Common Foodborne Illnesses

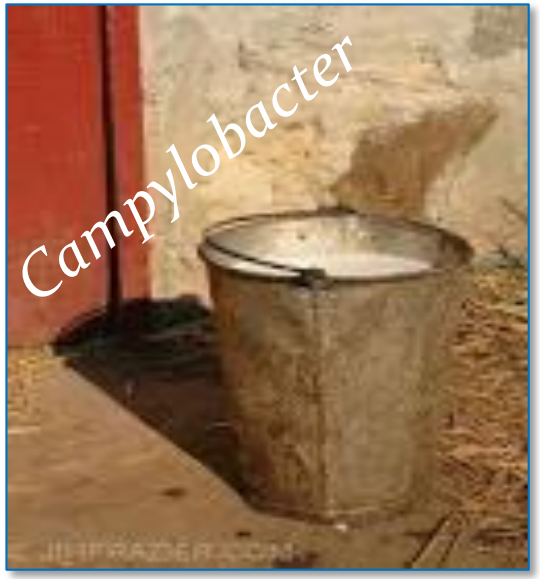
Causes, Diagnostics, Reporting

Objectives

- Describe recent significant foodborne outbreaks in the U.S.
- Describe current methods used to diagnose foodborne illness
- Understand the importance of reporting foodborne illnesses

Frequent Sources of Food Poisoning

Raw Milk



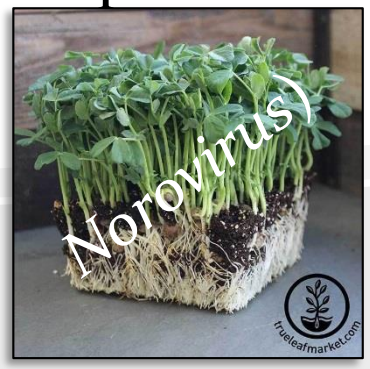
Under-cooked Chicken

Rare Burger

Romaine Lettuce

Raw Eggs

Sprouts



Unpasturized Cheese

How Pathogens Enter the Food Chain

- Contaminated raw product
- Cross-contamination of ingredients – *e.g.*, cutting boards
- Contamination of food by workers who are ill or infectious
- Insufficient time or temperature to kill microbes during cooking
- Improper cooling or storage that allows growth of bacteria or production of toxins in food

Outbreaks That Made the News

- ***E. coli* O103, 2019**
- Cause: ground beef
- Reported Cases: 196
- States: 10
- Hospitalizations: 28
- Deaths: 0

- ***E. coli* O157:H7, 2018**
- Cause: romaine lettuce
- Reported Cases: 210
- States: 36
- Hospitalizations: 96 (27 w/ HUS)
- Deaths: 5
- About 5–10% of people diagnosed with STEC O157 infection develop a life-threatening complication known as hemolytic uremic syndrome (HUS) https://www.cdc.gov/Features/ecoliinfection/

https://www.cdc.gov/ecoli/2018/0157h7-04-18/index.html

Salmonella

Cause:
Reported Cases: 17
States: 11
Hospitalizations: 2
Deaths: 0

Cause: Pre-cut Melons
Reported Cases: 137
States: 10
Hospitalizations: 38
Deaths: 0
Recall: Yes

https://www.cdc.gov/salmonella/typhimurium-01-19/index.html

Campylobacter jejuni– Multi-drug Resistant

Cause: was it Pet Store Puppies? Or Fried chicken?
Reported Cases: 113
States: 17
Hospitalizations: 23
Deaths: 0

- 12 isolates were resistant to azithromycin, ciprofloxacin, clindamycin, erythromycin, nalidixic acid, telithromycin, and tetracycline; 10 were also resistant to gentamicin, and 2 were even resistant to florfenicol.

https://www.cdc.gov/campylobacter/outbreaks/puppies-9-17/

Global Priority List of Antibiotic-Resistant Bacteria

- World Health Organization named a "Dirty Dozen"
- Four on the list are foodborne pathogens
  - *Campylobacter*, fluoroquinolone-resistant
  - *Salmonella* spp., fluoroquinolone-resistant
  - *Shigella* spp., fluoroquinolone-resistant
  - *E. coli*, carbapenem-resistant, 3rd gen cephalosporin-resistant
- "In the U.S., antimicrobial resistance causes more than 2 million infections and 23,000 deaths per year – the equivalent of a Boeing 747 crashing each week."
  - Health-policy adviser Nicole Fisher (in Forbes)

What Pathogens May Come to Your Picnic?

