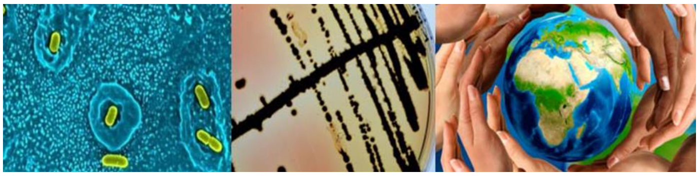

The Public Health Necessity for Food Regulations II/II
Foodborne Diseases of Public Health Importance and Additional Transboundary Disease

AGSC 5540: Food Policies and Regulations

8-26-2021

Tennessee State University, Nashville, TN

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Content

One Health, Rift Valley Fever; Tularemia; Trichinellosis

- **Exercise 1**

Avinan Influenza, New Castle Disease; Foot-and-mouth Diseases

- **Exercise 2**

Brief Introduction to Food Safety, Discussion of Foodborne Pathogens of Public Health Concern

- **Exercise 3**

- CDC NORS Data assignment discussion: **Due 9/2/2021.**
- Discussion of Topics of Term Papers.
- Very brief discussion of the syllabus and course highlights

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<u>One Health:</u> Interactions between people, animals, plants, and our environment

(1) **Human Populations**: Growth and expansion into new geographic regions.

(2) **Planetary Health:** Climate changes, land use, such as deforestation and intensive farming

(3) **Animals, and Animal Products**: international travel and trade

<u>Results in:</u>

Spread of **existing** or known (endemic) and new or **emerging** (new), or **re-emerging infectious disease**.

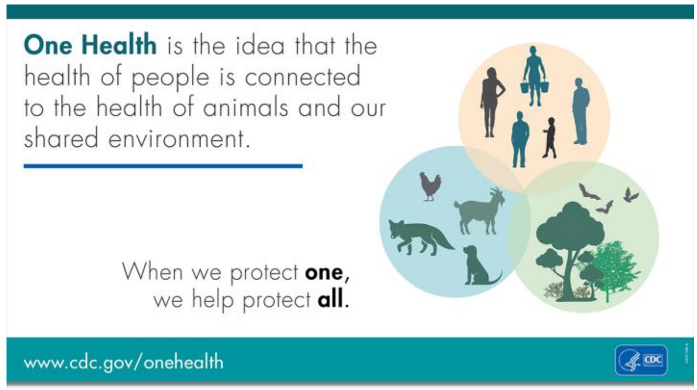
One Health is gaining recognition in the United States and globally as an effective way to fight health issues at the **human-animal-environment** interface.

An estimated **60% of known infectious diseases** and up to **75% of new or emerging infectious diseases** are zoonotic in origin*

<u>Most Common One Health Issues:</u>

- Rabies; *Salmonella* infection; West Nile virus infection; Q Fever (*Coxiella burnetii*); Anthrax; Brucellosis; Lyme disease; Ringworm; Ebola

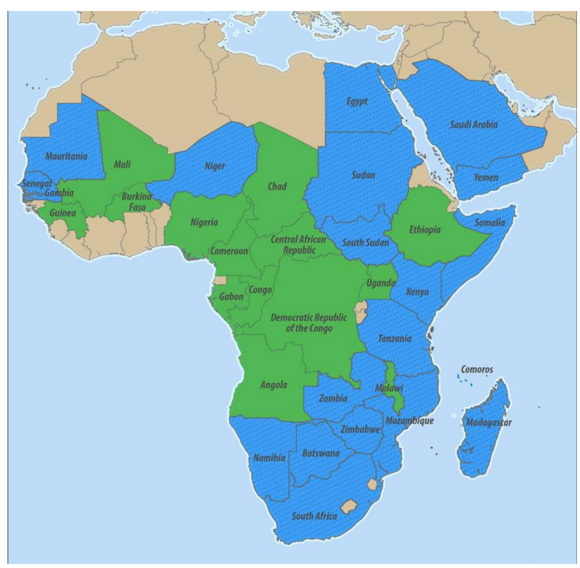
*Source: https://www.cdc.gov/onehealth/index.html and * Salyer, 2017*



Rift Valley Fever

- It is a **viral disease** caused by genus *Phlebovirus* in the family *Bunyaviridae*
- Commonly observed in **domesticated animals**:
  - Cattle
  - Buffalo
  - Sheep
  - Goats
- Has ability to infect and cause illness in humans (i.e. is a **zoonotic disease**)
- First reported in **Kenya**'s Rift Valley in the early **1910**
- Currently and **endemic throughout most Africa**

[Sporadic to Endemic, like HIV 1959 in Congo]



Rift Valley Fever

Outbreaks of disease in animal populations are called "**epizootics**."

The most notable RVF epizootic occurred in **Kenya in 1950-1951**, resulting in the death of an estimated 100,000 sheep.

Transmission:

-Mosquitoes (**vector-borne disease**)

Virus transmission from **female mosquitos** to their **offspring by the eggs**

Excessive rainfall enables more mosquito eggs to hatch

-**Aerosolized** virus from infected animals

-**Direct contact** with bodily fluids of infected animals

Symptoms:

-**Animals**: Abortion and death in neonates (asymptomatic adults)

-**Humans**: Flu-like symptoms, fever, headache, eye and systematic infection

Typically, one person touch his/her face upto 16 times per hour

[Infection control of hands in some culture…]

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One virus: 1×10^{-17} **kg**

I Kg= 100,000,000,000,000,000 virus

I kg =2.2 lb

Rift Valley Fever

Current Epidemiology/WHO estimates:

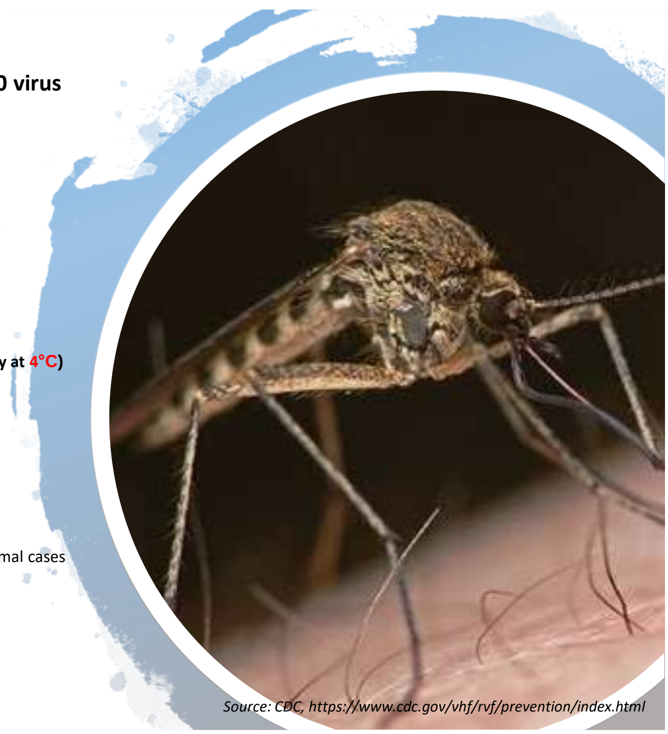
- As high as **5 kg (>10 lb) of virus** could be aerosolize every year
- Leading to **350,000 cases of human illness**
- About **400 death episodes (1% mortality**)
- The virus is **relatively stable in environment (>30 days without loss of infectivity at 4°C)**
- Could be in activated by various chemical sanitizers

[not like Bacterial biofilms …]

Recent Outbreaks:

- **Niger, 2016:** 33 deaths
- **Uganda, 2016:** 3-5 confirmed cases
- **South Africa and Namibia: 2009-2011:** 25 human death, >14,000 confirmed animal cases

[infection control: N95, KN95, Surgical masks …]



Source: CDC, https://www.cdc.gov/vhf/rvf/prevention/index.html

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Rift Valley Fever

Prevention in Livestock:
- **Vaccination** of ruminants in endemic area
- Control of **mosquitoes**
- **Limit human exposure** with infected animals
- **Separation** of infected animals

Prevention in Human:
- **No vaccines** are currently available for human vaccination
- **Surveillance** (close monitoring for infection in animals and humans)
- There is no documented case of **human-to-human transmission** of RVF virus

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Tularemia

- **Bacterial diseases** caused by: *Francisella tularensis*
- **Symptoms**
- **Sheep, young pigs, horses, dogs, cats**:
  - -Sudden fever
  - -Lethargy
  - -Stiffness
  - -Prostration
  - -Death

- **Wildlife:**
  - -Common in wildlife find dead
  - -Rabbits behave strangely
- **Cattle, older pigs resistant**

- **Humans**
- caused by ingestion of organism in **contaminated food** (undercooked meat).
- Could cause **skin** complication and **systematic infections**
- Could be **30 to 60% lethal** if untreated

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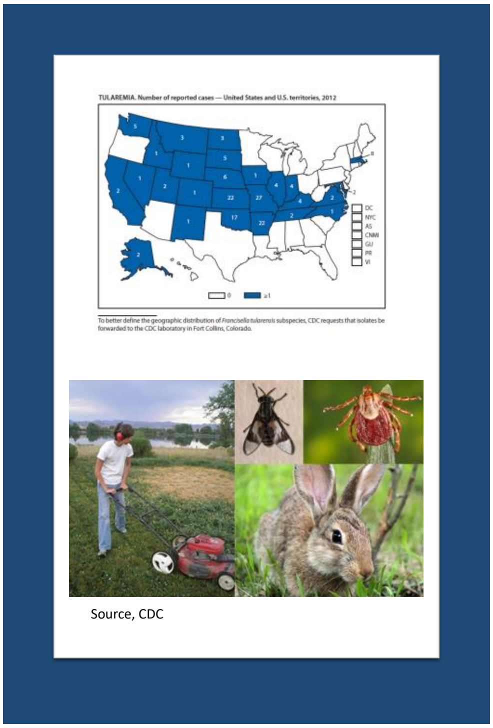
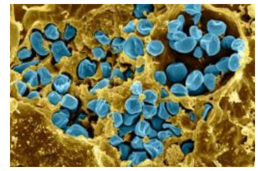


