

CIC Study Group

Week 4



HAI Prevention Program

Agenda

- Review
 - Chapter 77 Enterobacteriaceae
 - Chapter 86 *Legionella pneumophila*
 - Chapter 81 Diarrheal Diseases Viral, Bacterial, and Parasitic
 - Chapter 99 Viral Hepatitis
- Group Member Spotlight
- Next week's assignments

Chapter 77

Enterobacteriaceae

Enterobacteriaceae

- Among the most common life threatening and preventable health care-associated infections (e.g., bacteremia, pneumonias and surgical site infections).
- Large, diverse family of small, **gram-negative**, coccobacillary or straight **rods**.
- They inhabit a wide variety of niches, including soil, plants, water and **gastrointestinal tracts** of humans and animals.



Enterobacter cloacae

www.hygiene-in-practice.com/pathogen/enterobacter-cloacae-en/



Klebsiella pneumoniae

nursesed.net/klebsiella-pneumoniae-and-healthcare-acquired-infections/



Escherichia coli

www.livescience.com/64436-e-coli.html

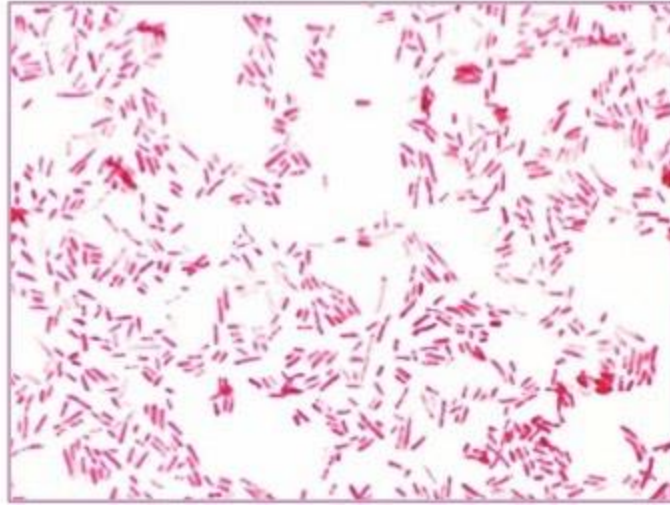


Salmonella typhi

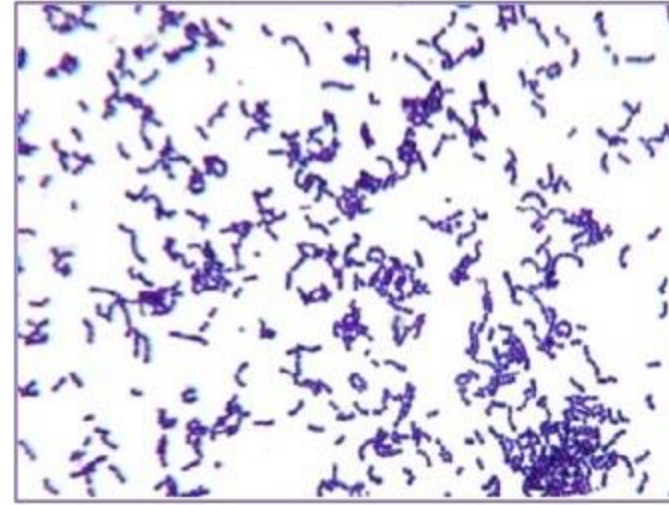
www.sciencemag.org/799391/view/salmonella-typhi-bacterium-sem