- The 5 most common food pathogens
  - *Norovirus, Salmonella, Clostridium perfringens, E. coli, Campylobacter*

Food poisoning has marked seasonality- summer months have 4-5 times the prevalence as winter-time

Most foodborne illnesses are private affairs

- Not multi-location outbreaks
- Almost all food will be contaminated with infectious doses of one or more agents.
  - *Campylobacter* has been found to be present on 84% of chicken in the UK, along with *Salmonella* and *C. perfringens*
- Good hygiene during food prep and proper cooking prevent most infections
- Most do not require treatment

J Food Prot. 2011 Nov;74(11):1912-6. doi: 10.4315/0362-028X.JFP-11-104.

https://www.cdc.gov/features/salmonellachicken/index.html

Is Food Poisoning a Big Problem in the USA?

- CDC estimates that each year
  - 48 million people get sick
  - 128,000 are hospitalized
  - 3000 die from foodborne illnesses
- World Health Organization estimates 1 in 10 people world-wide fall ill every year from eating contaminated food and 420 000 die as a result
- 125 000 children die from foodborne diseases every year

https://www.who.int/news-room/detail/03-12-2015-who-s-first-ever-global-estimates-of-foodborne-diseases-find-children-under-5-account-for-almost-one-third-of-deaths

https://www.cdc.gov/foodborneburden/

Viruses, Bacteria, and Parasites- All May Be Culprits

Pathogen	Lab confirmed cases	*Underdiagnosis Multiplier	Total 2006
Norovirus	NA	NA	20,865,958
Campylobacter spp.	43,696	30.3	1,322,137
STEC O157	3,704	26.1	96,534
STEC non–O157	1,579	106.8	168,698
Salmonella (nontyphoidal)	41,930	29.3	1,229,007
Giardia intestinalis	20,305	46.3	1,221,564

*Adjustment for underdiagnosis because of variations in medical care seeking, specimen submission, laboratory testing, and test sensitivity.

https://www.cdc.gov/foodborneburden/pdfs/scallan-estimated-illnesses-foodborne-pathogens.pdf

Mechanisms Foodborne Bacteria Use to Cause Illness

Class	Examples
Pre-formed Toxin	*Staphylococcus aureus, C. botulinum, C. perfringens*
Toxin secreted while bacteria adhere to gut lining	Enterotoxigenic *E. coli, Campylobacter jejuni*
Bacteria invade intestinal epithelial cells and secrete virulence proteins	*Shigella, Salmonella enterica*
Bacteria enter blood stream from intestinal tract	*Salmonella typhi, Listeria monocytogenes*

https://pmj.bmj.com/content/78/918/216

Clues for (Maybe) Recognizing Foodborne Illness

	Norovirus	*Salmonella*	*C. Perfringens*	*EHEC/STEC*	*Campylobacter*
Incubation period	**12-48 hrs**	1-3 days	**8-16 hrs**	1-8 days	2-5 days
Duration of illness	12-60 hrs	4-7 days	24-48 hrs	5-10 days	2-10 days
Symptoms	**Nausea**, **vomiting**, cramps, diarrhea, fever, myalgia	Diarrhea, fever, cramps, vomiting	Watery diarrhea, nausea, cramps; fever is rare	Severe diarrhea, often bloody, pain, vomiting, little fever	Diarrhea (may be bloody), cramps, fever, vomiting
Treatment	ORT, hygiene to prevent spread, **Abx not useful**	ORT, Abx not indicated	ORT; Abx not indicated	Supportive care, monitor renal function; **NO Abx**	ORT, erythromycin, quinolones- **increasing Abx^{r}**

https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5304a1.htm; MMWR 4/16/2004