Source, CDC

Tularemia



- Infection could occur in Human:

-Tick, deer, and fly bites
-Skin contact with infected animals or
-Ingestion of contaminated water or food
-Inhalation of contaminated aerosols or
-Agricultural dusts
-Drinking contaminated water
-Laboratory exposure

- **Person-to-person transmission not documented**

- In the United States, naturally occurring infections reported from **all states** except **Hawaii**

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Tularemia

- Bacterium is very stable and capable of forming biofilm
- In the US, 274 cases in 2019 with 0.1 in 100,000 people prevalence.
- **Could be aerosolized** with **low infective dose** via inhalation [unlike *Campylobacter* …]
- Case fatality: **30-60% (untreated)**
- **Antibiotics effective**, if given early or before exposure
- **Vaccine:**

  -For high-risk individuals
  -Unknown efficacy against inhalational tularemia

Other precautions to avoid Tularemia:

- Use of **insect repellent**
- **Wearing gloves when handling sick or dead animals**
- **Avoiding mowing over dead animals**

Source: cdc

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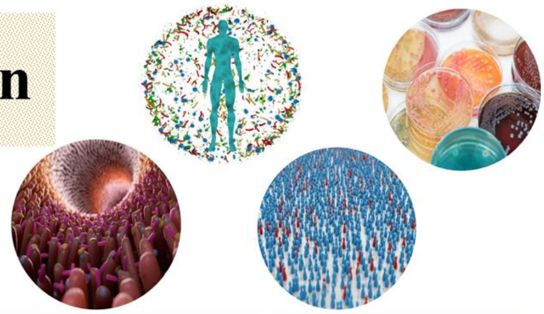
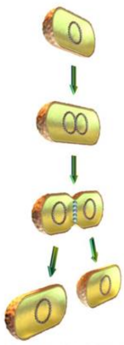
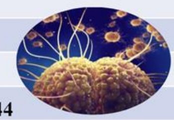
Bacterial Multiplication



Binary Fission: 20 minutes or less when intrinsic and extrinsic factors are optimal.



Time	# of Bacteria
0 minutes	1
20 minutes	2
40 minutes	4
1 hour	8
2 hours	64
4 hours	4,096
6 hours	262,144
8 hours	16,777,216
12 hours	68,719,476,736



Information and photos are modified and adopted from BBB of Food and Drug Administration, BAM Resources of Centers for Disease Control and Prevention. Photo Courtesy: Adobe Stock (standard license of photos purchased by the Public Health Microbiology laboratory).

Bacteria	Estimated Infective Dose*
Salmonella serovars	<10 cells
Shiga toxin-producing *E. coli*	10 to 100 cells
Cronobacter sakazakii	10 to 100 cells
Listeria monocytogenes	<1000 cells
Campylobacter spp.	5000 to 10,000 cells
Staphylococcus aureus	>100,000 cells
Vibrio cholerae	1,000,000 cells

** Calculated for oral ingestion based on epidemiological data from outbreaks and human feeding trials of volunteers. Data obtained from BBB of Food and Drug Administration (2nd edition).*

Public Health Microbiology Laboratory: Education, Research, Outreach, and Technical Assistance: https://publichealthmicrobiology.education/

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Trichinellosis (also known as Trichinosis)

Photos courtesy for Animal and Plant Health Diseases

Photos courtesy for Human Health Diseases. Public Health Image Library

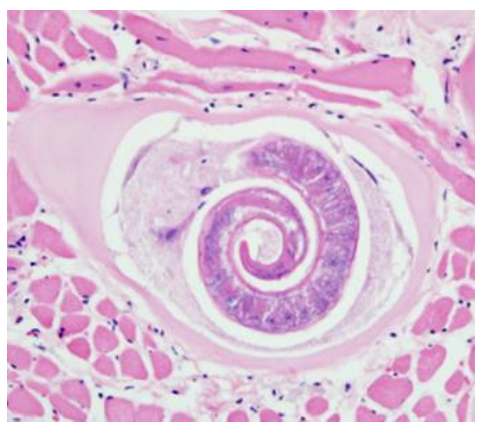
- Cause by a parasitic agent
- Infection very common in:

-Wild carnivorous **animals** such as bear or cougar

-Omnivorous **animals** such as **domestic pigs or wild boar**

- **Infection in human:**

-**Eating raw or undercooked meat** of animals infected with the larvae of a species of worm called *Trichinella*



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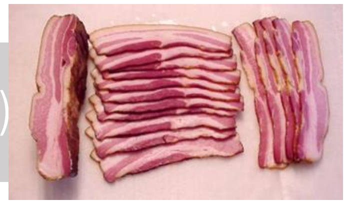
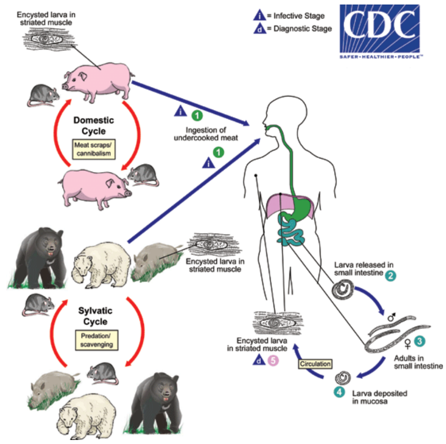
Trichinellosis (also known as Trichinosis)



- **Abdominal symptoms** can occur **1-2 days after infection**
- **Further symptoms** usually start **2-8 weeks** after eating contaminated meat

- **Symptoms** may range from very mild to severe
- **Mild cases** of trichinellosis are typically misdiagnosed **as flu**
- **Primary signs:** Nausea, diarrhea, vomiting, fatigue, fever, and abdominal.
- **Further signs:** headaches, fevers, chills, cough, swelling of the face and eyes, aching joints and muscle pains, itchy skin, diarrhea, or constipation may follow the first symptoms
- **Diagnosis:**
- A blood test or
- Muscle biopsy

Source: CDC, 2018



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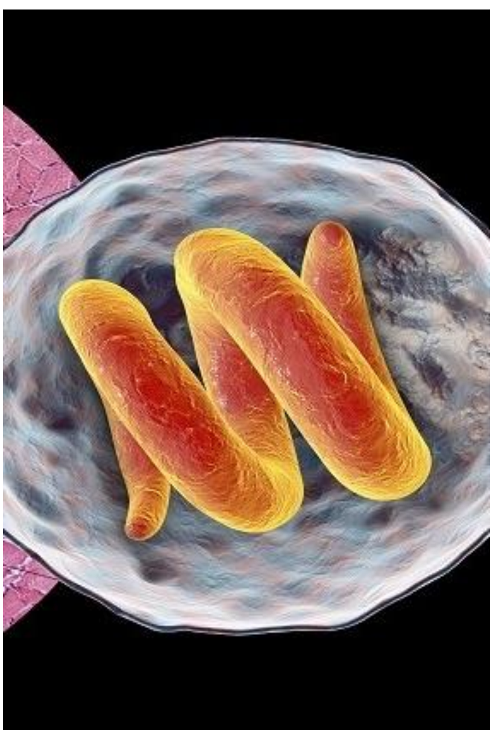

Trichinellosis (also known as Trichinosis)

Prevention:

- For **Ground Meat** (including wild game, excluding poultry) Cook to at least **160° F (71° C)** [Variations available, will discuss in Food Code Talk]

  [TN Variance Committee]
- For All **Wild Game** (whole cuts and ground) Cook to at least **160° F (71° C).** **[Intact and nonintact meat, around 75% carcass]**

Other preventive measure

- **Wash your hands** with warm water and soap after handling raw meat and hunting
- **Clean meat grinders** thoroughly after each use.
- Curing (salting), drying, smoking, or microwaving meat alone **does not** consistently kill infective worms;
- **Homemade jerky and sausage** were the cause of many cases of trichinellosis reported to CDC in recent years. **[Extension program, Extension Agents]**

- **<u>Freezing</u>: [not effective against most viruses and bacteria]**
- **Might** inactivate the parasite for **pork less than 6 inches** thick for 20 days at 5°F (**-15°C**)
- **Might not** be effective to inactivate all parasite in **wild game** meats due to **freeze-resistant phenotypes** of parasite

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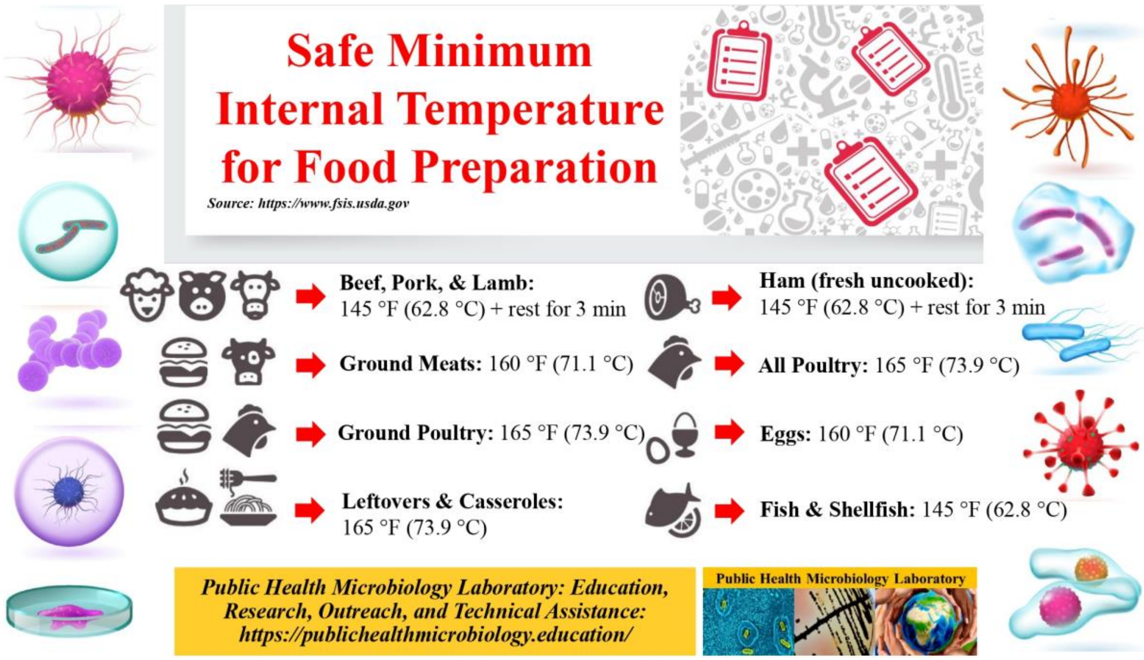