Pop Quiz! Gram Staining

GRAM NEGATIVE

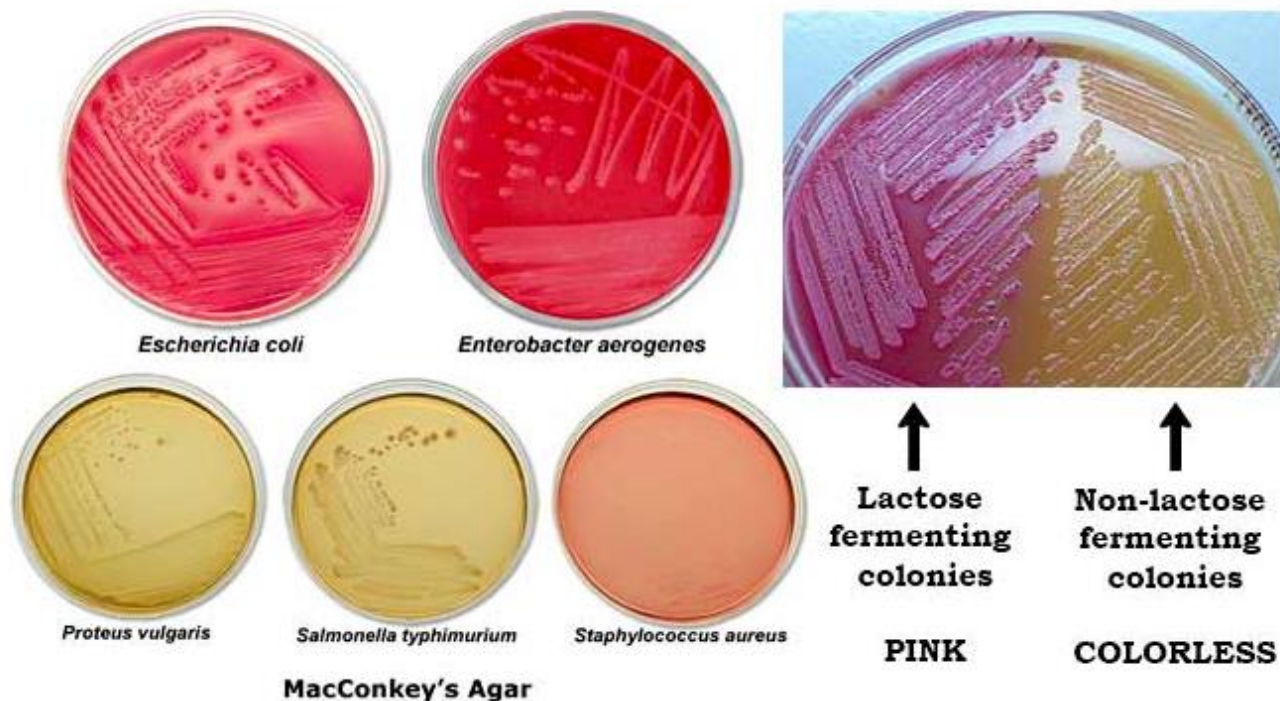


GRAM POSITIVE



Enterobacteriaceae Characteristics

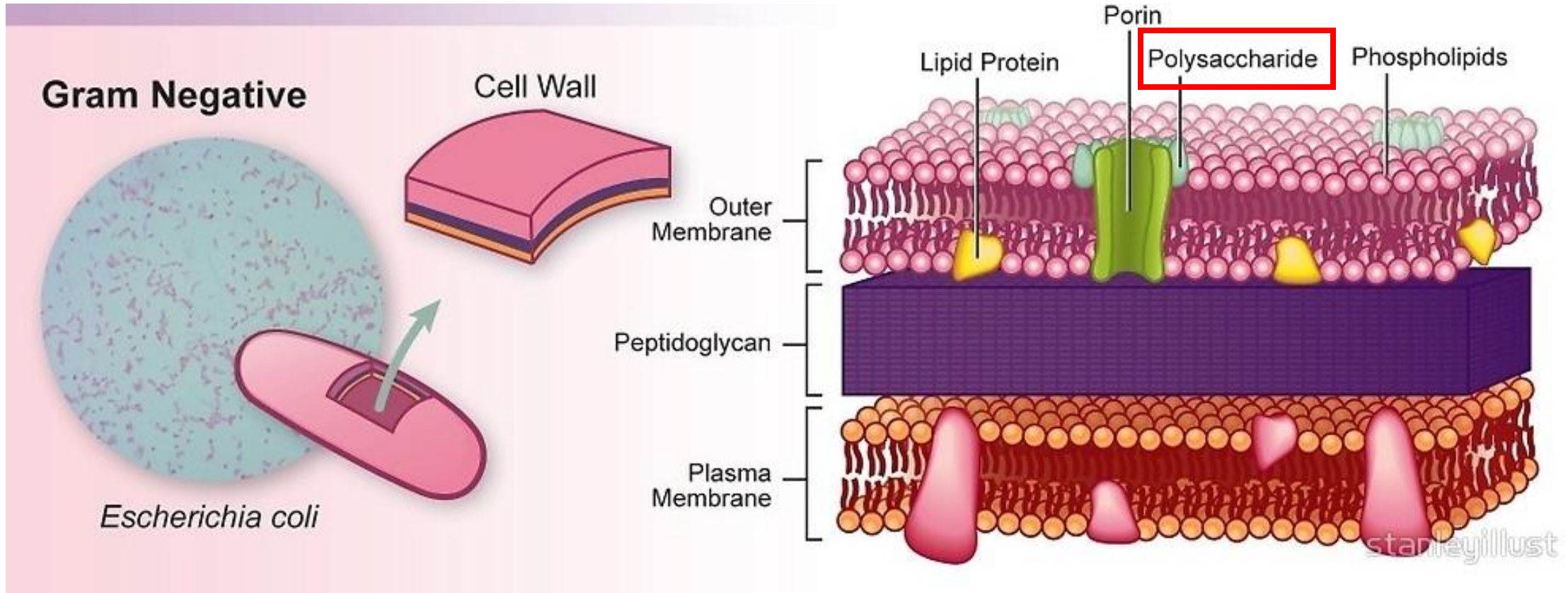
- Oxidase negative.
- Ferment glucose.
- Reduce nitrate.
- Grow equally as well in air (aerobic) or without air (anaerobic).
- All but three genera are motile.



Enterobacteriaceae Characteristics, Cont.

- **The O or somatic antigen** is a heat-stable lipopolysaccharide composed of three components:
 - An antigenic variable O polysaccharide (unique to species).
 - A core polysaccharide (common to all species).
 - Lipid A.
- Lipid A:
 - Endotoxin activity.
 - Released during growth, cell death or lysis.
 - Many of the adverse systemic manifestations (**fever, shock, disseminated intravascular coagulation [DIC]**) of gram-negative infections are due to endotoxin (lipid A).

Diagram of Gram Negative Bacterial Structure



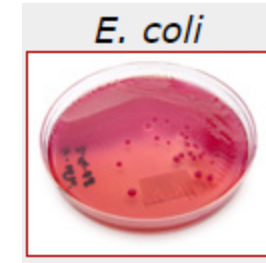
www.quora.com/How-can-we-change-gram-negative-to-gram-positive-in-bacteria

Lab Identification

- All Enterobacteriaceae grow on routine laboratory media such as **blood** or **MacConkey agar**.
- Selective and differential agars such as HE (Hekton enteric), XLD (xylose-lysine-deochocolate), and SS (*Salmonella-Shigella*) agars are commonly used to isolate enteric pathogens from feces and other gastrointestinal sites.



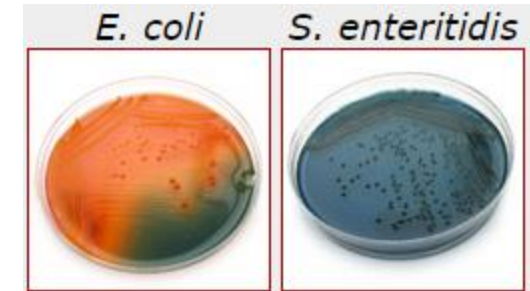
MacConkey Agar
Selective & Differential
Selects for gram-negative enterics and differentiates lactose fermenters from non-fermenters



E. coli
Lactose fermenter



Hektoen Agar
Selective & Differential
Detects lactose fermentation, H₂S production, inhibits non-enterics



E. coli
Lactose fermenter

S. enteritidis
Lactose non-fermenter

Concept Check

All of the following are types of Enterobacteriaceae EXCEPT?

- A. *Serratia marcescens*
- B. *Pseudomonas aeruginosa*
- C. *Proteus mirabilis*
- D. *Citrobacter freundii*
- E. *Yersinia pestis*

Concept Check

Enterobacteriaceae are associated most often with which of the following health care-associated infections:

1. Pneumonias
2. Surgical site infections
3. Bacteremia
4. Urinary tract infections

- A. 1, 2 and 3
- B. 1, 3, and 4
- C. 3 and 4
- D. 1, 2, 3 and 4

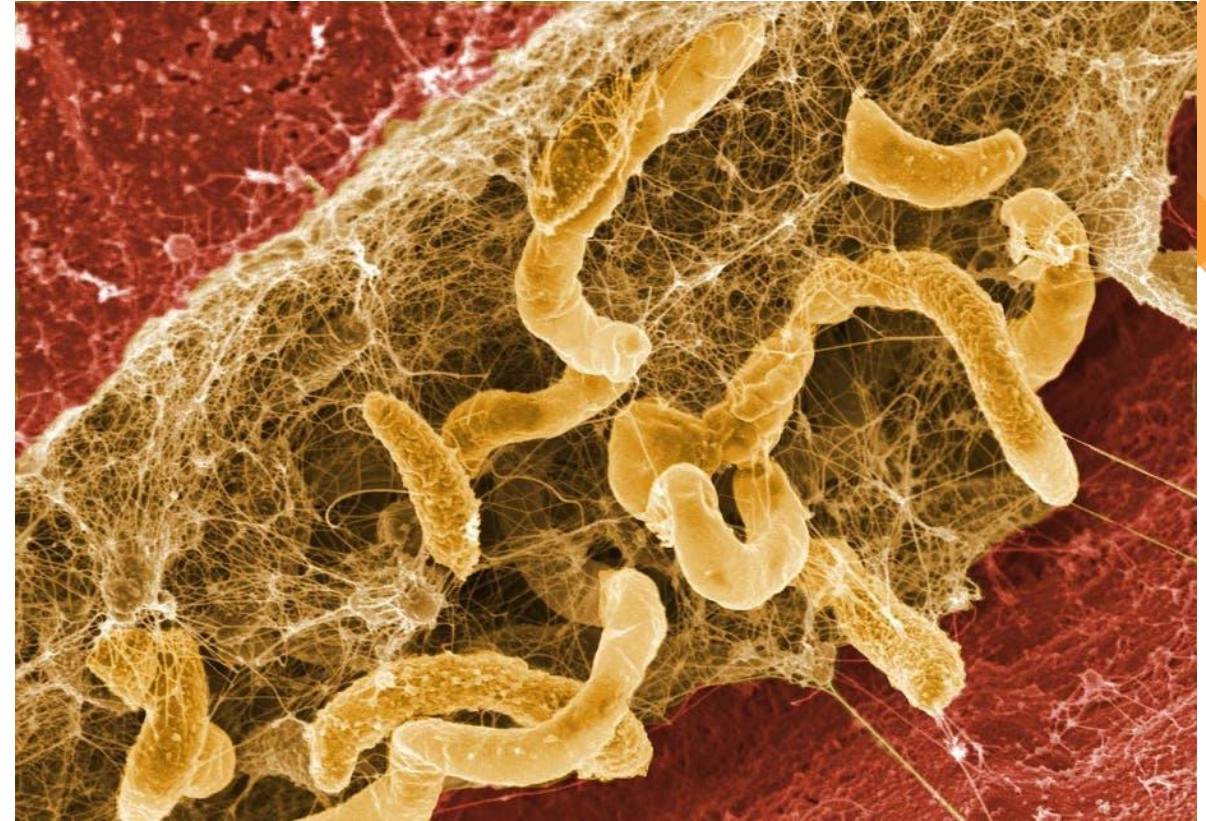
Concept Check

Which of the following virulence factors associated with the Enterobacteriaceae are associated with septic shock and DIC?

- A. Flagellar H antigens
- B. Capsule K antigens
- ☒ C. LPS and lipid A endotoxin
- D. Pathogenic islands

Biofilms

- Enterobacteriaceae can form biofilm on surfaces, medical devices and within living and dead tissues.
- Biofilms are highly resistant to antibiotics, immune clearance and eradication.
- Documented biofilm-associated enteric infections include biliary tract infection, bacterial prostatitis, intensive care unit (ICU) pneumonia, urinary catheter cystitis and biliary stent blockage.



theconversation.com/biofilms-the-bacterial-wound-communities-that-protect-themselves-from-attack-42218

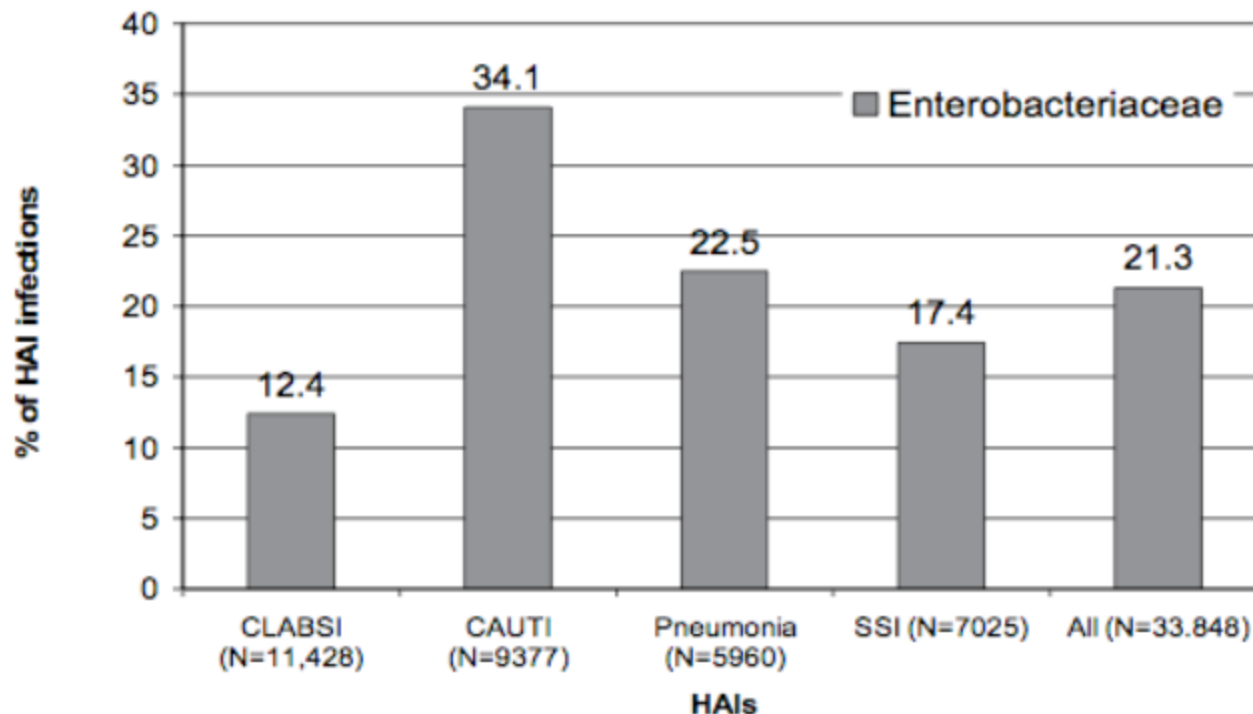
Infections

- Enterobacteriaceae rarely infect patients that are immunocompetent.
- **Host defenses must be breached for disease to occur.**
 - The skin or mucous membranes may be breached by:
 - Trauma.
 - Surgery.
 - Catheterization.
 - Tracheal intubation.
 - Antibiotic therapy.
- Opportunistic organisms or pathogens may gain entry through:
 - Third-degree burns.
 - Ulcers.
 - Intravenous catheters.
 - Surgical or Instrumental manipulation.
 - Contaminated food and beverages.

Clinical Syndromes

Enterobacteriaceae remain important pathogens in the four most common device- and procedure-related infections in acute-care facilities.

Figure 77-2.