Culture vs. CIDTs- Muddled Testing Choices

- "All specimens positive …. by culture-independent diagnostic testing and which require reporting **should be cultured** …. to ensure that outbreaks of similar organisms are detected and investigated."
- Also, a culture may be required in situations where antimicrobial susceptibility testing results would affect care.
- **But** ……. specimen transport, storage, delays from batch testing by CIDTs, or patient antibiotic treatment may make culture inaccurate.

Is Your Culture "Gold Standard" Reliable?

- *Campylobacter* die erratically if exposed to air during specimen handling, so culture must be done within hours of sample collection
- Transport media is not a "preservative" and may not prolong survival
- *C. jejuni* and *C. coli* are usually cultured on selective media; other pathogenic species (*C. lari, C. upsaliensis)* are often missed
- In one study, culture of *Campylobacter* spp. from stool missed 30% of positive specimens

Buss, *et. al.*, Campylobacter culture fails to correctly detect Campylobacter in 30% of positive patient stool specimens compared to non-cultural methods, Eur J Clin Microbiol Infect Dis. 2019 Jun;38(6):1087-1093

A Contrasting Example- When a CIDT is Problematic

- STEC infections are often identified by non-culture assays that detect the culprit Shiga toxin or gene
- **But…** Toxin gene expression can be lost during enrichment culture of the specimen prior to CIDT
- Toxin genes can be on an antibiotic-inducible plasmid in the infecting bacteria. This is why antibiotics are *dangerous* for STEC infected patients-- antibiotics may provoke more toxin

MMWR October 16, 2009 / 58(RR12);1-14

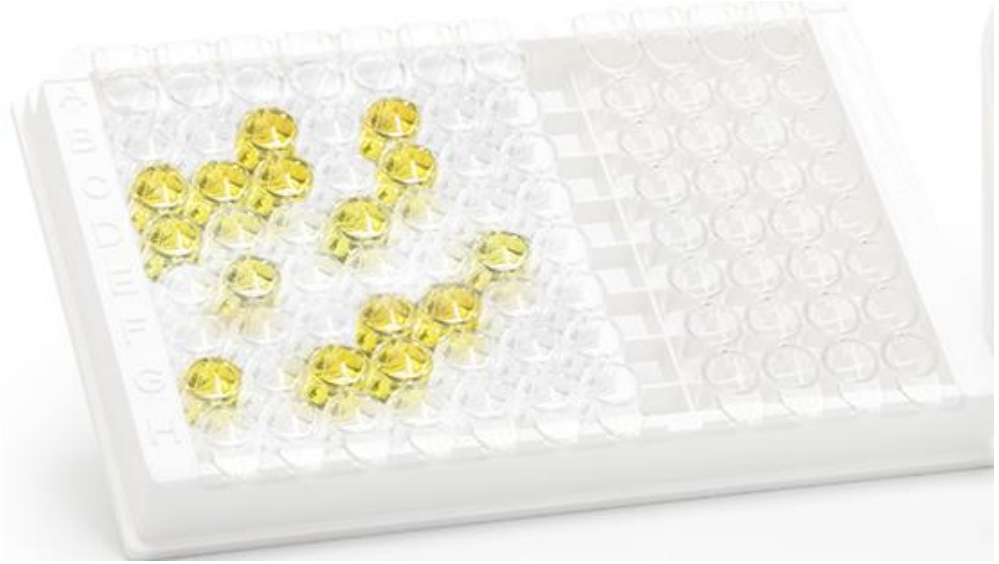
"CIDT" Diagnostics for Foodborne Illnesses