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Exercise 1

- Based information we discussed so far in the class, in your opinion why it is important to study infectious diseases in context of one Health?
- In what country and in What year Rift Valley Fever was first reported?
- What is the meaning of epizootic?
- What is the public health burden of Rift Valley Fever?
- What are symptoms of Tularemia in different species?
- What are the main symptoms of Trichinellosis and how long it takes to develop?
- Please name effective freezing condition and internal cooking temperature for reducing risk of Trichinellosis.
- What is the causative agent for each disease? Rift Valley Fever; Tularemia; Trichinellosis

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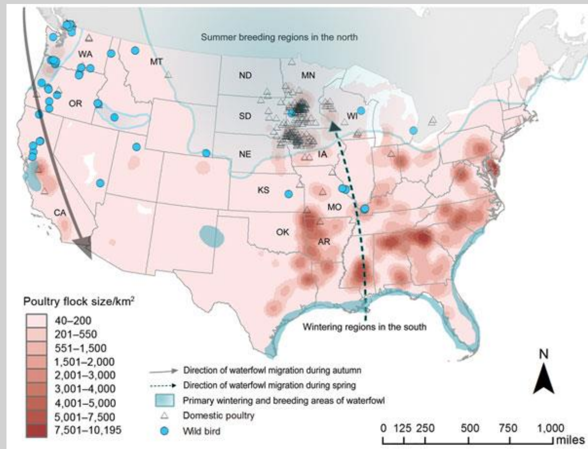
Zoonotic Infectious Diseases in Poultry

- New Castle Diseases
- Avian Influenza in Eastern Hemisphere
- Avian Influenza in Western Hemisphere
- Role of land-grant Universities and Cooperative Extension Program

[Great job opportunities …]

[Extension, funded by government agencies]

HPAI 2014-2019, United States



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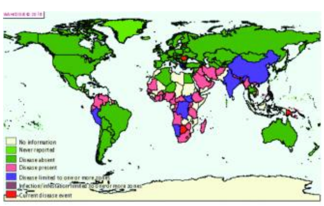

Source: Merck Veterinary Manual

Newcastle Disease- Etiology

- **Viral disease**
- It is a **worldwide problem**
- **Domestic poultry and other bird species**
- **Endemic in poultry**:

  Most of **Asia, Africa**, and some countries of **North and South America**.
- **Clinical signs**:
- Acute respiratory disease
- Nervous manifestations,
- Diarrhea
- Occurrence of the disease in the U.S. **reportable** and may result in **trade restrictions.**
- **Infected birds shed virus:**
  - In exhaled air
  - Respiratory discharges
  - Fecal metter

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Newcastle Disease- Epidemiology

Spread of Disease:

- Movement of infected birds
- Transfer of virus in **infective fecal metters** by the movement of people and
- contaminated equipment or litter

Epidemiology in the USA and Canada:

- Are free of pathogenic strains in poultry processing (eradicated).
- Maintain that status with **surveillance**, **import restrictions** and **eradication** by destroying infected poultry.
- NDV strains of **low virulence** are prevalent in poultry and **wild birds, especially waterfowl.**

Current Concern:

- **Cormorants, pigeons, and imported psittacine** species are more commonly infected with virulent (pathogenic) NDV and have also been sources of vNDV infections of poultry.

Source: Merck Veterinary Manual

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Newcastle Disease- Symptoms

- **Incubation period** in birds: 2-15 days

Symptoms in birds:

- Drop in egg production
- Neurological damage
- GI signs,
- Respiratory distress
- Numerous deaths within 24-48 hours

- Within a flock, deaths continue for 7-10 days
- **Morbidity 100%, mortality 90%** ***(concentration and genetic similarity)***
- Not a **major Zoonotic disease**

Symptoms in humans (poultry processing plants workers, public health workers):

Mild eye complications (Conjunctivitis)

Flu-like symptoms

Mostly self-limiting

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Newcastle Disease- Preventive measure

- No vaccines available for humans

[Self-limiting, average cost of new vaccine/drug development > $350 M]

[New Drug vs. New Food Additives> GRAS list talk]

- In Animals, ND vaccines **do not provide sterile immunity** (complete protection), and in many areas of the world vaccines are used to **prevent losses from sickness and death**.
- The **vaccinated birds will shed if infected** with vNDV

- **Preventive measure:**
- Isolation and
- Depopulation of the infected birds

Source: Merck Veterinary Manual

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Avian Influenza in Eastern Hemisphere

- 2004/5 –H5N1 **emerged in Asia**:
- Depopulation and death of **millions of poultry** and is **zoonotic disease**
- Concern that H5N1 would spread through **migrating birds and Commerce** from flyways in Europe/Asia to the **Western hemisphere**
- **Extensive surveillance programs established in U.S.**
- No detections of this strain of H5N1 in Western hemisphere
- **New strains** of H5 avian influenza detected in Canada and US fall **2014**

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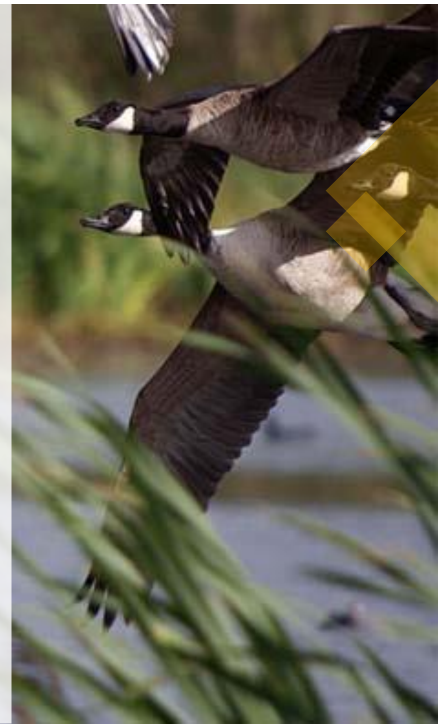
Avian Influenza in Western Hemisphere

- HPAI outbreak of **2014-2015, largest animal health emergency in history of the country**.
- >**48 million** birds had died or depopulated due to the diseases
- Diseases introduced by **wild migratory water fowl and** transmitted from farm to farm by personnel
- **Pathogens can be secreted** through feces, oral, and nasal secretions of the birds
- Prevention and biosecurity **to eliminate and minimize exposure**
- Currently **no treatment** available for **human** and infected animals. **Person-to-person transmission? Mortality rate? Endemic?**
- [*Example of Prevention Program*]
- [*Extension Agents, Extension Services, Land-grant Universities*]
- [Extension, funded by government agencies]



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Birds Health and Prevention of Infectious Diseases

- **Stablished controlled access:** minimizing the exposure of potentially contaminated ***personal*** and ***vehicles*** to your backyard farm.
- **Structural barriers**: Keeping free flying birds and four-legged animal out
- **Securing the doors and entrances**.
- **Have separate clothing for farm activities.**
- **Designated foot baths** for each pen or a designated pair of shoes for each pen (disinfectant mats)
- **Protective clothing** for service personnel, veterinarians, and all visitors.

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Pre-Harvest Prevention

- **Feed and water** are stored in covered area and free of contaminants to avoid wild fowl and pests (small batches)
- **Clean and disinfect** all equipment, farm equipment, egg baskets etc.
- **Wash hands and arms** before and after entering chicken houses.
- **Hunters** with exposure to wild fowl would need to change cloths and shower before re-entrance to chicken houses, specially after contact with water fowl that harbor avian influenza without signs of sickness.
- Keeping poultry away from natural or man-made **ponds or rivers** would also reduce the exposure risk.

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Pre-Harvest Prevention

- **Separation** of younger birds from older and separation of chickens from different races would also reduce the likelihood of infectious disease spread (separation of chickens from turkeys). This may help to reduce *Salmonella* and *Campylobacter* colonization.
- Proper and timely **disposal** of dead birds, to avoid flies, pests, and scavengers.
- Contact **state laboratory** after observing sick or dying birds to identify and diagnose the infectious agents. In case of sudden spike in mortality (>50%).
- **Do not visit farms with high mortality** rate among their birds
- Other helpful strategies are use **of antibiotics, probiotics, prebiotics, botanical feed additives, and vaccines**.
- [Carvacrol, thymol as feed additive, …]

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Foot-and-Mouth Disease

- Highly communicable **viral disease** (*Aphthovirus* of the family Picornaviridae).
- **Livestock hosts**:
  cattle, pigs, sheep, goats (experimental infections in alpacas and llamas).

Symptoms:

- fever
- vesicles in the **mouth** and on the muzzle, and feet.
- In susceptible population, **morbidity reaches 100%**

Transmission:

Spreads through direct contact or aerosolized virus via:

- respiratory secretions
- milk
- semen
- **ingestion of feed** from infected animals (**meat, offal, milk**).

