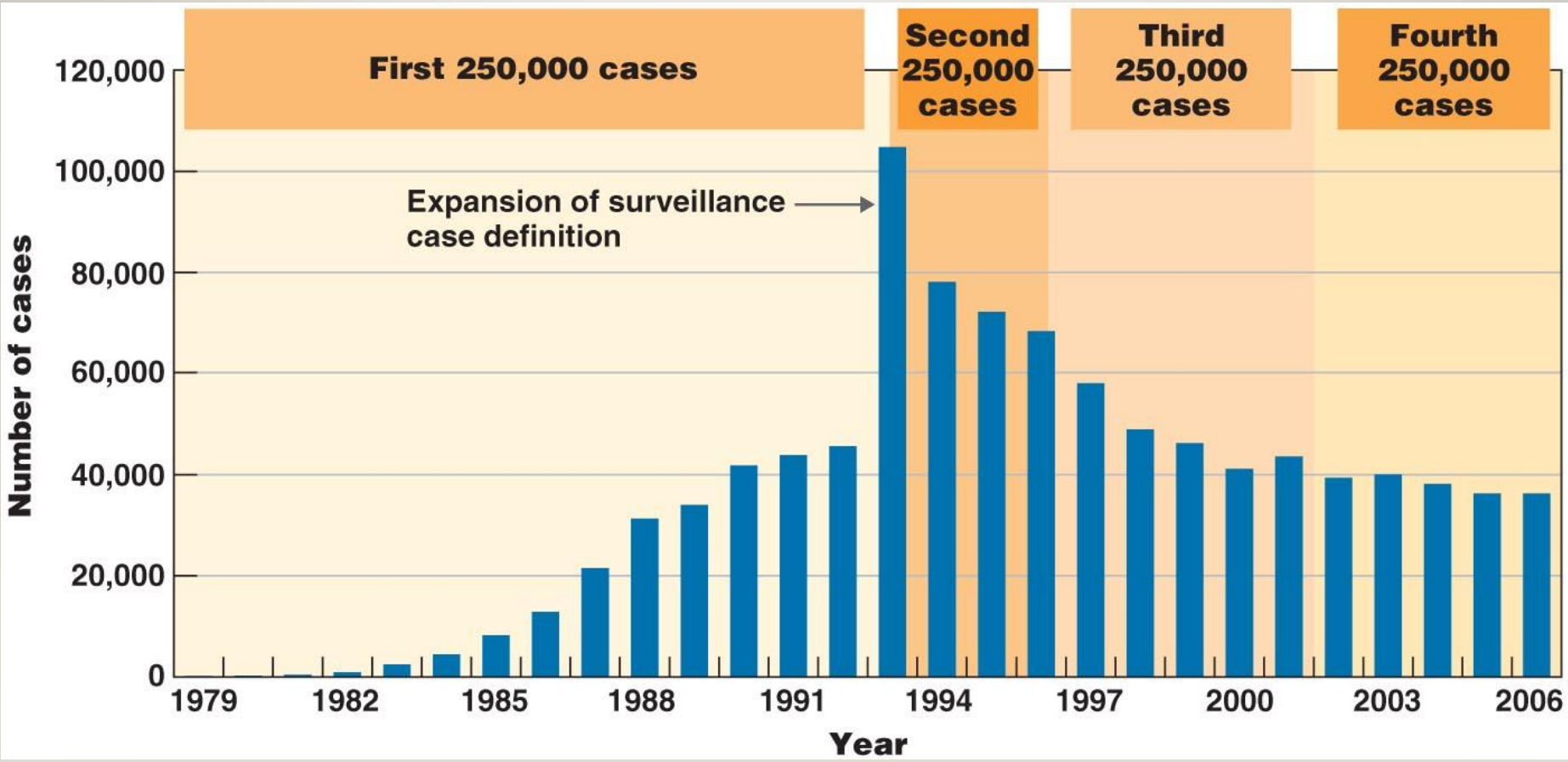


Figure 14.4

REPORTED AIDS CASES IN THE UNITED STATES

What is an endemic?

A)Sudden outbreak of disease
B)World-wide out break of a disease
C)Disease is constantly present (in population)

Figure 14.4

PRINCIPLES OF EPIDEMIOLOGY

- Factors that influence epidemiology of disease
  - Dose
    - Probability of contracting disease is often proportional with dose
      - Minimum number of bacteria required to establish disease
  - Incubation period
    - Disease with long incubation period can spread extensively before first case appears
  - Population characteristics
    - Certain populations are more susceptible than others to certain pathogens

PRINCIPLES OF EPIDEMIOLOGY

Virus	Strain	Dose		Route of administration	References
		$TCID_{50}$	PFU		
[a]Coronavirus	HCoV-229E	13	9	NR	Watanabe [8]
[b]Influenza	H1N1	1.0×10^3	700	IN	Hayden [9]
	H2N2	0.6–3	0.42–2.1	Aerosol	Alford [10]
	H3N2	1.0×10^7	7 000 000	IN	Treanor [11]
[c]Rhinovirus	RV15	0.032	0.0224	IN	Couch [12]
[d]Adenovirus	Type 4	0.5	0.35	Aerosol	Couch [13]
[e]Coxsackievirus	A21-48654	6	4.2	IN	Couch [12]
[f]RSV	Ts-1	30–40 (33% infected)	21–28	IN	Parrott [14]
	Type 39	100	70	Aerosol	Bischoff [15]

tissue culture infectious dose, or $TCID_{50}$

Karimzadeh S, Bhopal R, Nguyen Tien H. Review of infective dose, routes of transmission and outcome of COVID-19 caused by the SARS-COV-2: comparison with other respiratory viruses. *Epidemiology and Infection*. 2021;149:e96. doi:10.1017/S0950268821000790