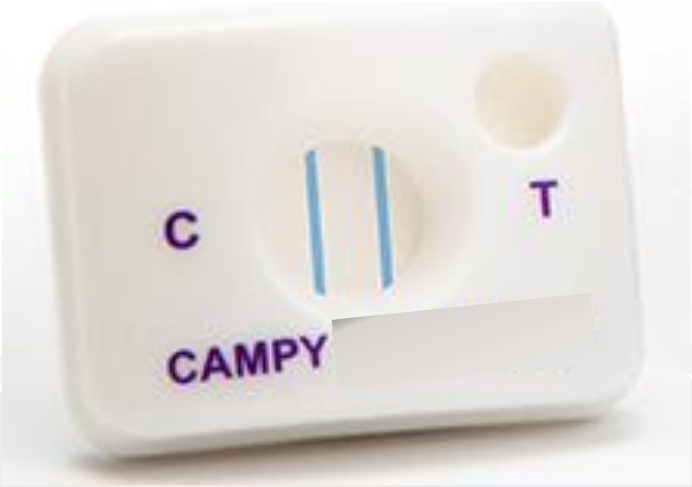
- Advantages: More rapid than culture; objective results; work on non-viable bacteria
- Disadvantages: No culture available for epidemiology or antibiotic testing (but can reflex culture)

Foodborne Pathogen Assays

Enzyme immunoassay	Microwell and Membrane; visual and fluorescent; single molecule
Lateral flow immunoassay	Latex colored beads, gold nanobeads, fluorescent nanobeads
Molecular	Single and Multiplex Syndrome panels
Combination	Immunocapture/PCR amplify

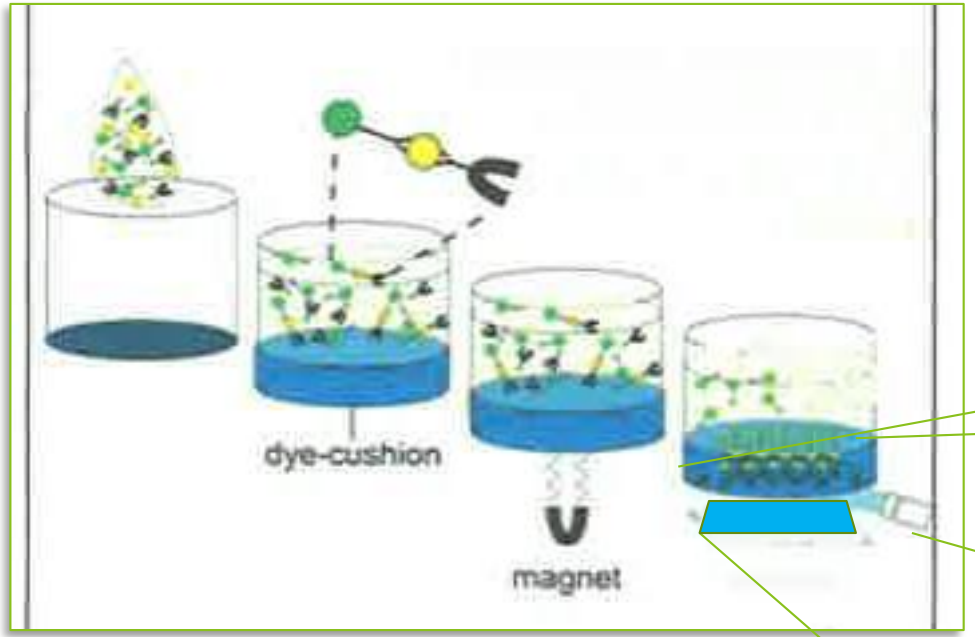
Immunoassay- Microwell and Membrane- ng/mL