Source: Merck Veterinary Manual

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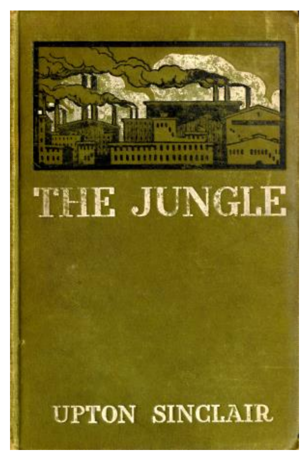
Foot-and-Mouth In the United States

- US had total of **9 FMD outbreaks (many sporadic cases)** in addition to many sporadic cases
- **Historic outbreak and some of the earliest regulation:**
- 1870, 1880 and 1884: **imported** animals, lead to **federal inspection and quarantine programs** that had been successful to preventing the disease to occur from imported animals since 1884. [The book Jungle]
- 1902, 1908, 1914, 1924 (twice) and 1929 from pathogen existing on **mainland**
- **The six later** were controlled by: **stopping movement** and **stamping out**
- Currently **only sporadic cases** in north America that is **controlled aggressively** with stamping out
- [Without continued public health program may easily return, like measles]



Source: Center for Food Security and Public Health, Iowa, Zoonotic Diseases
Source: Merck Veterinary Manual

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Foot-and-Mouth- Global Prevalence

World Organization for Animal Health (OIE):

- 178 member countries
- 96 countries are **endemic** (never been free of FMD)
- 66 countries **free of FMD**
- 11 countries have **free zones** (with or without vaccination)
- 5 countries were free, recently suffered from **re-emergence of FMD**

WORLD ORGANISATION FOR ANIMAL HEALTH

Source: Center for Food Security and Public Health, Iowa, Zoonotic Diseases
Source: Merck Veterinary Manual

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Evolving Practices in Handling FMD Outbreak

- Stop movement
- Stamping Out
- Slaughter of all clinically affected and in-contact susceptible animals (within 24 hours or as soon as possible) [Feedlot Operations]
- **Trace back/Trace forward epidemiology**: **28 days prior to outbreak**
- Rapid Diagnostics
- **Vaccines available**: **Difficulty** but must be matched to the specific **type** and **subtype** of virus causing the outbreak
- Vaccination, usually used to slow spread (Vaccinate to kill/slaughter; Vaccinate to live)

Source: Center for Food Security and Public Health, Iowa, Zoonotic Diseases
Source: Merck Veterinary Manual

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Burden of the Disease

- Animals at risk in the United States
  - 100 million cattle
  - 60 million swine
  - 7 million sheep
  - 40 million wildlife
  - Not horses
- **Humans rarely infected**
- FMD is not a public health or food safety threat.
- Huge economic impact
- Commercially produced meat, milk and dairy products would be **safe to consume** in an **FMD outbreak**.

Hand, foot, and mouth disease

- **(Not the same virus, similar symptoms)** is a common viral illness that usually **affects infants and children younger than 5 years** old. However, it can sometimes occur in older children and adults
- There is **no specific treatment** for hand, foot, and mouth disease. However, you can do some things to relieve symptoms: OTC **pain relieve** and mouthwash to reduce symptoms. (Immunocompromised)

Animal Disease Emergencies, 2008 - IHSEMD, IDALS, CFSPH; https://www.cdc.gov/hand-foot-mouth/index.html; Photo courtesy: CDC

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Exercise 2

- What is the main source of 2014/2015 Avian Influenza outbreak in the US?
- Which Disease is caused by a bacterial agent?

-Avian Influenza

-Newcastle Disease

-Foot-and-mouth Diseases

-Listeriosis

- What is the current status of pathogenic (virulent) and low virulent New Castle Virus in North America? What is a potential source of concern for pathogenic (virulent) New Castle Virus in the United States?
- What are the symptoms and incubation period of Newcastle Disease?
- What is OIE and based on information discussed from OIE about foot-and-mount disease what is the importance of currently in place public health practices against this viral disease?
- Based on the information discussed in the last two classes, in your opinion what are the best practices to control the transboundary infectious disease that are zoonotic in nature?

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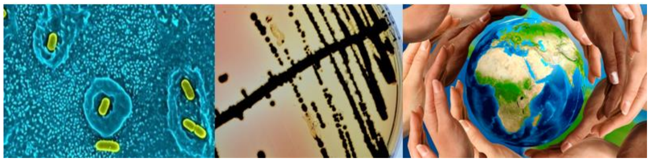

Foodborne Diseases of Public Health Importance

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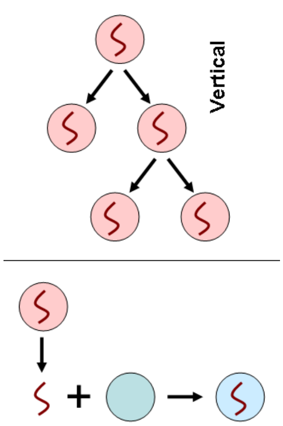
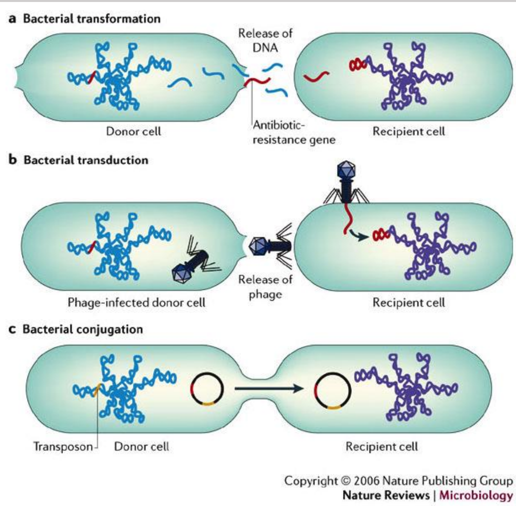
Emerging pathogens

Diversity, moving towards *"fitness" and Emerging Pathogens*

Photo Courtesy: http://www.daviddarling.info/encyclopedia/B/binary_fission.html





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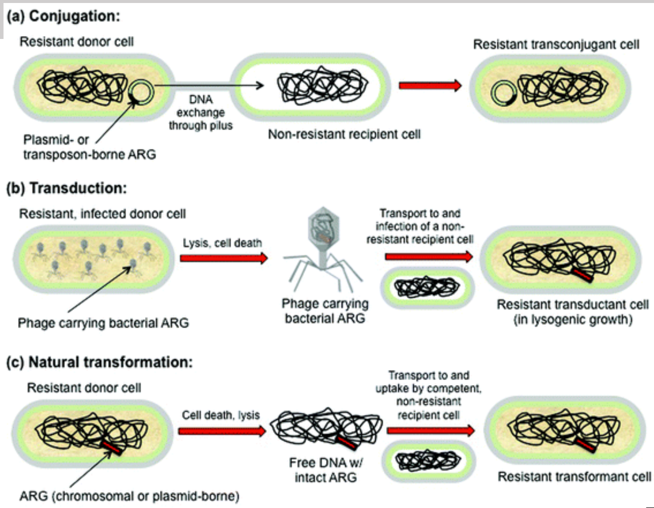
Horizontal Gene Transfer



Donn, 2012

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Planktonic cells and Biofilm Communities

Photo Courtesy: http://prometheus.matse.illinois.edu/glossary/biofilms/

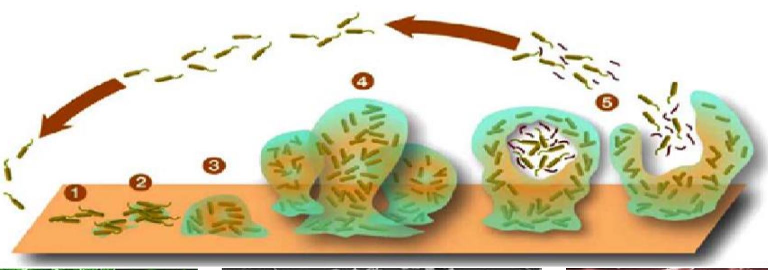


Photo Courtesy: http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

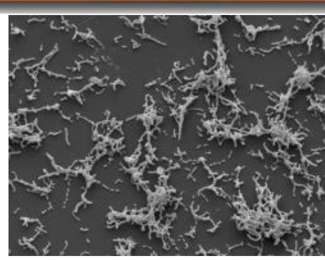


Photo Courtesy: http://www.ifenergy.com/50226711/boosting_microbial_fuel_cells_with_biofilm.php

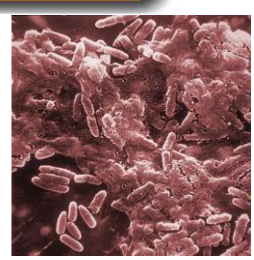
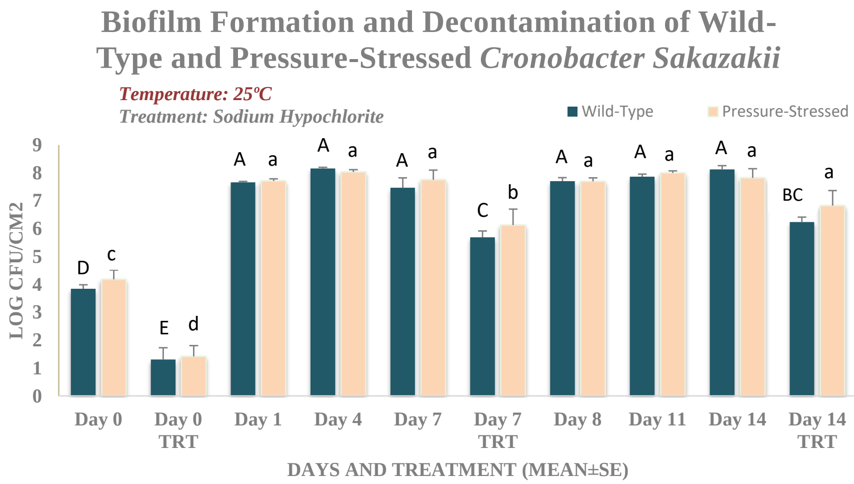
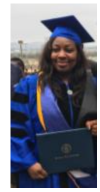


Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/

36

Cronobacter sakazakii
Two outbreaks in Tennessee (1998, Memphis; 2001 Knoxville)





Allison et al., 2021

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Quorum Sensing and Biofilm formation
Shiga toxin-Producing E. coli and antibiotics treatment