PRINCIPLES OF EPIDEMIOLOGY

Virus	Host	Dose (PFU)	Route of inoculation	Numbers and/or %, signs of infection	References
SARS-CoV-2	[a]Ferret	221 359	IN	6/6	Kim [16]
		500	IN	16.7,1/6	Ryan [17]
		50 000	IN	6/6	
		5 000 000	IN	6/6	
		420 000	IN	4/4	Richard [18]
SARS-CoV-2	[b]hACE2 mice	70 000	IN	36.8,7/19	Bao [19]
		400 000	IN	3/3	Sun [20]
		4 000 000	IG	1/3	
		630	Aerosol	2/2	Bao [21]
		21 000	IN	50% Lethal	Jiang [22]
		100 000	IN	40% Lethal	Dinnon [23]
	BALB/c mice	16 000	IN	3/3	Gu [24]
HCoV-OC43	BALB/c and C57B6 mice	70 000	IP/IC	100% Lethal	Jacomy [25]
	BALB/c mice	70	IC	100% Lethal	Shen [26]
SARS-CoV-1	tgMice	280	IN	NR	Watanabe [8]
MERS-CoV	tgMice	0.7	IN	NR	Tao [27]
		7	IN	50% Lethal	

PFU: Plaque forming units
tissue culture infectious dose, or $TCID_{50}$

PRINCIPLES OF EPIDEMIOLOGY

Incubation period

Aetiology	Outbreak incubation periods Median Hours	Median outbreak incubation period range 70% of outbreaks (15^{th}–85^{th} percentile) Hours	Median outbreak incubation period range 95% of outbreaks (2.5^{th}–97.5^{th} percentile) Hours	Outbreaks No. (%)
Staphylococcus aureus	4	2–5	2–8	153 (4)
Bacillus cereus	4	1.5–13.5	1–28	60 (1)
Clostridium perfringens	10	8–13	5–16	291 (7)
Vibrio parahaemolyticus	17	11–33	7–72	39 (1)
Norovirus	32	27–37	12–47	2172 (53)
Salmonella enterica	32	17–67	7–132	937 (23)
Shigella spp.	45	31–53	11–72	86 (2)
Campylobacter spp.	62	37–92	12–168	141 (3)
Escherichia coli (Shiga-toxin producing)	87	57–112	37–144	178 (4)
Hepatitis A	672	576–744	348–1008	31 (1)
Total				4088 (100)

Table 1. Reported outbreak incubation periods[a] in foodborne outbreaks by aetiology, United States – Foodborne Disease Outbreak Surveillance System, 1998–2013

Chai SJ, Gu W, O'Connor KA, Richardson LC, Tauxe RV. Incubation periods of enteric illnesses in foodborne outbreaks, United States, 1998–2013. *Epidemiology and Infection*. 2019;147:e285. doi:10.1017/S0950268819001651

PRINCIPLES OF EPIDEMIOLOGY

Incubation period

Incubation period of a pathogen influences an epidemic. Identify correct statement.

A) The shorter the incubation period is the longer it takes for patients to realize that they sick

B) The longer the incubation period is the longer it takes for patients to realize that they sick

Chai SJ, Gu W, O'Connor KA, Richardson LC, Tauxe RV. Incubation periods of enteric illnesses in foodborne outbreaks, United States, 1998–2013. *Epidemiology and Infection*. 2019;147:e285. doi:10.1017/S0950268819001651

PRINCIPLES OF EPIDEMIOLOGY

Incubation period

Incubation period of a pathogen influences an epidemic. Identify correct statement.

A) The shorter the incubation period is the more difficult it is to control an epidemic