CLABSI: Central line-associated bloodstream infection

CAUTI: Catheter-associated urinary tract infection

Pneumonia

SSI: Surgical site infection

*Other infections include central nervous system infections and gastrointestinal tract infections.

Common Pathogens, Cont.

More E. coli cases linked to Chipotle; may be a different outbreak

The five new cases are the same strain as the other 53 cases but have a different DNA fingerprint

The five individuals ate at one of two locations, either in Kansas or Oklahoma

ate at a Kansas location. Their symptoms began between November 18 and November 26 and all the individuals had consumed food from Chipotle within a week of becoming ill.

These five cases have a different DNA fingerprint than the rare strain of E. coli identified in the outbreak linked to the same restaurant chain that has caused 53 cases or illness in nine states since October. The CDC reported the latest of these cases on Monday, an individual from Pennsylvania who became ill in early November. The strain is shiga toxin-producing E. coli O26, or STEC O26.

Concept Check

Which of the following Enterobacteriaceae is the most common cause of community and health care-associated urinary tract and bloodstream infections?

- A. *E. coli*
- B. *K. pneumoniae*
- C. *Y. pestis*
- D. *Salmonella bongori*

Concept Check

TRUE or FALSE:

All of these diarrheagenic *E. coli* strains have been associated with human disease:

- ETEC
- EIEC
- EPEC
- EHEC
- EAggEC

Enterobacteriaceae as Biological Weapons

Yersinia pestis

- Bubonic plague.
- High-impact biological agent that presents a heightened bioterrorism risk.



Bubonic plague



Septicemic plague

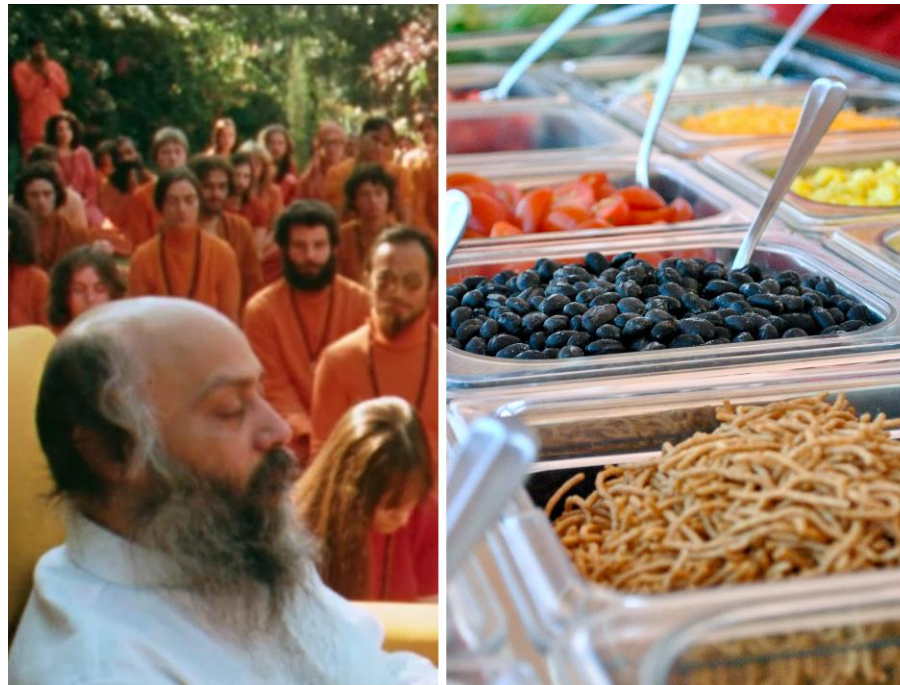


Pneumonic plague

www.cdc.gov/plague/symptoms/index.html

Rajneeshee Bioterror Attack

- Largest bioterror attack in U.S. history.
- Poured *Salmonella*-tainted liquid on items in the salad bar.
- The Rajneeshees hit a total of 10 restaurants, as well as a handful of other public areas.
- 751 people were stricken with *Salmonella* poisoning.



www.vice.com/en/article/kzp4n9/wild-wild-country-netflix-salad-bar-bioterror-attack

Antibiotic Resistance

- Extended-spectrum beta-lactamases (ESBLs).
 - The most common ESBL-producing pathogens include *Klebsiella* species and *E. coli*.
 - The ESBL-resistant genes are carried on plasmids or other mobile genetic elements, along with resistance to the fluoroquinolones and aminoglycosides.
 - They can readily be transmitted to other members of the family.
- Other beta-lactamases, AmpC and carbapenem-producing Enterobacteriaceae (CPE) are capable of hydrolyzing most beta-lactam antibiotics.

Carbapenem-Producing and Carbapenem-Resistant Enterobacteriaceae (CRE)

- Carbapenems are usually the last option for the treatment of multidrug-resistant infections.
- **Carbapenemases** are hydrolyzing enzymes that confer resistance to the expanded spectrum cephalosporins, monobactams and the carbapenems (imipenem, meropenem and ertapenem).
- The carbapenemase family of enzymes include:
 - *Klebsiella pneumoniae* carbapenemases
 - (KPC-1, KPC-2, KPC-3)
 - *Serratia marcescens* enzyme
 - (SME-1, *Serratia* species)
 - Verona integron-encoded metallo-beta-lactamase (VIM-1)
 - Predominantly of the KPC, VIM, IMP, NDM and OXA-48 types

Antibiotic Resistance Threats in the US, 2019 (CDC)

Urgent Threats

These germs are public health threats that require urgent and aggressive action:



CARBAPENEM-RESISTANT
ACINETOBACTER



CANDIDA AURIS



CLOSTRIDIoidES DIFFICILE



CARBAPENEM-RESISTANT
ENTEROBACTERIACEAE



DRUG-RESISTANT
NEISSERIA GONORRHOEAE

Source: <https://www.cdc.gov/drugresistance/biggest-threats.html>



WHAT YOU NEED TO KNOW

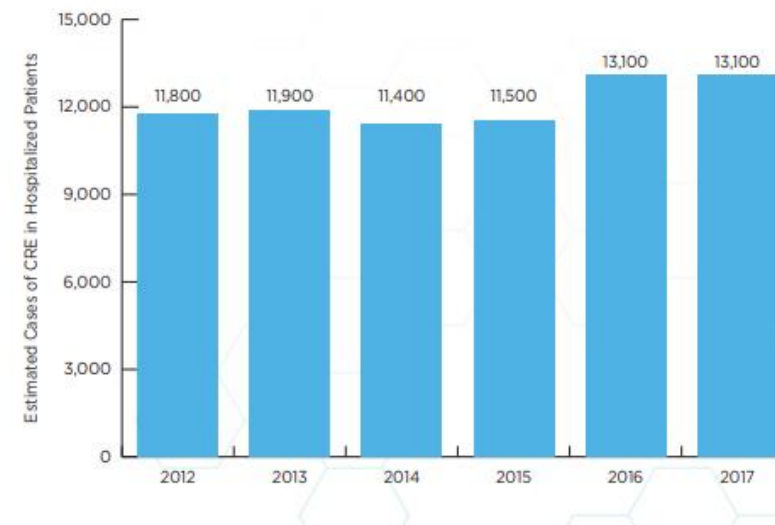
- Patients who require devices (e.g., catheters) and patients taking long courses of some antibiotics are most at risk for CRE infections.
- CRE can carry mobile genetic elements that are easily shared between bacteria. Approximately 30% of CRE carry a mobile genetic element that can make an enzyme, which makes carbapenem antibiotics ineffective and rapidly spreads resistance that destroys these important drugs.
- Preventing CRE infections and containing the spread of carbapenem resistance is important to protect people.