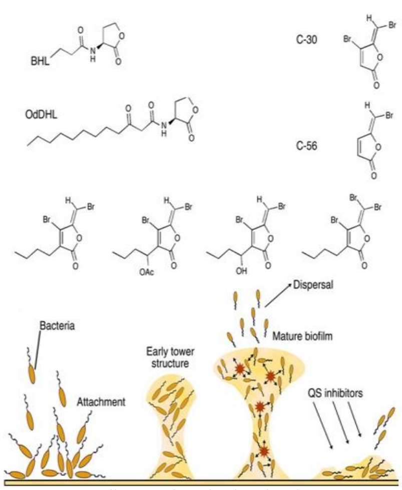

Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

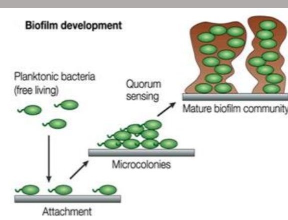

Photo Courtesy: http://labrat.fieldofscience.com/2010/07/quorum-sensing-and-biofilms.html

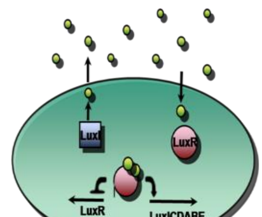

Photo Courtesy: http://2009.igem.org/Team:Aberdeen_Scotland/WetLab/quorumsensing

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Infectious Diseases in Animals and Human is a Moving Target…

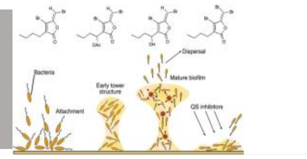


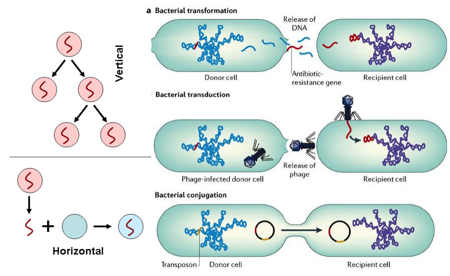
Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

- It is estimated only 1% of microbial community has been identified.
- Currently **etiological agent** of **80.3% of foodborne illnesses**, **56.2% of hospitalization**, and **55.5% of deaths** remain unknown.

"Emerging" Pathogens:

- Vertical and horizontal gene transfer spores and biofilm formation
- Quorum sensing and cell to cell communication

"It is the microbes who will have the last word."
-Louis Pasteur



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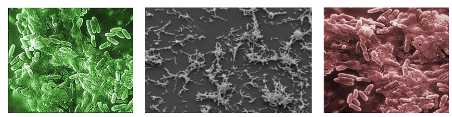

Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/
http://www.ifenergy.com/50226711/boosting_microbial_fuel_cells_with_biofilm.php
http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

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A superbug resistant to every available antibiotic in the U.S. kills Nevada woman

BY HELEN BRANSWELL, STAT January 13, 2017

Rare strain of E. coli strikes across Canada: source unknown

A dozen cases of E. coli O121 have been confirmed in three Canadian provinces, according to matching genetic fingerprint data, but the source of the outbreak has not yet been identified.

The Public Health Agency of Canada reports four of the rare O121 cases were confirmed in British Columbia, four in Saskatchewan and four in Newfoundland and Labrador. The illness onset dates were in November and December of 2016.

Four of the victims have been hospitalized. Those individuals have recovered or are in the process of recovery. An investigation to determine the source of the relatively rare E. coli O121 contamination is ongoing.

The Public Health Agency of Canada says improper handling of ground meat and eating raw ground meat are two of the most common sources of E. coli illnesses. Other common sources are contaminated raw fruits

New outbreaks linked to Italian style meats; one third of patients hospitalized

By Coral Beach on August 24, 2021

Inspectors are looking for specific sources of two new Salmonella outbreaks that have been associated with Italian-style meats. Three dozen people from 17 states have been confirmed infected so far.

One of the recalled products

Almost 200 sick in UK-wide Salmonella outbreak

By Joe Whitworth on August 24, 2021

Nearly 200 people across the United Kingdom are part of a Salmonella outbreak linked to pork scratching products.

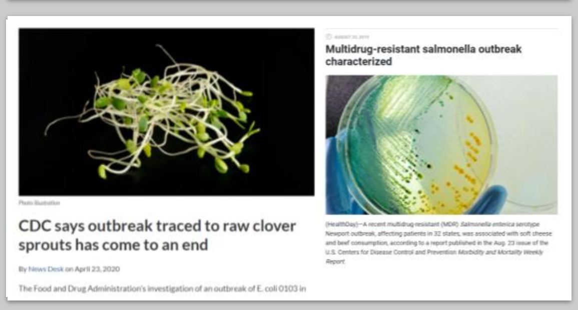


Photo Illustration

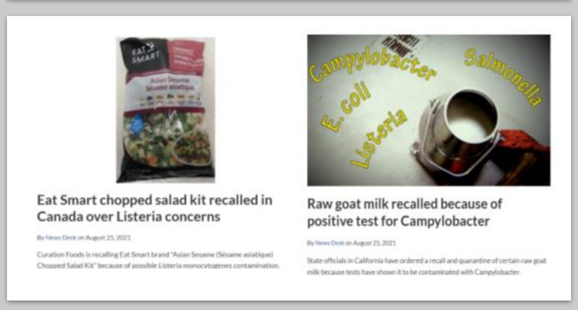
CDC says outbreak traced to raw clover sprouts has come to an end

By News Desk on April 23, 2020

The Food and Drug Administration's investigation of an outbreak of E. coli O103 in

Multidrug-resistant salmonella outbreak characterized

(HealthDay)—A recent multidrug-resistant (MDR) *Salmonella enterica* serotype Newport outbreak, affecting patients in 32 states, was associated with soft cheese and beef consumption, according to a report published in the Aug. 23 issue of the U.S. Centers for Disease Control and Prevention *Morbidity and Mortality Weekly Report*.



Eat Smart chopped salad kit recalled in Canada over Listeria concerns

By News Desk on August 25, 2021

Curation Foods is recalling Eat Smart brand "Asian Sesame (Sésame asiatique) Chopped Salad Kit" because of possible Listeria monocytogenes contamination.

Raw goat milk recalled because of positive test for Campylobacter

By News Desk on August 25, 2021

State officials in California have ordered a recall and quarantine of certain raw goat milk because tests have shown it to be contaminated with Campylobacter.

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Epidemiology of Foodborne Diseases

- **Based on data from 1990s:** *(Mead et al., 1999)*

76 million illnesses, 323,000 hospitalizations, **5,200 deaths** in the United States.

- **More recent estimates show:** *(Scallan et al., 2011)*

47.8 million illnesses, 127,839 hospitalizations, and more than **3,037** deaths in the United States.

- 9.4 million illnesses, 55,961 hospitalizations, and 1,351 deaths are cause by 31 known foodborne agents.
- In addition to consumer insecurity, foodborne diseases cause around $**77.7 billion** for losses in productivity and economical losses.
- Approximately 30% of population are especially “at risk” for foodborne diseases (The **YOPI**’s: The young, the old, Pregnant, and Immunocompromised)

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Significant foodborne pathogens… *based on Mead et al., 1999 and Scallan et al., 2011 studies*

- **Leading etiological agents for illnesses**: *Norovirus* (58%), Nontyphoidal *Salmonella* serovars (11%), *Clostridium perfringens* (10%), and *Campylobacter* spp (9%).
- **Leading etiological agents for hospitalization:** Nontyphoidal *Salmonella* serovars (35%), *Norovirus (26%), Campylobacter* spp (15%), and *Toxoplasma gondii* (8%).
- **Leading etiological agents for death:** Nontyphoidal *Salmonella* serovars (28%), *T. gondii* (24*%), Listeria monocytogenes* (19%), and *Norovirus (11%).*

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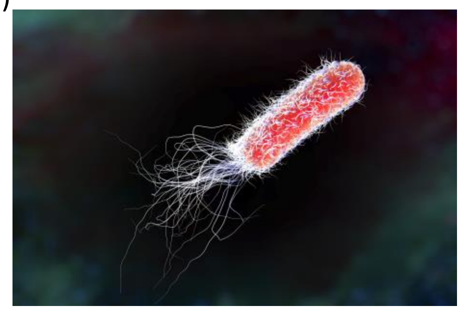
Signs and Symptoms of Foodborne Diseases

- Mild illness (no medical care sought)
- **Guillain–Barré syndrome** (*Campylobacter* and *Salmonella*)
- **Post-infectious irritable bowel syndrome** (*Campylobacter* and *Salmonella*)
- **Reactive arthritis** (*Campylobacter* and *Salmonella*)
- **Haemolytic uraemic syndrome** (*E. coli* O157)
- **End-stage renal disease** (*E. coli* O157)
- Death



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Significant Foodborne Pathogens of Public Health Concern: Considering DALY and QALY *(Scallan et al., 2015)*

- **Disability Adjusted Life Year** ***(DALY)****. Loss of life and health due to illness compared with 'perfect' health*

- Non-typhoidal *Salmonella* (329000)
- Toxoplasma (32700)
- *Campylobacter* (22500)
- Norovirus (9900)
- *Listeria monocytogenes* (8800)
- *Clostridium perfringens* (4000)
- *Escherichia coli* O157 (1200)

62% bacterial agents; 29% parasitic agents; 9% viral agents

- Mild illness (no medical care sought)
- **Guillain–Barré syndrome** (*Campylobacter* and *Salmonella*)
- **Post-infectious irritable bowel syndrome** (*Campylobacter* and *Salmonella*)
- **Reactive arthritis** (*Campylobacter* and *Salmonella*)
- **Haemolytic uraemic syndrome** (*E. coli* O157)
- **End-stage renal disease** (*E. coli* O157)
- Death

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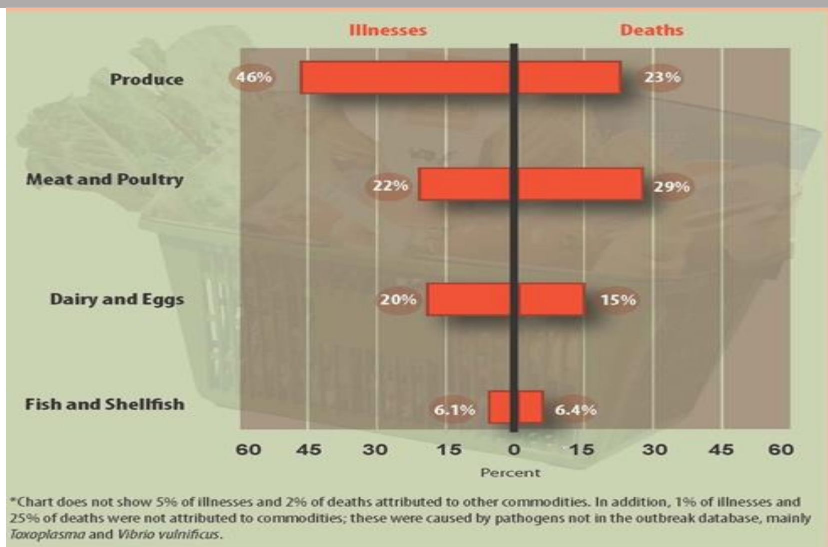
CDC Estimates of Food Safety Burden

http://www.cdc.gov/foodborneburden/attribution-image.html#foodborne-illnesses



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Are these outbreaks associated with corporates and lager manufactures?