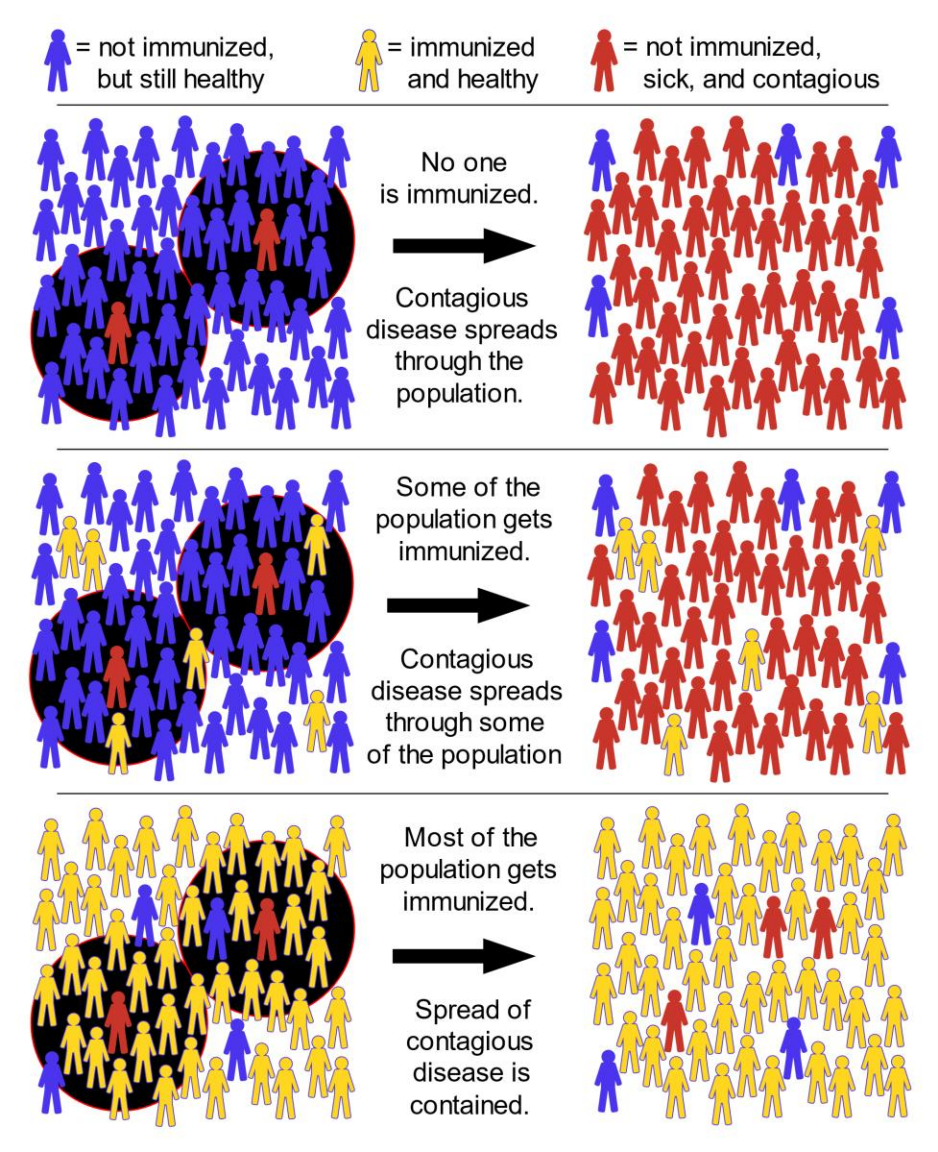
B) The longer the incubation period is incubation the more difficult it is to control an epidemic

Chai SJ, Gu W, O'Connor KA, Richardson LC, Tauxe RV. Incubation periods of enteric illnesses in foodborne outbreaks, United States, 1998–2013. *Epidemiology and Infection*. 2019;147:e285. doi:10.1017/S0950268819001651

PRINCIPLES OF EPIDEMIOLOGY

- Population characteristics that influence occurrence of disease
  - Immunity to pathogen
    - Previous exposure or immunization of population decreases susceptibility of population to organism
    - Can lead to herd immunity
      - Unimmunized protected due to lack of reservoir of infection
      - also known as population immunity
      - form of indirect protection that occurs when a large portion of a population is immune to a contagious disease (vaccination or immunity from previous infection).
  - General health
    - Stressors such as malnutrition or overcrowding increase susceptibility of population
  - Age
    - Very young and very old tend to be at greater risk
      - Young due to underdeveloped immune system
      - Old due to waning immune system

PRINCIPLES OF EPIDEMIOLOGY



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PRINCIPLES OF EPIDEMIOLOGY

- Population characteristics that influence occurrence of disease
  - Gender
    - Gender influences disease distribution
      - Often due to anatomical differences
  - Religious and cultural practices
    - Cultures that routinely breast feed babies see less infectious disease in children
  - Genetic background
    - Natural immunity can vary with genetic background
    - Difficult to assess relative importance of genetics

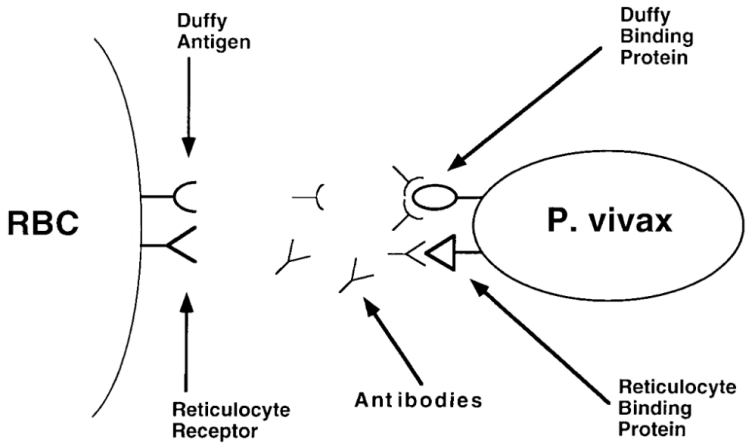
PRINCIPLES OF EPIDEMIOLOGY
GENETIC BACKGROUND

VOL 89, NO 9 MAY 1, 1997

REVIEW ARTICLE

From Malaria to Chemokine Receptor: The Emerging Physiologic Role of the Duffy Blood Group Antigen

By Terence J. Hadley and Stephen C. Peiper



erythroid and nonerythroid tissue.[5-8] Here we will focus on the Duffy blood group antigen, a structure that has been of particular interest because it serves as a receptor on the RBC for the malarial parasite, *Plasmodium vivax* (*P vivax*).[8-10]

EPIDEMIOLOGICAL STUDIES

- Epidemiologists investigate disease outbreak to determine
  - Causative agent
  - Reservoir
  - Route of transmission
- Allows them to recommend ways to minimize spread