U.S. Department of
Health and Human Services
Centers for Disease
Control and Prevention

CASES OVER TIME

Containment strategies have prevented further spread of some types of CRE in the United States, but continued action is needed.



Source: <https://www.cdc.gov/drugresistance/pdf/threats-report/CRE-508.pdf>

Chapter 86

Legionella pneumophila

Background

- Identified in 1976 American Legion Convention held in Philadelphia, Pennsylvania hotel.
- Relatively common cause of both community-acquired and health care-associated pneumonia.
- Infection has been linked to drinking water distribution systems of acute-care and extended-care facilities, with **warm water** systems typically implicated.
- **Legionnaires' disease:** pneumonia.
- **Pontiac fever:** flu-like illness.



www.osha.gov/legionnaires-disease

Deadly Legionnaires' outbreak at Atlanta hotel is the largest on record in Georgia



By Jacqueline Howard, CNN

Updated 12:07 PM EDT, Mon August 12, 2019



www.gpb.org/news/2019/08/05/legionnaires-disease-in-atlanta-the-impacts-on-health-and-tourism

One person died of the disease and 11 other cases were confirmed after stays or visits at the Sheraton Atlanta Hotel between June 12 and July 15, Nancy Nydam, a spokeswoman for the Georgia Department of Public Health, said in an email.

There also have been 63 probable cases, Nydam said. Probable cases are those who have symptoms of the disease but have not yet had a laboratory test to confirm it. Last week, there were 61 probable cases.

www.cnn.com/2019/08/11/health/legionnaires-outbreak-sheraton-atlanta-largest-in-georgia/index.html

Microbiology

- Aerobic gram-negative.
- Fastidious.
 - Requires specialized culture media.
- **Urinary antigen** is the most used test for diagnosis.



specialpathogenslab.com/legionella-culture-2/



www.fishersci.com/shop/products/binaxnow-legionella-urinary-antigen-test-kit/BNX852000

Clinical Presentation: Legionellosis

- Pneumonia is the most common clinical infection.
- Incubation period: 2–10 days.
- Associated symptoms: nonproductive cough, fever (usually exceeds 104°F), shortness of breath, malaise, myalgia, anorexia, headache, confusion, watery diarrhea, nausea, vomiting, abdominal pain.
- *Legionella* is the most frequently reported cause of infection in outbreaks associated with **drinking water**.

Chest radiographs usually show a new infiltrate, which increases in size and density and may progress to multiple lobes.



casesjournal.biomedcentral.com/articles/10.1186/1757-1626-2-9151

Clinical Presentation: Pontiac Fever

- Pneumonia is **not** present.
- Incubation period: 24–48 hours.
- Associated symptoms: high fevers, chills, myalgia, headache.
 - Symptoms resolve within 2–5 days without treatment.
- Whirlpool spas have been the source of some outbreaks.



legacywhirlpool.com/hot-tubs/inspire

Risk Factors

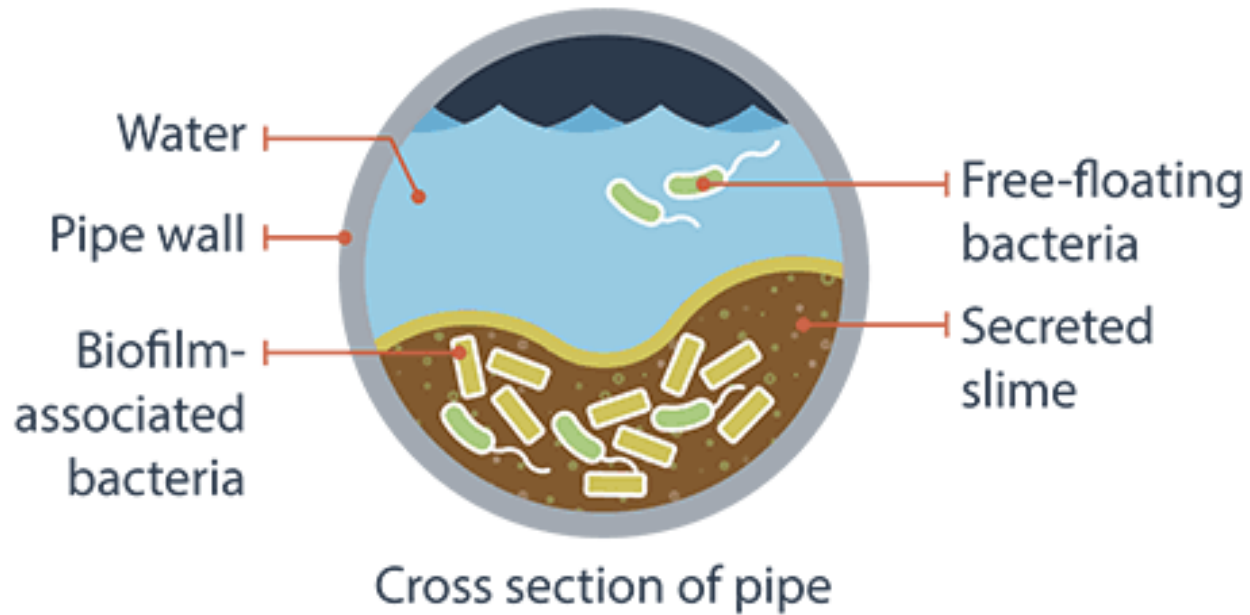
- Advanced age.
- Male.
- Cigarette smoking.
- Alcohol abuse.
- Chronic pulmonary disease.
- Immunosuppression.
- Solid organ transplant (Highest risk).
- Corticosteroid usage.
- Renal failure.