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Prevalence of Pathogens in Medium-sized Poultry Operations

- 200–300 ft houses, 3000 to 5000 birds, conventional operation

(Alali et al., 2010)

	Salmonella serovars
Fecal samples (n=420)	38.8%
Feed (n=140)	27.5%

- Total of 135 sample from commercial free-range chicken producers
(Bailey et al., 2005)

	Salmonella serovars
Chicken Carcasses in Operation 1	64%
Chicken Carcasses in Operation 2	31%

Alali et al., 2010, J Foodborne Pathogens and Diseases; Bailey et al., 2005, J Food Protection

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Prevalence of Pathogens in Small Poultry Farms

- Study of 60 Small poultry slaughterhouses (fewer than 200 birds slaughtered per day)

Sampling sites	*Salmonella* serovars *(Albany, Hadar, Indiana, and Enteritidis sub-species)*
Carcasses after slaughter	42%
Utensils	23.1%
Storage freezers and refrigerators	71.4%

- The Study concluded *"The widespread occurrence of Salmonella in small slaughterhouses reinforces the need for implementation of effective control measures…"*

Terumi et al., 2000, Journal of Food Protection

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Climate Change and Public Health Microbiology

Non-typhoidal *Salmonella enterica* serovars

- **Global death:** 50,000 global death in 2010 (WHO, 2020)
- **Public Health Burden in the U.S.:** >1 million annual cases in 2011 (CDC, 2011)

Climate Change:

- **1 °C increase : 5 to 10% increases in Salmonellosis (WHO, 2010)**
- 2500 to 5000 additional global death
- 50,000 to 100,000 U.S. morbidity

At our current rate:

- >1.5 °C by 2040
- >4.8 °C by 2100


microorganisms MDPI

Editorial

Safety of Food and Water Supplies in the Landscape of Changing Climate

Aliyar Cyrus Fouladkhah [1,*], Brian Thompson [2] and Janey Smith Camp [3]

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In response to evolving environmental, production, and processing conditions, microbial communities have tremendous abilities to move toward increased diversity and fitness by various pathways such as vertical and horizontal gene transfer mechanisms, biofilm formation, and quorum sensing [1,2]. As such, assuring the safety of water and food supplies from various natural and anthropogenic microbial pathogens is a daunting task and a moving target. Recent outbreaks of *Listeria monocytogenes* in South Africa associated with a ready-to-eat product (affecting close to 1000 individuals) and the 2018 outbreak of Shiga toxin-producing *Escherichia coli* O26 associated with ground meat in the United States (leading to the recall of more than 132,000 pounds of products) are bitter reminders of the devastating influences of foodborne diseases on the public health and food manufacturing [3,4].

Recent epidemiological studies of world populations indicate that 420,000 people lose their lives every year due to foodborne diseases, with around one-third of those being 5 years of age or younger. It is further estimated that every year, 1 in 10 individuals experience foodborne diseases around the globe, leading to an annual loss of 33 million healthy life years [5]. These episodes of food and water

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Main Bacterial Pathogens Associated with Animal and Human Health Diseases

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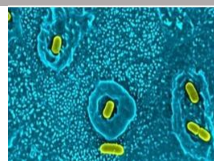
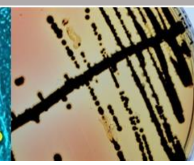
Foodborne Pathogens of Public Health Concerns >200 foodborne diseases


- *Salmonella* serovars
- *Staphylococcus aureus*
- *Campylobacter* spp.
- *Bacillus cereus*
- Shiga Toxin-Producing *Escherichia coli* (STEC)
- *Vibrio* spp.
- *Yersinia enterocolitica*
- *Streptococcus* spp.
- *Shigella* spp.
- *Listeria monocytogenes*
- *Mycobacterium bovis*
- *Cronobacter sakazakii*

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Salmonella serovars

- **Annual illness (death): 1,027,561 (378) in American adults and children**
- **Infection** causes nausea, vomiting, diarrhea, fever, headache
- **Primary sources**: Intestinal tract of people and animals
- **Transmitted by** meat, poultry, eggs, raw milk, unpasteurized juice, many other foods (nuts, spices, produce, chocolate, flour) [Low-moisture environment]
- **Contributing factors**: cross-contamination, undercooked food, poor agricultural practices

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5.2°C)	95-109°F (35-43°C)	115°F (46.2°C)
pH	3.7	7-7.5	9.5
a_W	0.94	0.99	>0.99
Other	Non-spore former		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition, Scallan et al., 2011, and FSPCA

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Salmonella serovars

- **Carriers**: **Reptiles** (turtles, lizards, and snakes); **Amphibians** (frogs and toads); **Poultry** (chicks, chickens, ducklings, ducks, geese, and turkeys); **Other birds** (parakeets, parrots, and wild birds); **Rodents** (mice, rats, hamsters, and guinea pigs); Other **small mammals** (hedgehogs); **Farm animals** (goats, calves, cows, sheep, and pigs); **Dogs; Cats; Horses. [Pretty much ubiquitous!]**
- **Dogs and cats** that become ill from *Salmonella* infection generally will have **diarrhea** that may contain blood or mucus
- Some cats do not have diarrhea, but will have a **decreased appetite, fever, and excess salivation**.

Prevention:

- **Minimizing direct contact**, **washing hands**, and **cleaning up after the pets** could minimize the risk of transmission from infected animals to human.

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Salmonella serovars

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

Salmonella Outbreaks Linked to Backyard Poultry

Investigation Notice

Posted July 23, 2021

One in four sick people is a child younger than 5 years. Don't let young children touch chicks, ducklings, or other backyard poultry.

Fast Facts

- Illnesses: 672 (198 new)
- Hospitalizations: 157 (54 new)
- Deaths: 2 (1 new)
- States: 47 (1 new)
- Investigation status: Active

FDA U.S. FOOD & DRUG ADMINISTRATION

Pet Turtles: Cute But Commonly Contaminated with Salmonella

Turtles commonly carry bacteria on their outer skin and shell surfaces that can make people very ill. Geckos and bearded dragons can also infect people.

54

Staphylococcus aureus

Foodborne Diseases
- Infection
- Intoxication
- Toxico-infection

- **Annual illness (death): 241,148 (6) Americans every year**
- Both causes infection and toxico-infection
- Produces **heat stable toxins** after extensive growth
- **Primary sources**: Boils, nasal passages and skin (around 20% positive on nasal passage, >10% hands)
- **Transmitted** by recontaminated **cooked foods**, and foods with high salt or high sugar (**Gram-positive, poor competitor**)
- **Contributing factors**: Recontamination and **time/temperature abuse**

Growth parameters	Minimum		Optimum		Maximum	
	Growth	Toxin	Growth	Toxin	Growth	Toxin
Temperature	45°F (7°C)	50°F (10°C)	99°F (37°C)	104-113°F (40-45°C)	122°F (50°C)	118°F (48°C)
pH	4	4	6-7	7-8	10	9.8
a_W	0.83	0.85	0.98		>0.99	
Other	Poor competitor, non-sporeformer					
Atmosphere	Facultative – grows with or without oxygen, but slower without					

Sources: ICMSF 1995 and Bad Bug Book 2nd edition, Scallan et al. 2011, and FSPCA

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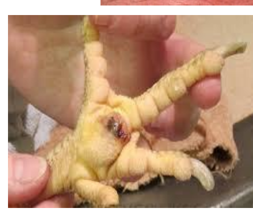
Staphylococcus aureus

- **Methicillin-resistant *Staphylococcus aureus*** (**MRSA**) a major concern for animal and human health.
- Humans working closely in **animal feeding operations** are in elevated risk of exposure to this pathogen particularly the **antibiotic resistant phenotypes**
- A **contagious bacterium** responsible for vast majority of environmental **Mastitis in dairy** operations.
- Cause of "bumblefoot" in chickens
- A major pathogen of farm rabbits



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Campylobacter spp.

- **Annual illness (death): 845,024(76)**
- Infection causes diarrhea, and potential nerve damage
- **Primary sources**: Intestinal tract of animals
- **Transmitted** by raw poultry, raw milk products, contaminated water, poultry (dump tank, nearly 80%). Relatively high infective dose
- **Contributing factor**: cross contamination and undercooking

Growth parameters	Minimum	Optimum	Maximum
Temperature	86°F (30°C)	108-109°F (42-43°C)	113°F (45°C)
pH	4.9	6.5-7.5	9.5
a_W	>0.987	0.997	-
Other	Non-spore former		
Atmosphere	3-5% oxygen optimum		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition and FSPCA

57

Campylobacter spp.