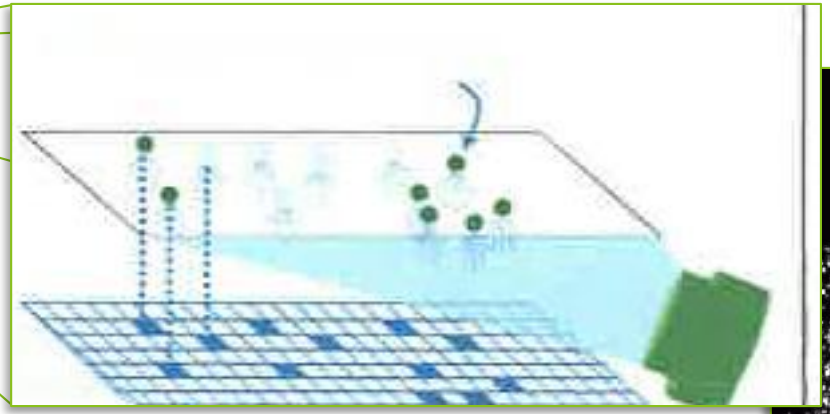




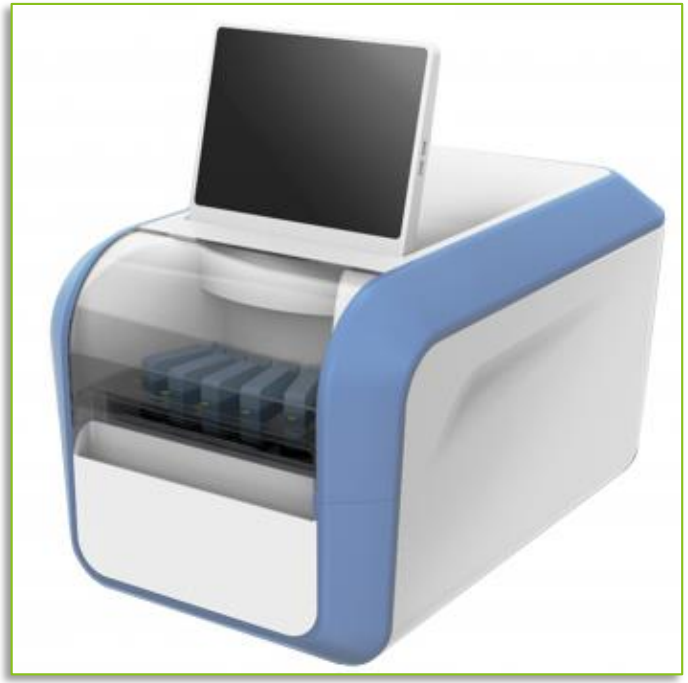
Lateral Flow- ng/mL

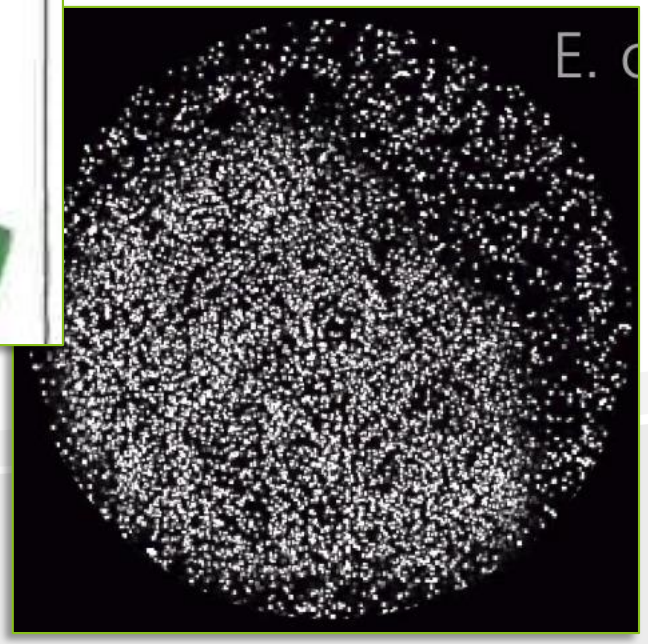
Single Molecule-Fluorescence- pg/mL





Camera chip - pixels





Molecular GI Panels can detect pathogens and colonizers

BACTERIA:
- *Campylobacter (jejuni, coli, and upsaliensis)*
- ***Clostridium difficile* (toxin A/B)**
- *Plesiomonas shigelloides*
- *Salmonella*
- *Yersinia enterocolitica*
- *Vibrio (parahaemolyticus, vulnificus, and cholerae)*
- *Vibrio cholerae*