Modes of Transmission

- **Aerosolization:**
 - From devices such as humidifiers and nebulizers.
- **Aspiration** (Significant route of transmission in health care-associated pneumonia):
 - Intubation.
 - Surgery requiring general anesthesia.
 - Nasogastric tubes.
- **Instillation:**
 - Inoculated directly into the lungs through the use of devices rinsed with *Legionella*-containing tap water, such as transesophageal echocardiogram probes.
- **Person-to-person transmission** documented in 2016:
 - One probable reported case was reported in an elderly woman with close contact with her infected son.
 - Isolation of Legionnaires' disease patients is not required.

Growth and Spread of *Legionella*

Legionella can live and grow in biofilm



www.cdc.gov/legionella/wmp/overview/growth-and-spread.html



www.hortweek.com/warning-gardeners-rise-cases-legionella-disease/parks-and-gardens/article/1444517

Prevention

- Water safety plan that includes routine culturing of the hospital drinking water.
- If health care-associated Legionnaires' disease is suspected, culturing of the water sites to which the patient was potentially exposed is indicated.
 - Distal sites include water faucets, ice machines, water used in respiratory tract devices and any other water source to which the patient is exposed.
 - Recommended sampling sites should include the cold-water supply, the outlet of the heating system, the inlet (return) to the heating system and at least 3 samples from floors that house ill patients, to comprise at least 10 sites in facilities with less than 500 beds and two sites per 100 beds for facilities with more than 500 beds.

Control Measures

- Maintain hot water temperature at 60°C (140°F).
- Selection of the disinfection system should be made in consultation with the infection preventionist, facility engineers and the water safety team.
 - Use of U.S. EPA-registered and labeled disinfectants is recommended.
- Copper-silver ionization systems.
- Chlorine dioxide.
- Monochloramine.
- Point-of-use water filters.
- Hyperchlorination.

Concept Check

A patient has been diagnosed with Legionnaires' disease that was possibly acquired during his stay in the hospital. What is the recommended first response to this incident?

- A. All water sites in the health care facility to which the patient was exposed should be cultured for *L. pneumophila*
- B. The patient should be placed on respiratory isolation until 24 hours after treatment has started
- C. The water system should be superheated and flushed immediately
- D. All patients should immediately be provided with bottled water for drinking

Concept Check

All of the following are modes of transmission for *Legionella* EXCEPT?

- A. Aerosolization from a humidifier
- B. Aspiration from a contaminated nasogastric tube
- C. Instillation into the lungs from a contaminated TEE probe
- D. Touching a patient who was diagnosed with Legionnaires' Disease

Chapter 81

Diarrheal Diseases Viral, Bacterial, and Parasitic

Diarrheal Diseases: Viral

Key Concepts

- Leading cause of diarrheal disease in children.
- **Rotavirus** is the most common cause of severe diarrhea in children.
- **Noroviruses** cause the majority of viral gastroenteritis worldwide.
- **Fecal-oral spread** is the most common mode of transmission of viral gastroenteritis agents.
- Secondary transmission may occur with viral gastroenteritis agents.
- Acute gastroenteritis is one of the most common diseases in humans worldwide.
- Most cases of gastroenteritis resolve in 5 to 10 days.

Diarrheal Diseases: Bacterial

Key Concepts

- Outbreaks of severe gastroenteritis have been associated with multiple strains of enteropathogenic *Escherichia coli*.
- Other common bacterial causes of diarrhea include *Salmonella*, *Shigella* and *Campylobacter* species.
- Bacterial agents of diarrhea are often linked to food sources that have become contaminated with human or animal fecal waste.

Typhoid Mary

- Typhoid fever is most often caused by *S. enterica* subspecies enterica serovar Typhi, referred to as *S. typhi* for simplification.
- Transmitted by the fecal-oral route through food and water contaminated by infected individuals or chronic carriers.
- The incubation period ranges between 5 and 21 days, depending on the inoculum dose of the ingested bacteria.



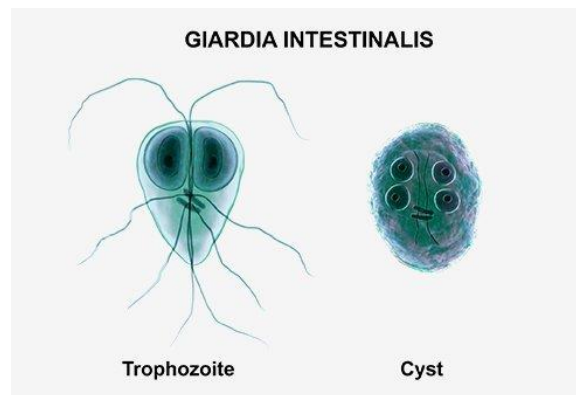
Diarrheal Diseases: Parasitic

Key Concepts

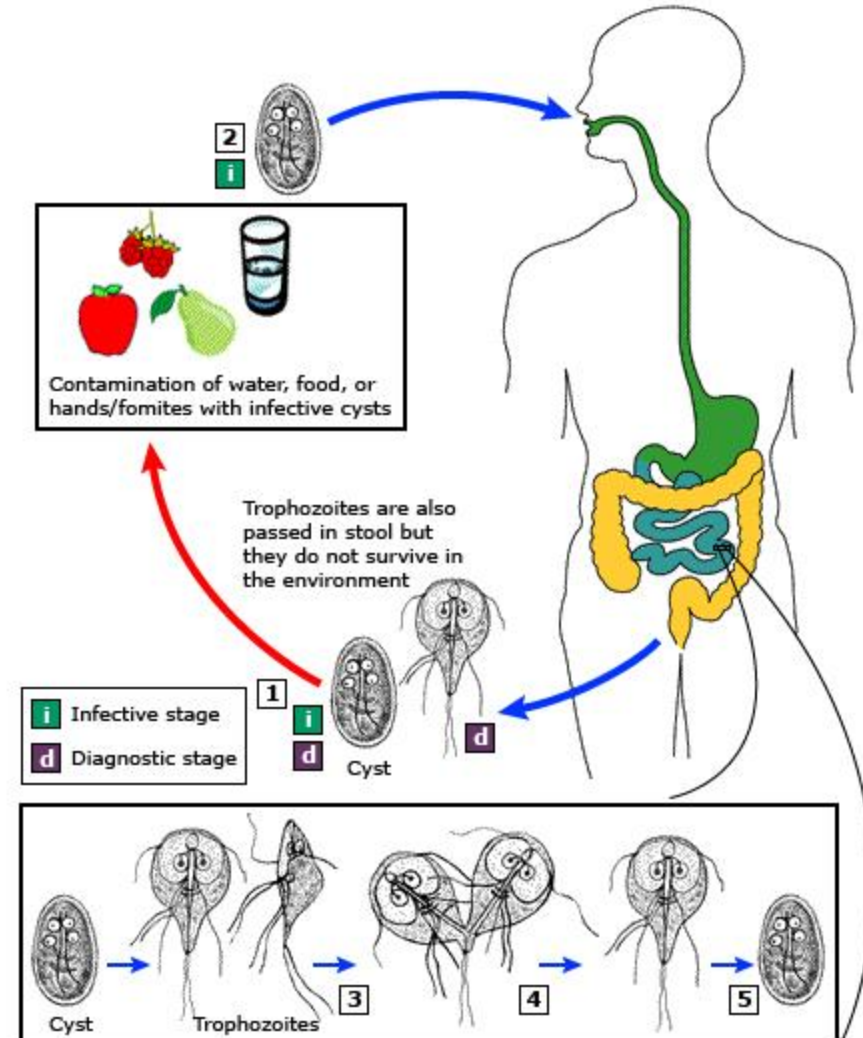
- Although many of the parasitic agents of diarrhea are tropical in distribution, some, such as giardia and cryptosporidium, are prevalent worldwide.
- Fecal-oral is the most common route of transmission for parasitic agents causing gastroenteritis.