- Bacterium exist in GI track of **many healthy farm and companion** animals.
- **Dogs six week and younger** are prone to Campylobacteriosis with symptoms:
  - -Fever
  - -Vomiting
  - -Loss of appetite
  - -Enlarged lymph nodes
- **Staying in kennels** that increases the **exposure to fecal matter** and contact with contaminated food and water are main sources of disease in dogs.

58

Bacillus cereus

- **Annual illness (death): 63,400 (0)**
- Produces spores and toxins and extensive growth is required for illness
- **Primary source**: soil and GI track
- **Transmitted** by: rice and starchy foods, meats, vegetables, milk products, sauces
- Contributing factors: **temperature abuse**

Growth parameters	Minimum	Optimum	Maximum
Temperature	39°F (4°C)	82-95° F (28-35°C)	131°F (55°C)
pH	4.3	6.0-7.0	9.3
a_W	0.92	-	-
Other	Spore former; toxin is heat stable		
Atmosphere	Facultative – grows with or without oxygen		

Sources: Seafood Hazards Guide, ICMSF 1995, Bad Bug Book, Scallan et al. 2011, and FSOCA

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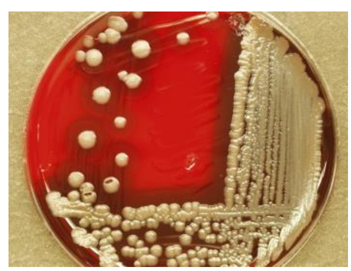
Bacillus cereus

- Some studies indicate the bacterium could behave as an agent of mammary gland **infection in cows** and **goats** thus causing **mastitis.**
- Cases of **food poisoning in dogs and cats** had also been reported, although not very frequent in nature.
- Many agricultural animals carry the **bacterium in their intestinal area** without symptoms.



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Shiga Toxin-Producing *Escherichia coli* (STEC)

- **Annual illness (death): 176,152 (20)**
- **Notable outbreak:** 1992-1993 outbreak in pacific northwest- Very important regulatory status (adulterant)
- **Infection causes** bloody diarrhea, and sometimes kidney failure and death [HUS in kids]
- **Primary sources**: Intestinal tract of ruminant animals (e.g., cows, sheep)
- **Transmitted** by raw and undercooked beef, poultry, leafy greens, and unpasteurized milk and juices
- **Contributing factors**: poor GAP, inadequate heating, and person-to-person

Growth parameters	Minimum	Optimum	Maximum
Temperature	**44°F (6.5°C**)	95-104°F (35-40°C)	121°F (49.4°C)
pH	4	6-7	10
a_W	0.95	0.995	-
Other	Non-spore forming		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition,Scallan et al. 2011, and FSPCA

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Shiga Toxin-Producing *Escherichia coli* (STEC)

- **Animals that can spread *E. coli* O157 to humans include**:
  - -Cattle, especially calves (As high 80% in some herds),
  - *[Concentrated and genetic similarity]*
  - -Goats
  - -Sheep
  - -Deer
- *E. coli* infection very common in **cats and puppies younger than one week**.
- **Colostrum**, plays a pivotal role in protecting a newborn the animal's undeveloped immune system against *E. coli* infection.
- As high as **80% of agricultural animals could carry various serogroups of shiga-toxigenic *E. coli*** without having symptoms

62

Vibrio spp.

- Causing about **80,000 illness and 100 death** annually in the United States.
- **Infection symptoms** vary depending on strain, ranging from diarrhea to high fever
- Vibrio is a **halophilic bacterium** and is a major concern in aquaculture industry
- **Primary sources**: Salt water environments and seafood
- Requires salt to reproduce (halophile)

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5°C)	99°F (37°C)	114°F (45.3°C)
pH	4.8	7.8-8.6	11
a_W	0.94	0.98	0.996 (10% NaCl)
Other	Non-sporeformer, requires salt		
Atmosphere	Facultative - grows with or without oxygen		

Sources: Seafood Hazards Guide 2011, ICMSF 1995 and Bad Bug Book 2nd edition

63

Yersinia enterocolitica

- *Not a reportable disease, no statistics available*
- **Infection causes** abdominal pain, fever and diarrhea. May mimic appendicitis.
- **Primary sources**: Raw pork, raw milk
- **Contributing factors**: Cross-contamination between raw pork products and RTE foods

Growth parameters	Minimum	Optimum	Maximum
Temperature	30°F (-1.3°C)	77-99°F (25-37°C)	108°F (42°C)
pH	4.2	7.2	10
a_W	0.945	-	-
Other	Non-spore former, raw milk in fridge?		
Atmosphere	Facultative - grows with or without oxygen		

Sources: Seafood Hazards Guide, ICMSF 1995, and Bad Bug Book

64

Foodborne *Streptococcus* spp.

- *Not a reportable disease, no statistics available (not part of active surveillance data of CDC)*
- **Infection causes** sore throat, tonsillitis and fever
- **Primary sources**: **Infected sites of humans and animals**, **raw milk**
- **Contributing factors**: Infected **workers handling food** and **consumption of raw milk** or **meat products**.
- **Symptoms**: meningitis, sepsis, and pneumonia (>200,000 sepsis cases per year, not foodborne)
- **Found in**: cattle, horses, dogs, rabbits, guinea pigs and mice
- Important cause of mastitis in cows.

Growth parameters	Minimum	Optimum	Maximum
Temperature	50°F (10°C)	99°F (37°C)	<113°F (<45°C)
pH	4.8-5.3	7	>9.3
%NaCl (salt)	-	-	<6.5
Other	Non-sporeformer		
Atmosphere	Facultative - grows with or without oxygen		

Sources: Seafood Hazards Guide, ICMSF 1995, and Bad Bug Book

65

Shigella spp.

- **Infection in humans causes** diarrhea, which may be watery to bloody. The infection is also known as dysentery [Taxonomy similar to *Salmonella* serovars]
- **Primary sources**: Human and Animal intestinal tract
- **Transmitted** by **fecal contamination** from contaminated **water** or **infected food**.
- **Clinical signs are rare in dogs and cats**, mostly mild diarrhea.
- Many species such dogs, cats, rodents and nonhuman primates could **carry the pathogen asymptomatically.**

Growth parameters	Minimum	Optimum	Maximum
Temperature	43°F (**6.1°C**)	-	117°F (47.1°C)
pH	4.8	-	9.3
a_W	0.96	-	-
Other	Non-spore former		
Atmosphere	Facultative - grows with or without oxygen		

Sources: Seafood Hazards Guide 2011, ICMSF 1995 and Bad Bug Book 2nd edition

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Mycobacterium bovis

- **Infection** causing respiratory symptoms and **tuberculosis**
- **Primary sources**: Cattle and raw milk
- **Other source**: bison, elk, and deer.
- **Contributing factors**: Lack of milk **pasteurization** and exposure to aerosols from infected animals
- **Grows very slowly and under reduced oxygen (microaerophilic)**
- The **US has nearly eliminated** *M. bovis* infection from cattle, over **one million animal is tested** for the bacterium by inspectors. [USDA FSIS]
- *M. bovis* can be found in **wild animals** such as bison, elk, and deer; uninfected cattle that come into contact with these wild animals can become infected.

Source: CDC at https://www.cdc.gov/tb/publications/factsheets/general/mbovis.pdf

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Listeria monocytogenes

- **Infection causes** severe illness in susceptible people – mortality 15-30%
- **Primary sources**: Occurs widely in agriculture (soil, plants and water) –(Important during pregnancy)
- **Transmitted by**: Refrigerated RTE foods that support growth (South Africa, Largest in History in 2018)
- **Contributing factors**: Environmental pathogen spread by environmental contamination, equipment, people, incoming raw ingredients (ubiquitous in nature)
- **Common in domesticated ruminates particularly** sheep, poultry, and birds.
- **Could cause sporadic and farm outbreaks in ruminants**
- **Could cause: Encephalitis, late abortion, and GI problems in ruminants**.

Growth parameters	Minimum	Optimum	Maximum
Temperature	31°F (-0.4°C)	99°F (37°C)	113°F (45°C)
pH	4.4	7.0	9.4
a_W	0.92	-	-
Other	Non-sporeformer		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition

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Cronobacter Sakazakii

- **Recently reclassified** bacteria (2006-07), formerly known as ***Enterobacter sakazakii***
- The **Genus *Cronobacter*** was derived from the Greek term "Cronos," a Titans of ancient mythology who swallowed each of his infants as soon as they were born (he was afraid to be replaced by his infants).
- The **species name, *sakazakii***, is named in honor of the Japanese microbiologist, Riichi Sakazaki, when the bacterium was first explained in 1980.
- Gram-negative, rod-shaped bacteria.
- Facultative anaerobic
- The growing temperature range is 6°C-45°C
- Primarily associated with **Powered Infant Formula**
- There has been several outbreaks associated with the bacterium and neonatal meningitis and death including two outbreaks in **Tennessee** (**1998 and 2001**).

APHA Compendium of Methods, Salfinger and Lou Tortorello, Fifth Edition

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Cronobacter Sakazakii

Prevention (CDC & WHO guidelines)

- Breastfeed
- Practice careful hygiene
- Clean and sanitize properly
- Prepare Powered Infant Formula as recommended

Symptoms:

- poor feeding response,
- irritability,
- jaundice,
- grunting **respirations**,
- **instability of body temperature**,
- Could lead to: **seizures, brain abscess**, hydrocephalus, and developmental delay, or **death**

One of the student from class published a great article about this pathogen:

https://www.mdpi.com/2076-2607/7/3/77

APHA Compendium of Methods, Salfinger and Lou Tortorello, Fifth Edition

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Exercise 3

- What is DALY and how bacterial, parasitic, and viral foodborne diseases are ranked based on this public health index?
- What are the leading causative agents for foodborne illness in the United States?
- What are the leading causative agents for foodborne hospitalization in the United States?
- What are the leading causative agents for foodborne death in the United States?
- What food categories are responsible for vast majority of foodborne illness and death in the United States?
- Please name two foodborne bacterium that could grow at refrigeration temperature?
- Please name a foodborne bacterium that is capable of forming spores.
- Which bacterium was halophilic and predominantly exist in seafood? What is the definition of halophilic?
- What are the symptoms of *Cronobacter sakazakii* infection in infants and what are the prevention strategies?