EPIDEMIOLOGICAL STUDIES

- Descriptive studies
  - Used to define characteristics such as
    - Person
      - Determine profile of those who become ill
        - Age, occupation, ethnicity, etc.
    - Place
      - Geographic location identifies general site of contact
      - Give clues about potential reservoirs and vectors
    - Time
      - Rapid rise in numbers suggests common source epidemic
      - Gradual rise likely contagious
        - Termed propagated epidemic
        - First case called index case

EPIDEMIOLOGICAL STUDIES

- Analytical studies
  - Determine which potential factors from descriptive study are relevant
- Cross-sectional studies
  - Survey range of people to determine prevalence of number of characteristics
- Retrospective studies
  - Done following disease outbreak
  - Compare actions and events surrounding outbreak
- Prospective studies
  - Look ahead to see if risk factors from retrospective study predict tendency to develop disease

EPIDEMIOLOGICAL STUDIES

- **Experimental** studies
  - Used to judge the cause and effect relationship of risk factors or preventative factors and disease development
  - Done most frequently to determine effectiveness of prevention or treatment
    - Treatment compared to placebo
  - Double blind studies used to avoid bias

PATHOLOGY, INFECTION, AND DISEASE

- **Pathology**: The study of disease
- **Etiology**: The study of the cause of a disease
- **Pathogenesis**: The development of disease
- **Infection**: Colonization of the body by pathogens
- **Disease**: An abnormal state in which the body is not functioning normally

CLASSIFYING INFECTIOUS DISEASES

- **Symptom**: A change in body function that is felt by a patient as a result of disease
- **Sign**: A change in a body that can be measured or observed as a result of disease
- **Syndrome**: A specific group of signs and symptoms that accompany a disease

THE STAGES OF A DISEASE

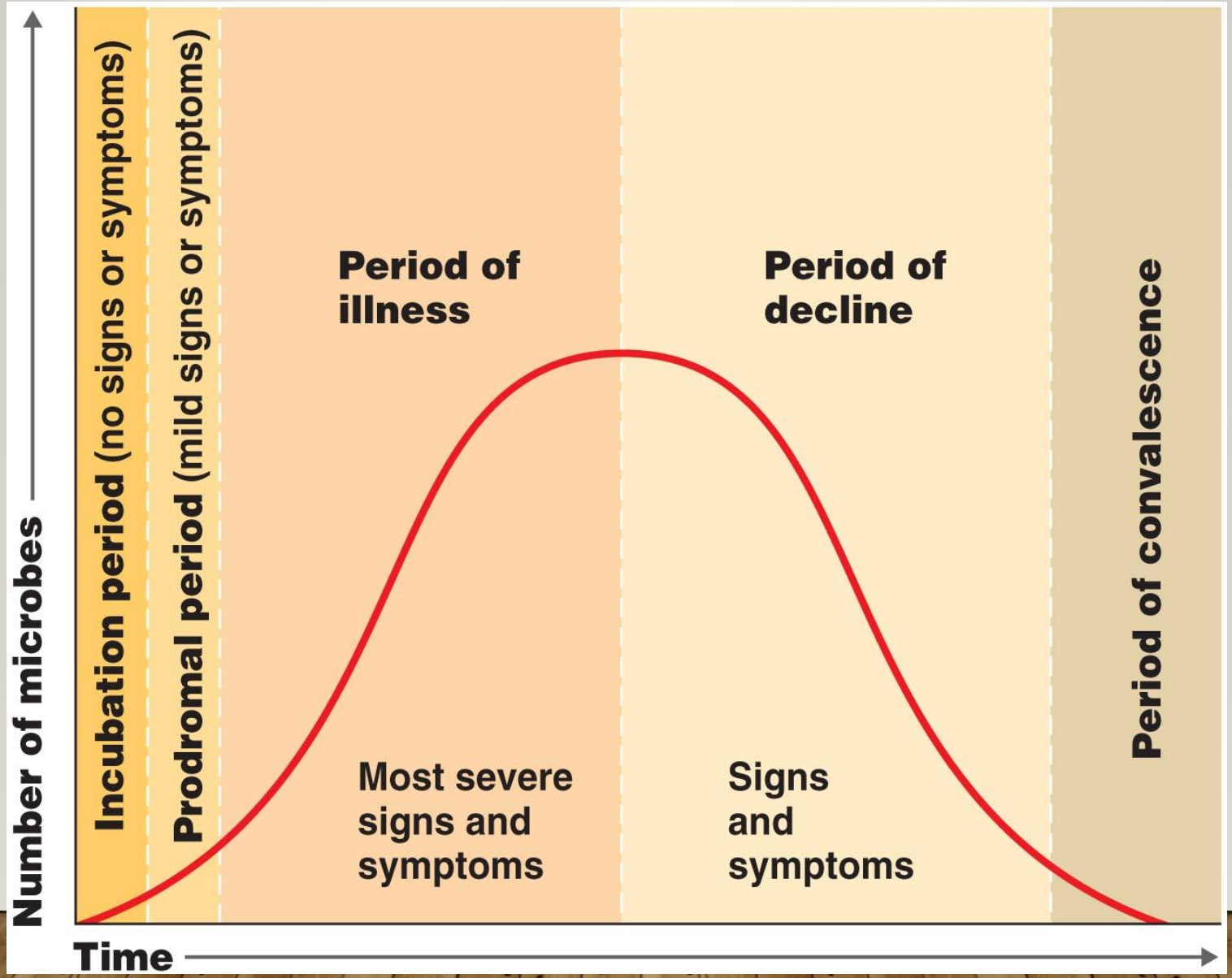


Figure 14.5

SYMBIOSIS

- In **commensalism**, one organism benefits, and the other is unaffected
- In **mutualism**, both organisms benefit
- In **parasitism**, one organism benefits at the expense of the other
- Some normal microbiota are **opportunistic pathogens** (cause disease when opportunity is given, immunity is decreased)