Giardia (lamblia) duodenalis

- Flagellated protozoa.
- It has both a trophozoite stage (the replicative stage) and a cyst stage (the infective stage of the organism).
- Transmission is seen most commonly via ingestion of cysts in contaminated water sources.
- Fecal-oral transmission.



www.medicinenet.com/giardia_lamblia/article.htm



[microbeonline.com/giardia-lamblia-life-cycle-diseases-and-laboratory-diagnosis//](http://microbeonline.com/giardia-lamblia-life-cycle-diseases-and-laboratory-diagnosis/)

Chapter 99

Viral Hepatitis

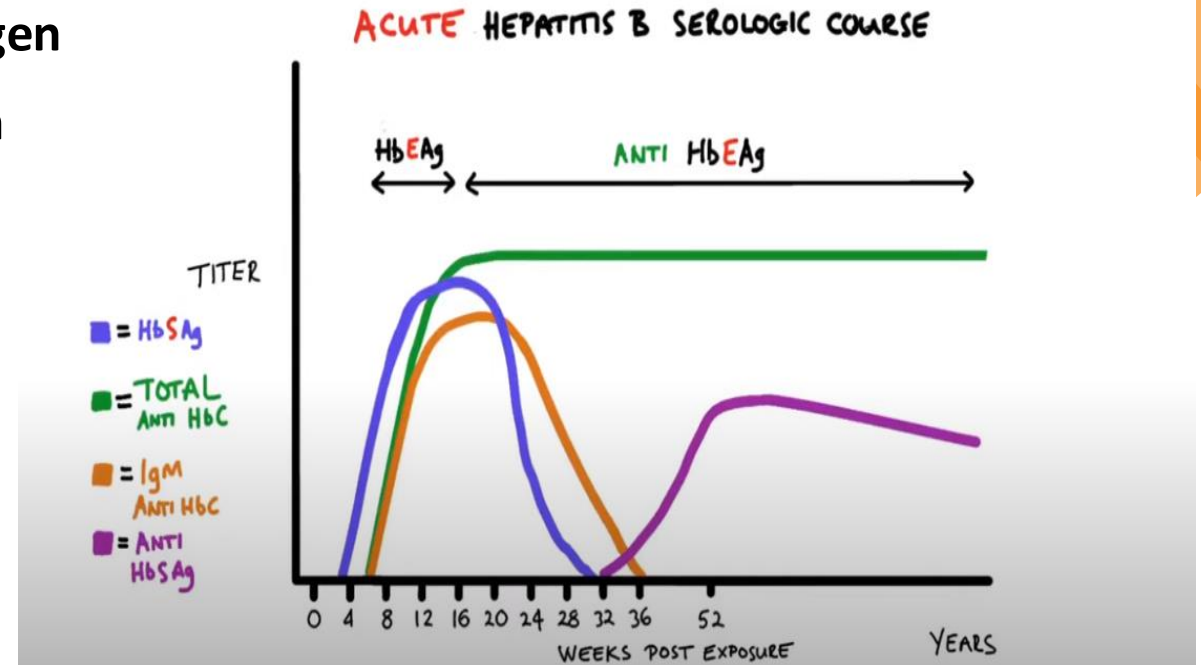
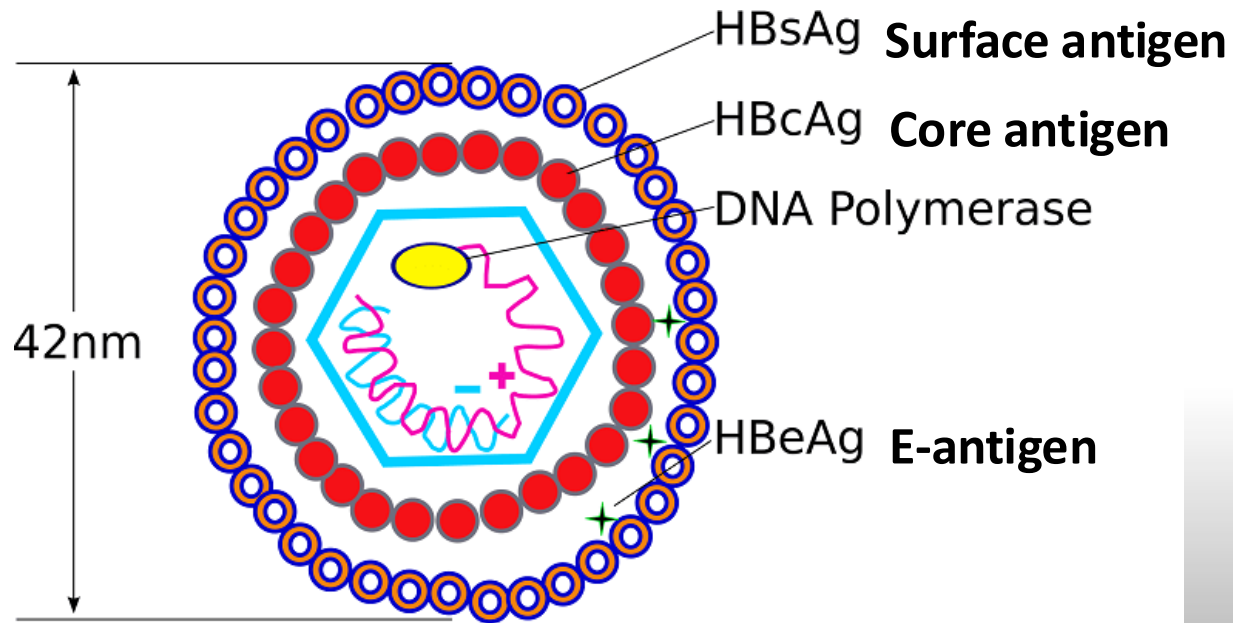
Overview: Hepatitis A Virus (HAV)

- Only found in humans and primates.
- Fecal-oral transmission.
- **Prevention:**
 - HAV vaccine.
 - Unvaccinated adults ages 40 years or younger with recent (within 2 weeks) exposure to HAV.
 - Immune globulin (Ig).
 - Preferred for persons ages 40 and over with recent (within 2 weeks) exposure to HAV.