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Assignment #1: CDC NORS data Assignment Due before start of the class on 9/2/2021

- Various serovars of non-typhoidal *Salmonella* are currently the leading etiological agent for foodborne hospitalizations and deaths in the United States. Please utilize the National Outbreak Reporting System (NORS) data of Centers for Diseases Control and Prevention (CDC) and answer the following questions.

From 1998 to 2018:

- **1.A.** How many outbreaks were associated with *Salmonella* serovars nationwide?
- **1.B.** What are the dominant food categories associated with these nationwide outbreaks?
- **1.C.** What are the number of deaths, hospitalizations, and illnesses associated with these nationwide *Salmonella* outbreaks?
- **1.D.** How many of these *Salmonella*-related outbreaks occurred in Tennessee?
- **1.E.** What are the dominant food categories associated with Tennessee *Salmonella* outbreaks?
- **1.F.** What are the number of deaths, hospitalizations, and illnesses associated with Tennessee *Salmonella* outbreaks?
- **1.G.** Please answer questions 1.D to 1.F for another state of your choice. Please indicate in your response what state have you chosen.

***Hint:** You can access the database at: https://wwwn.cdc.gov/norsdashboard/, then, download the data spreadsheet by clicking on "Download all NORS Dashboard data (Excel).," and then after opening the spreadsheet use the search option on top of each column to obtain answers for the above questions.*

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Term Paper Progress
Due before start of the class on 9/9/2021

- What is the topic of your term paper?
- Among the three options discussed in the Syllabus, what option you are planning to choose?
- Please list the references that you are planning to use for your term paper. I would suggest you identify at least 10 peer-reviewed articles related to your paper topic.

Hint. *I would also suggest you use APA style to cite you references as APA is the style graduate school's thesis and dissertation. You could access APA style of citing references here:*

https://apastyle.apa.org/style-grammar-guidelines/references

- **9/9/2021 Due date for term paper topic, option, and list of references**

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AGSC 5540: Food Policies and Regulations
FALL 2021 Syllabus

Suggested Textbooks:

Fouladkhah, A.; Bisha, B. *Advances in Prevention of Foodborne Pathogens of Public Health Concern during Manufacturing*. 1st ed. 2019. MDPI, Basel, Switzerland.

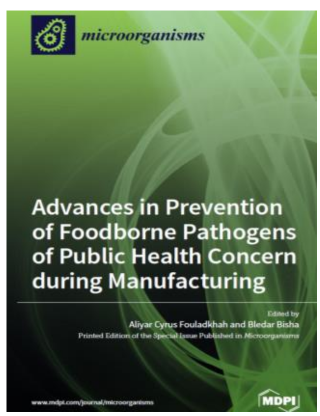
Wilde, P. 2018. *Food Policy in the United States: An Introduction*. Routledge.

Pomeranz, J.L., 2015. *Food Law for Public Health*. Oxford University Press.

Heinzerling, L, 2017. Food Law: Cases ad Materials. Georgetown Law center.

Fortin, N.D., 2016. *Food regulation: law, science, policy, and practice*. John Wiley & Sons.

IAFP. 2011. *Procedures to Investigate Foodborne Illness*. Sixth Edition, Springer.



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AGSC 5540: Food Policies and Regulations FALL 2021 Syllabus

- **Evaluation:**
- Term Paper 30 %*
- Attendance and Class Activities 25 %**
- Mid-term Exams 25 %
- Class Assignments 10 %
- Final Exam (optional) 10 %
- Total 100 %

To be emailed after class to instructor at afouladk@tnstate.edu

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AGSC 5540: Food Policies and Regulations FALL 2021 Syllabus

- **Term Paper**

Option 1. Standard Course Paper. This would need to be original writing of the student by using at least 10 peer-reviewed articles.

Option 2. Food for Public Health Series Factsheet. This would need to be original writing of the student by using at least 10 peer-reviewed articles, further developed, and edited to be suitable for publication as a factsheet. You can access the factsheet of your peers from last year at: https://publichealthmicrobiology.education/food-for-public-health-1

Option 3. Full-Length Review Paper. For those who are willing to publish their work and receive up to 50 extra credit points, their review paper should be a critical and evidence-based evaluation of at least 20-50 peer-reviewed articles. Depending on the extent and quality of the review article, students in this category are eligible to receive up to $1200 *Publication Scholarship* of Public Health Microbiology program to be used towards the open access fees of the publication in the below special issue.

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Term Paper Example

Papers will be analyzed for similarity index

Option 1: Brief Term Paper
10 pages double Space

Food For Thought: The Complexity of Obesity with the Black Community

Lauren Odum

Studies show that two-thirds of African Americans 20 years of age or older are obese or overweight. The purpose of this paper is to outline why obesity is such a prevalent issue within the black community, and actions that can be taken to reduce these staggering statistics. Topics explored will include effects of being overweight, lack of access to healthy, affordable food and adequate health care, along with the cultural standards within the black community that perpetuate this epidemic. The goal of this research is to shed light on an often-overlooked topic and provide possible long-term solutions.

Option 2: An Outreach Article
10-20 pages double Space
To be converted to 3-page outreach article

Food for Public Health Series

Consumption of Meat Products and Risk of Various Cancers

By: Gloria Andrade-Feraud, BS, MS candidate

Food for Public Health Series

Breastfeeding While Black

By: Micah Davis, BS, MS candidate

Option 3: Review Paper

microorganisms

MDPI

Review

Outbreak History, Biofilm Formation, and Preventive Measures for Control of *Cronobacter sakazakii* in Infant Formula and Infant Care Settings

Monica Henry [1] and Aliyar Fouladkhah [1,2,*]

Received: 18 January 2019; Accepted: 9 March 2019; Published: 12 March 2019

Abstract: Previously known as *Enterobacter sakazakii* from 1980 to 2007, *Cronobacter sakazakii* is an opportunistic bacterium that survives and persists in dry and low-moisture environments, such as powdered infant formula. Although *C. sakazakii* causes disease in all age groups, infections caused by this pathogen are particularly fatal in infants born premature and those younger than two months. The pathogen has been isolated from various environments such as powdered infant formula manufacturing facilities, healthcare settings, and domestic environments, increasing the chance of infection through cross-contamination. The current study discusses the outbreak history of *C. sakazakii* and the ability of the microorganism to produce biofilms on biotic and abiotic surfaces. The study further discusses the fate of the pathogen in low-moisture environments, articulates preventive measures for healthcare providers and nursing parents, and delineates interventions that could be utilized in infant formula manufacturing to minimize the risk of contamination with *Cronobacter sakazakii*.

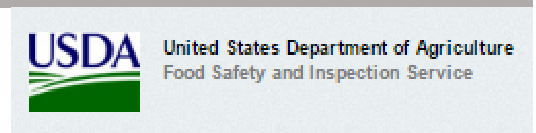
Keywords: *Cronobacter sakazakii*; powdered infant formula; *Cronobacter* outbreaks; preventive measures; infant care setting

Suggested topics…
For those who are "shopping" for topics

- Recent Advancements in control of ***Listeria monocytogenes*** in processed and ready-to-eat meat products
- Advances in preventing O157 and non-O157 **Shiga toxin producing *Escherichia coli*** using natural antimicrobials and emerging technologies
- Recent advances in **non-thermal pasteurization** of fluid milk
- Fortifying lives from the early days: **folic acid**
- Vegetarian diet and **vitamin B12**
- Reducing the **sodium** content of processed food
- **Hemp seed**: nutritional composition and health benefits

South Africa works to eradicate listeria from its processed meat facilities

Additional Resources



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Additional Resources:

Centers for Disease Control and Prevention:

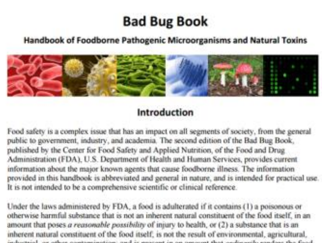
https://www.cdc.gov/ophss/csels/dsepd/ss1978/ss1978.pdf

Center for Food Security and Public Health, Iowa, Zoonotic Diseases:

http://www.cfsph.iastate.edu/Zoonoses/

Food and Agriculture Organization of the United Nation:

http://www.fao.org/emergencies/emergency-types/transboundary-animal-diseases/en/



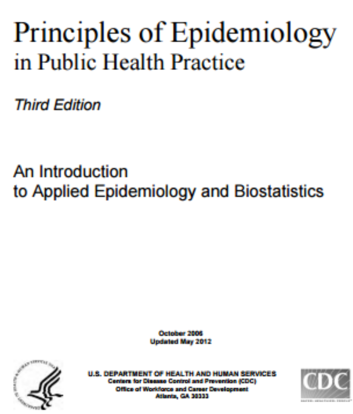
Bad Bug Book

Handbook of Foodborne Pathogenic Microorganisms and Natural Toxins

Introduction

Food safety is a complex issue that has an impact on all segments of society, from the general public to government, industry, and academia. The second edition of the Bad Bug Book, published by the Center for Food Safety and Applied Nutrition, of the Food and Drug Administration (FDA), U.S. Department of Health and Human Services, provides current information about the major known agents that cause foodborne illness. The information provided in this handbook is abbreviated and general in nature, and is intended for practical use. It is not intended to be a comprehensive scientific or clinical reference.

Under the laws administered by FDA, a food is adulterated if it contains (1) a poisonous or otherwise harmful substance that is not an inherent natural constituent of the food itself, in an amount that poses *a reasonable possibility* of injury to health, or (2) a substance that is an inherent natural constituent of the food itself, is not the result of environmental, agricultural, industrial, or other contamination, and is present in an amount that *ordinarily* renders the food



Principles of Epidemiology
in Public Health Practice

Third Edition

An Introduction
to Applied Epidemiology and Biostatistics

October 2006
Updated May 2012

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention (CDC)
Office of Workforce and Career Development
Atlanta, GA 30333

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