INFECTIOUS DISEASE SURVEILLANCE

- National Disease Surveillance Network
  - Depends heavily on network of agencies across the country
    - Agencies monitor disease development
  - Agencies include
    - Centers for Disease Control and Prevention (CDC)
    - Public Health Departments

INFECTIOUS DISEASE SURVEILLANCE

- Centers for Disease Control and Prevention
  - a.k.a CDC
  - Part of US Department of Health and Human Services
  - Provides support for infectious disease laboratories worldwide
  - Collects data of public health importance
    - Publishes data in weekly publication
      - Morbidity and Mortality Weekly Report (MMWR)

INFECTIOUS DISEASE SURVEILLANCE

- Centers for Disease Control and Prevention
  - Conducts research relating to infectious disease
    - Can dispatch teams worldwide to assist in identification and control of epidemics
  - Provides refresher courses to laboratory and infection control personnel

INFECTIOUS DISEASE SURVEILLANCE

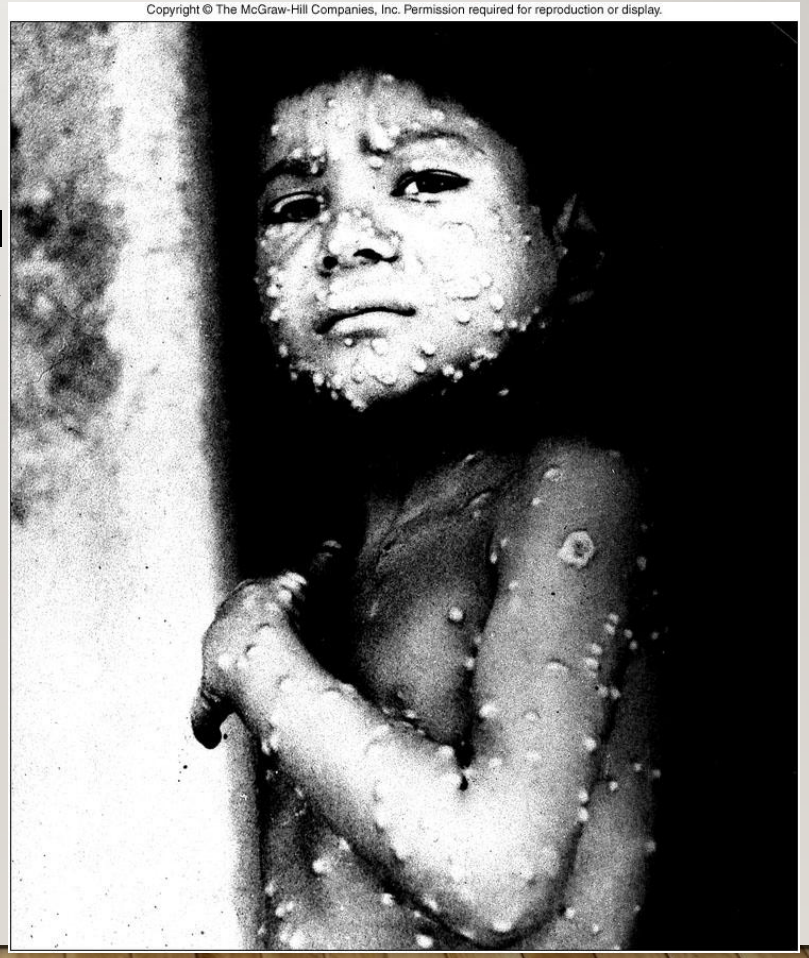
- Public health departments
  - Each state has public health department
  - Responsible for infection surveillance and control
  - Individual states have authority to mandate which diseases are reportable
    - These diseases must be reported by physician to state laboratory
  - Public schools and hospital laboratories are also part of public health network

INFECTIOUS DISEASE SURVEILLANCE

- Worldwide disease surveillance
  - World Health Organization (WHO)
    - International agency
    - Four main functions
      - Provide worldwide guidance in the field of health
      - Set global standards for health
      - Cooperatively strengthen national health programs
      - Develop and transfer appropriate health technology

INFECTIOUS DISEASE SURVEILLANCE

- Reduction and eradication of disease
  - Humans have been very successful at developing ways to eliminate or reduce disease
  - Efforts have been directed at
    - Improving sanitation
    - Reservoir and vector control
    - Vaccination
    - Antibiotic treatment
  - Small pox has been globally eradicated as a disease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INFECTIOUS DISEASE SURVEILLANCE

- **Emerging disease**
  - Organisms equally adept at taking advantage of new opportunities of infection
    - New diseases emerge
      - Increase in incidence in past two decades
    - Old controlled diseases make a comeback