PARASITES:
- *Cryptosporidium*
- *Cyclospora cayetanensis*
- *Entamoeba histolytica*
- *Giardia lamblia*

VIRUSES:
- Adenovirus F40/41
- Astrovirus
- Norovirus GI/GII
- Rotavirus A
- Sapovirus (I, II, IV, and V)

DIARRHEAGENIC E. COLI/SHIGELLA:
- *Enteroaggregative E. coli* (EAEC)
- *Enteropathogenic E. coli* (EPEC)
- *Enterotoxigenic E. coli* (ETEC) *lt/st*
- *Shiga-like toxin-producing E. coli* (STEC) *stx1/stx2*
- *E. coli* O157
- *Shigella/Enteroinvasive E. coli* (EIEC)

The Impact of Multi-Pathogen Panel Tests

- What if the assay reports more than one possible pathogen?
- Use wise clinical judgement and attention to patient symptoms
  - Grandpa in the nursing home might be asymptomatically colonized by *C. difficile* but experiencing acute symptoms from norovirus brought in by the grandkids just back from a cruise
- **Conundrum**- if both organisms are reportable
- Happens more often than we think-- in USA and globally
  - Bangladeshi children with diarrhea and very large amounts of *C. jejuni* harbored an average of 2 other pathogens, with many having 6 diarrheagenic organisms at one time

Lancet Glob Health. 2018 Dec;6(12):e1309-e1318. doi: 10.1016/S2214-109X(18)30349-8.

Schnee, *et al.*, J Clin Microbiol (2018) 56:e00702-18. https://doi.org/10.1128/JCM.00702-18.

Diagnostics—2017 Cases, Incidence, Prevalence

- The list of national notifiable infectious diseases and conditions for 2017 and their national surveillance case definitions are available at https://wwwn.cdc.gov/nndss/conditions/notifiable/2017/infectious-diseases/

Disease	Case count	Incidence /100,000	Prevalence among tested samples
Campylobacteriosis	67,537	20.73	0.9-9.3%
Salmonellosis	54,285	16.67	1.9-4.8%
Shiga toxin-producing *E. coli*	8,672	2.66	0-4.1%

Distinction Between Reportable and Notifiable Disease

- *Reportable* diseases are *mandatory* to be reported to state jurisdictions when identified by a health provider, hospital, or lab
  - Each state has its own laws and regulations defining what diseases are reportable.
  - California includes *Campylobacteriosis, STEC infection, Salmonellosis, Listeriosis and Foodborne Disease*
- *Notifiable* diseases can be *voluntarily* reported to CDC by state and territorial jurisdictions for nationwide aggregation and monitoring of disease data
  - The list of national notifiable diseases is reviewed and modified annually.

https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/ReportableDiseases.pdf

https://wwwn.cdc.gov/nndss/data-collection.html

Reporting Chain

1 Patient

A person feels ill and goes to the doctor.

2 Healthcare Team

Doctor diagnoses or laboratory tests confirm a disease that is reportable by state law to the local or state public health department.

Doctor or lab sends information about this disease to the local or state public health department.

REPORTABLE

3 Public Health Department

The public health department receives disease data and uses them to:

- identify and control disease outbreaks
- ensure that the patient is effectively treated so disease is not spread
- provide testing and preventive care to those exposed to the disease
- control sources of exposure.

The state public health department sends information about national notifiable diseases to CDC.

NOTIFIABLE

4 CDC National Notifiable Diseases Surveillance System Team

NNDSS collects national notifiable disease data on behalf of CDC.