Overview: Hepatitis B Virus (HBV)

- Historically, HBV was the most common bloodborne pathogen with risk for HCP.
 - The incidence of HBV among HCP dramatically fell in the 1990s because of preventive measures mandated by the **OSHA Bloodborne Pathogen Rule of 1991**.
- Transmitted through blood or blood products, sexual contact or perinatal exposure of an infant.
- Prevention:
 - Standard precautions.
 - Hepatitis B vaccine.
 - HBIG for postexposure prophylaxis.
 - Persons not already immune to HBV when they have percutaneous or mucosal exposure.
 - Recent sexual contacts of all HBV-infected persons who are not HBV immunized.
 - Infants born to mothers who are HBsAg positive.

Overview: HBV, Cont.



*Antibodies can form for each antigen
(anti___)

Hepatitis B Serology MADE EASY - How
to Interpret Hepatitis B Serology in
under 5 minutes!

www.youtube.com/watch?v=SEQw-SjAhY

Interpretation of Hepatitis B Serologic Test Results

***Must memorize**

Hepatitis B serologic testing involves measurement of several hepatitis B virus (HBV)-specific antigens and antibodies. Different serologic "markers" or combinations of markers are used to identify different phases of HBV infection and to determine whether a patient has acute or chronic HBV infection, is immune to HBV as a result of prior infection or vaccination, or is susceptible to infection.

HBsAg anti-HBc anti-HBs	negative negative negative	Susceptible
HBsAg anti-HBc anti-HBs	negative positive positive	Immune due to natural infection
HBsAg anti-HBc anti-HBs	negative negative positive	Immune due to hepatitis B vaccination
HBsAg anti-HBc IgM anti-HBc anti-HBs	positive positive positive negative	Acutely infected
HBsAg anti-HBc IgM anti-HBc anti-HBs	positive positive negative negative	Chronically infected
HBsAg anti-HBc anti-HBs	negative positive negative	Interpretation unclear; four possibilities: 1. Resolved infection (most common) 2. False-positive anti-HBc, thus susceptible 3. "Low level" chronic infection 4. Resolving acute infection

Adapted from: A Comprehensive Immunization Strategy to Eliminate Transmission of Hepatitis B Virus Infection in the United States: Recommendations of the Advisory Committee on Immunization Practices. Part I: Immunization of Infants, Children, and Adolescents. MMWR 2005;54(No. RR-16).

■ Hepatitis B surface antigen (HBsAg):

A protein on the surface of hepatitis B virus; it can be detected in high levels in serum during acute or chronic hepatitis B virus infection. The presence of HBsAg indicates that the person is infectious. The body normally produces antibodies to HBsAg as part of the normal immune response to infection. HBsAg is the antigen used to make hepatitis B vaccine.

■ Hepatitis B surface antibody (anti-HBs):

The presence of anti-HBs is generally interpreted as indicating recovery and immunity from hepatitis B virus infection. Anti-HBs also develops in a person who has been successfully vaccinated against hepatitis B.

■ Total hepatitis B core antibody (anti-HBc):

Appears at the onset of symptoms in acute hepatitis B and persists for life. The presence of anti-HBc indicates previous or ongoing infection with hepatitis B virus in an undefined time frame.

■ IgM antibody to hepatitis B core antigen (IgM anti-HBc):

Positivity indicates recent infection with hepatitis B virus (≤ 6 mos). Its presence indicates acute infection.

Overview: Hepatitis C Virus (HCV)

- Common cause of cirrhosis and hepatocellular carcinoma.
- No vaccine.
- **Transmission:**
 - Blood injection (injecting drug users).
 - Organ transplantation.
 - Transfusion of HCV-infected blood or blood products.
- **Prevention:**
 - Testing of blood products prior to transfusions.
 - Testing of organs and tissues.
 - Modifying high-risk behaviors.

Overview: Hepatitis D Virus (HDV)

- **Depends on simultaneous infection with HBV.**
- New infections occur principally among IV drug users.
- **Transmission:**
 - Percutaneous exposure.
 - Inefficiently transmitted by sexual intercourse like HBV.
- **Prevention:**
 - Modifying high-risk behaviors.
 - Postexposure passive immunization with HBIG with HBV vaccine.
 - Preexposure active immunization with HBV vaccine will prevent co-infection with HDV.

Overview: Hepatitis E Virus (HEV)

- **High mortality rate among pregnant women.**
 - Infection during pregnancy results in a high frequency of fetal loss, and vertical transmission can occur in up to 50 percent of cases.
- Thought to cause at least 50% of sporadic acute viral hepatitis in developing countries.
- Epidemics of HEV seem to occur cyclically related to heavy rainfall and flooding in endemic areas.
- **Transmission:**
 - Fecal-oral via ingestion of contaminated water.
- **Prevention:**
 - Ensuring separation of the water supply from sewage.
 - Pregnant women should be cautious about travel to endemic regions due to elevated mortality risk.

Concept Check

Which one of the following viral hepatitis types are transmitted through blood and body fluid?

- A. HBV
- B. HCV
- C. HDV
- D. HEV
- E. All of the above
- ☒ F. A, B, and C
- G. A and B only

Concept Check

HDV is associated with a co-infection of:

- A. Hepatitis V
- B. Hepatitis C
- ☒ C. Hepatitis B
- D. Hepatitis E

Concept Check

For a labor and delivery/nursery employee, which of the following would be MOST important to provide protection to the nurse from infectious disease?

- A. Chickenpox or shingles history
- B. Tetanus/diphtheria immunization status
- C. Measles, mumps, rubella immune status
- D. Hepatitis B immunity

Group Member Spotlight

Mandy Spangler, MPH, CIC



- I returned to college for my MPH in 2018. I received an internship at the Florida Department of Health that began just as the COVID pandemic began. The administrator for the county health department felt there was no better way to learn about the public health system than to experience it during a pandemic. I started as an intern in May, 2020 which turned into a full time job within 4 weeks. This was the first taste of Epidemiology and when I began considering taking my CIC exam. I was invited to the very first Cohort study offered. I felt so lost because there was so much more to learn. After my temporary position during COVID came to an end in 2022, I moved into the acute care infection prevention arena. I re-joined Cohort 2 and again Cohort 3. Each brought new information to my ears and mind.

Week 5 Assignments

Action Items

Assigned chapter readings:

- Chapter 10 General Principles of Epidemiology
- Chapter 11 Surveillance
- Chapter 12 Outbreak Investigations