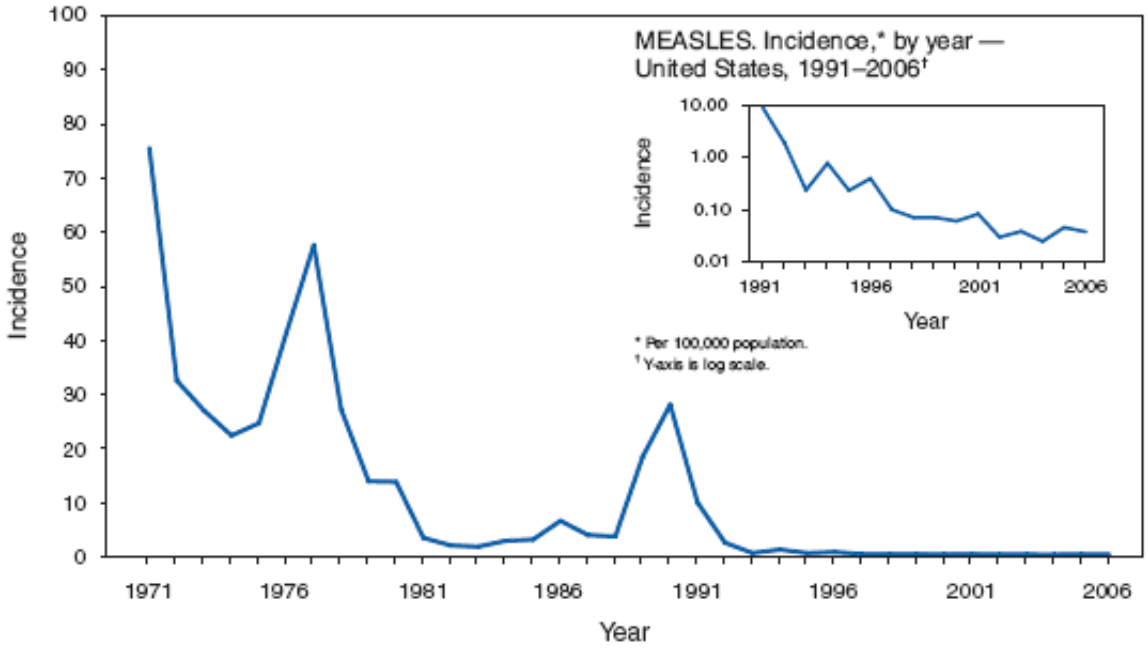
- Factors that contribute to emergence and reemergence include
  - Microbial evolution
  - Complacency and breakdown of public health
  - Changes in human behavior
  - Advances in technology
  - Population expansion
  - Development
  - Mass distribution and importation of food
  - War and civil unrest
  - Climate changes

RATES OF DISEASE

- Epidemiologists focus on the **rate** (proportion)of disease (not absolute numbers)
  - **Attack rate** : cases with disease versus exposed numbers
  - **Morbidity rate** : cases of illness per population
  - **Mortality rate** : cases of death per population (e.g. 100,000)
  - **Incidence** : new cases of disease per population
  - **Prevalence** : total cases (new and old) of disease per population
  - Diseases that are constantly present in a population are **endemic**;
  - an unusually large number of cases in a population constitutes an **epidemic** (Fig 20.2);
  - worldwide epidemic is **pandemic**, e.g. AIDS/HIV

RATES OF DISEASE

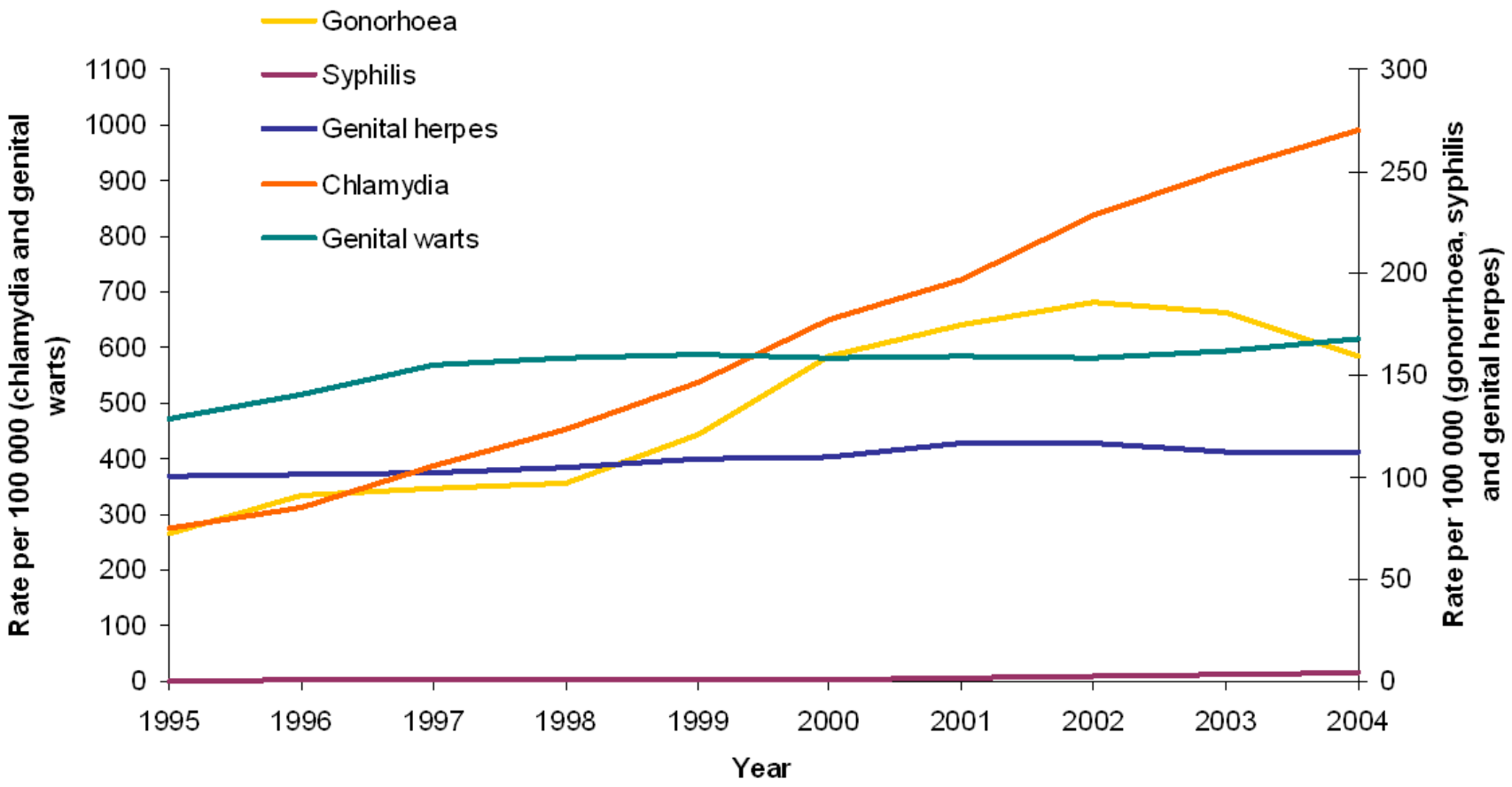
MEASLES. Incidence,* by year — United States, 1971–2006