The NNDSS team receives, secures, processes, and provides these data to disease-specific programs across CDC.

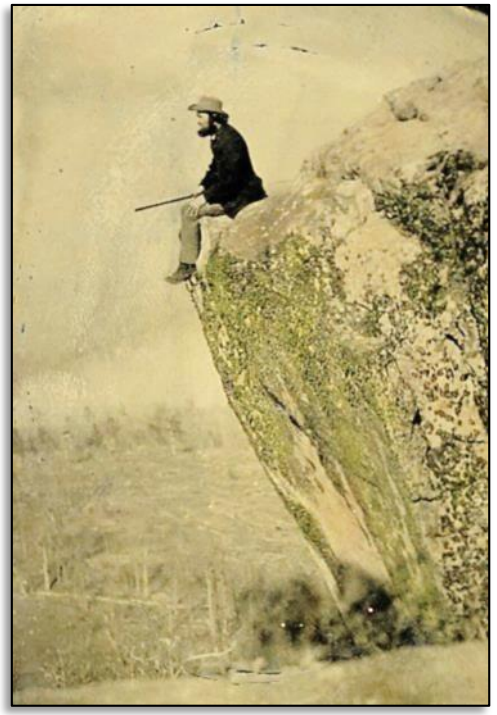
5 CDC Disease Program

CDC programs use disease-specific data to:

- support recognition of disease outbreaks
- monitor shifts in disease patterns
- evaluate and fund disease control activities.

What if You Discover the Sentinel Case of an Outbreak?

- Local and state health agencies first learn about foodborne illness outbreaks through reports of individual cases **from health care providers and laboratories**
- Local, state, and Federal government agencies share responsibility for investigating foodborne illness outbreaks that are reported



Notifiable Diseases Causing Infectious Diarrhea 2017

- Campylobacteriosis
- Cholera
- Cryptosporidiosis
- Cyclosporiasis
- Giardiasis
- Salmonellosis
- Shiga toxin–producing *E. coli*
- Shigellosis
- Trichinellosis (trichinosis)
- Typhoid fever
- Vibriosis

https://wwwn.cdc.gov/nndss/conditions/notifiable/2017/):

Who Wants Your Report?

- In most cases, healthcare professionals should report foodborne illnesses to their county or city health department.
  - Please refer to your state health department website
- The National Antimicrobial Monitoring System (NARMS) can test antimicrobial susceptibility to a range of antibiotics
- Outbreaks are reported to the National Outbreak Reporting System (NORS)
  - used by local, state, and territorial health departments in the United States to report all waterborne and foodborne disease to the CDC

Surveillance Systems

- State and local health departments voluntarily report epidemiologic and laboratory data from their foodborne illness outbreak investigations
  - Reporting is to CDC through the Foodborne Disease Outbreak Surveillance System (FDOSS) and the National Environmental Assessment Reporting System (NEARS)
  - NEARS is the only available system that includes characteristics of retail establishments with foodborne illness outbreaks
  - FDOSS The Foodborne Disease Outbreak Surveillance System (FDOSS) collects information from state and local health departments about foodborne disease outbreaks

Reporting- the Federal Level

- If public health investigators detect and report a possible multistate outbreak, CDC coordinates the public health investigation to determine the source of infection
- CDC works with the U.S. Food and Drug Administration (FDA), the U.S. Department of Agriculture (USDA), and state and local health officials as necessary

A Digest of Causes, Diagnostics, Reporting

- Outbreaks- 48 million people a year in the USA,
  - Half are norovirus, followed by *Campylobacter, Salmonella, C. perfringens,* and *E. coli*
  - Increaseing antibiotic resistance will make illnesses more difficult to treat
- Immunoassay and molecular CIDTs are rapidly replacing culture
  - Don't be surprised if GI panels report multiple pathogens
- Health care labs are the frontline for reporting foodborne illnesses of an outbreak

Don’t kiss the chickens!