* Per 100,000 population.

Measles vaccine was licensed in 1963. Evidence suggests that measles is no longer endemic in the United States.

Fig 4.31: Rates of diagnosis of genital chlamydia[1], gonorrhoea[1], syphilis, genital warts[2] and genital herpes[2] in young people (16-24)



[1]Uncomplicated
[2]First attack
Data source: KC60 and STISS/ISD(D)5 returns from GUM clinics, United Kingdom

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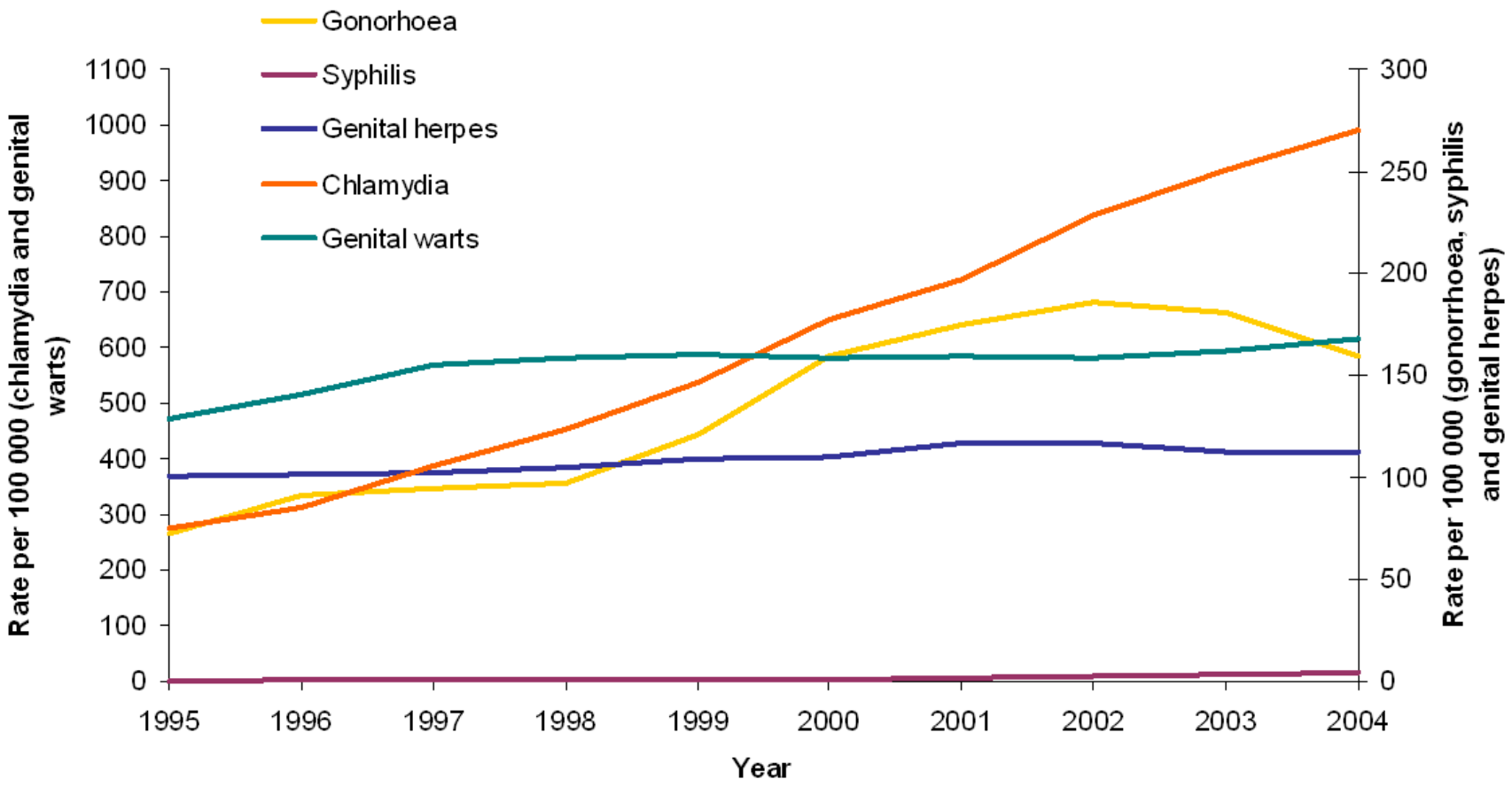

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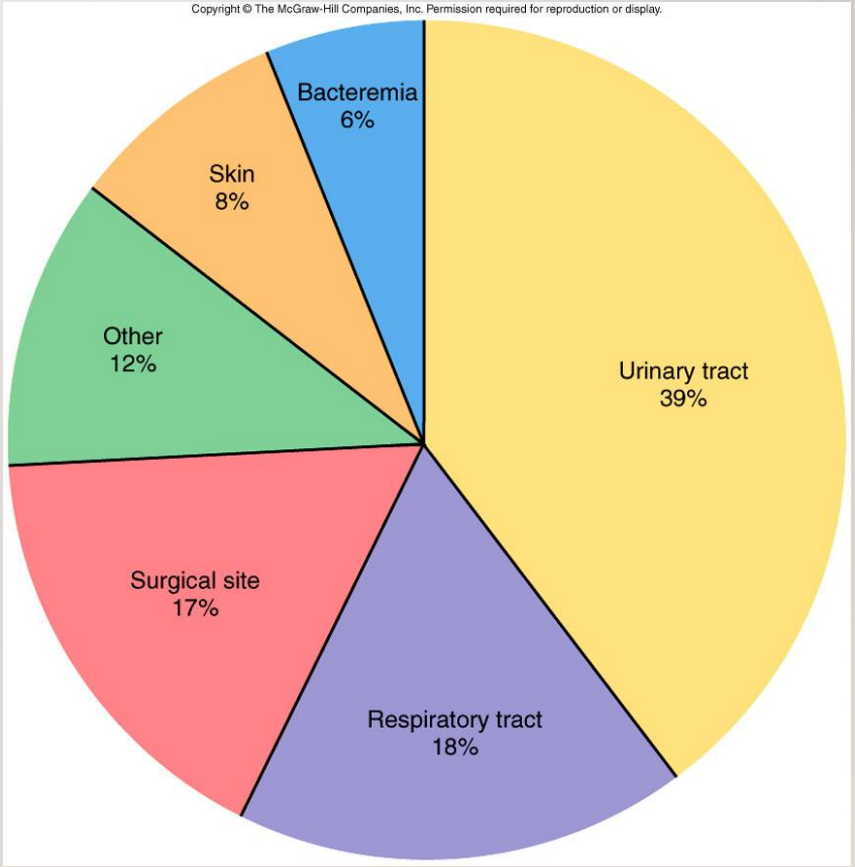
NOSOCOMIAL INFECTIONS

- Nosocomial infections are defined as hospital-acquired infections
  - Infections may range from mild to fatal
- Numerous factors determine which organisms and agents are responsible
  - Length of time of exposure
  - Manner of exposure
  - Virulence and number of organisms
  - State of host defenses



NOSOCOMIAL INFECTIONS

- Commonly implicated organism include
  - *Enterococcus* species
    - Part of normal intestinal flora
  - *Escherichia coli* and other species in family *Enterobacteriaceae*
    - Part of normal intestinal flora
  - *Pseudomonas* species
    - Common cause of nosocomial pneumonia and urinary tract and burn infections
  - *Staphylococcus aureus*
    - Survives in environment for prolonged periods
    - Easily transmissible to fomites
  - Other *Staphylococcus* species
    - Often part of normal skin flora

NOSOCOMIAL INFECTIONS

- Reservoirs of infectious agents in hospitals
  - Other patients
    - Patients can harbor infectious agents and discharge into environment
  - Hospital environment
    - Certain bacteria do not require many nutrients and can survive long periods on surfaces
    - Many of these organism are antibiotic resistant
      - Due to continual exposure to antibiotics
  - Health care workers
    - Outbreaks can sometimes be traced to hospital worker
      - Often as a result of improper handwashing or sterile technique
  - Patient's own normal flora
    - Invasive treatments often introduce surface flora to interior regions of body

NOSOCOMIAL INFECTIONS

- Transmission of infectious agents in hospitals
  - Medical devices
    - Devices routinely breach first-line barr
      - Catheterization, mechanical respirator and inadequately sterilized instrument
  - Healthcare personnel
    - Handwashing between patients effectiv against spread of disease
  - Airborne
    - Airflow is regulated to specific parts of hospital
      - Keeps certain areas contained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NOSOCOMIAL INFECTIONS

- Preventing nosocomial infections
  - Most important step is to recognize their occurrence and establish policies to prevent their development
    - Infection Control Committee
      - Committee often chaired by hospital epidemiologist trained in hospital infection control
    - Infection control practitioner
      - Active surveillance of types and numbers of infections occurring in the hospital setting

NOSOCOMIAL INFECTIONS

Preventing Nosocomial Infections

The most important steps in preventing nosocomial infections are to first **recognize** their **occurrence** and then **establish policies** to prevent both their development and spread.
The Infection Control Committee and the **Hospital epidemiologist** (a professional specially trained in hospital infection control) .
Infection Control Practitioner performs active surveillance of types and number s of infectins that occur in the hospital.
The CDC established the Hospital Infection Control Program Advisory Committee (HICPAC), the guidelines of **Standard Precautions** (Handwashing, gloves, Mask/eyeprotection/face shield/gown, Patient-care equipment, Environmental control, Linen, Occupational health & blood-borne pathogens, Patient placement)and the guidelines of **Transmission-based Precautions**.