

# Food Safety

# Overview

- Organisms
- History
- Epidemiology
- Transmission
- Foodborne illness
- Prevention and Control

# Organisms

- Estimated 250 foodborne pathogens
- Foodborne illness
  - 2 or more cases of a similar illness resulting from ingestion of a common food
  - Bacteria most common cause
  - Also viruses, parasites, natural and manufactured chemicals, and toxins from organisms

**TABLE 1. Number of reported foodborne-disease outbreaks, cases, and deaths, by etiology — United States,\* 1993–1997 †**

Etiology	Outbreaks		Cases		Deaths	
	No.	(%)	No.	(%)	No.	(%)
<b>Bacterial</b>						
<i>Bacillus cereus</i>	14	( 0.5)	691	( 0.8)	0	( 0.0)
<i>Brucella</i>	1	( 0.0)	19	( 0.0)	0	( 0.0)
<i>Campylobacter</i>	25	( 0.9)	539	( 0.6)	1	( 3.4)
<i>Clostridium botulinum</i>	13	( 0.5)	56	( 0.1)	1	( 3.4)
<i>Clostridium perfringens</i>	57	( 2.1)	2,772	( 3.2)	0	( 0.0)
<i>Escherichia coli</i>	84	( 3.1)	3,260	( 3.8)	8	( 27.6)
<i>Listeria monocytogenes</i>	3	( 0.1)	100	( 0.1)	2	( 6.9)
<b>Salmonella</b>	<b>357</b>	<b>( 13.0)</b>	<b>32,610</b>	<b>( 37.9)</b>	<b>13</b>	<b>( 44.8)</b>
<i>Shigella</i>	43	( 1.6)	1,555	( 1.8)	0	( 0.0)
<i>Staphylococcus aureus</i>	42	( 1.5)	1,413	( 1.6)	1	( 3.4)
<i>Streptococcus</i> group A	1	( 0.0)	122	( 0.1)	0	( 0.0)
<i>Streptococcus</i> other	1	( 0.0)	6	( 0.0)	0	( 0.0)
<i>Vibrio cholerae</i>	1	( 0.0)	2	( 0.0)	0	( 0.0)
<i>Vibrio parahaemolyticus</i>	5	( 0.2)	40	( 0.0)	0	( 0.0)
<i>Yersinia enterocolitica</i>	2	( 0.1)	27	( 0.0)	1	( 3.4)
Other bacterial	6	( 0.2)	609	( 0.7)	1	( 3.4)
<b>Total bacterial</b>	<b>655</b>	<b>( 23.8)</b>	<b>43,821</b>	<b>( 50.9)</b>	<b>28</b>	<b>( 96.6)</b>
<b>Chemical</b>						
Ciguatoxin	60	( 2.2)	205	( 0.2)	0	( 0.0)
Heavy metals	4	( 0.1)	17	( 0.0)	0	( 0.0)
Monosodium glutamate	1	( 0.0)	2	( 0.0)	0	( 0.0)
Mushroom poisoning	7	( 0.3)	21	( 0.0)	0	( 0.0)
Scombrototoxin	69	( 2.5)	297	( 0.3)	0	( 0.0)
Shellfish	1	( 0.0)	3	( 0.0)	0	( 0.0)
Other chemical	6	( 0.2)	31	( 0.0)	0	( 0.0)
<b>Total chemical</b>	<b>148</b>	<b>( 5.4)</b>	<b>576</b>	<b>( 0.7)</b>	<b>0</b>	<b>( 0.0)</b>
<b>Parasitic</b>						
<i>Giardia lamblia</i>	4	( 0.1)	45	( 0.1)	0	( 0.0)
<i>Trichinella spiralis</i>	2	( 0.1)	19	( 0.0)	0	( 0.0)
Other parasitic	13	( 0.5)	2,261	( 2.6)	0	( 0.0)
<b>Total parasitic</b>	<b>19</b>	<b>( 0.7)</b>	<b>2,325</b>	<b>( 2.7)</b>	<b>0</b>	<b>( 0.0)</b>
<b>Viral</b>						
patiti A	23	( 0.8)	729	( 0.8)	0	( 0.0)
Norwalk	9	( 0.3)	1,233	( 1.4)	0	( 0.0)
Other viral	24	( 0.9)	2,104	( 2.4)	0	( 0.0)
<b>Total viral</b>	<b>56</b>	<b>( 2.0)</b>	<b>4,066</b>	<b>( 4.7)</b>	<b>0</b>	<b>( 0.0)</b>
<b>Confirmed etiology</b>	<b>878</b>	<b>( 31.9)</b>	<b>50,788</b>	<b>( 59.0)</b>	<b>28</b>	<b>( 96.6)</b>
<b>Unknown etiology</b>	<b>1,873</b>	<b>( 68.1)</b>	<b>35,270</b>	<b>( 41.0)</b>	<b>1</b>	<b>( 3.4)</b>
<b>Total 1993–1997</b>	<b>2,751</b>	<b>(100.0)</b>	<b>86,058</b>	<b>(100.0)</b>	<b>29</b>	<b>( 100.0)</b>

\*Includes Guam, Puerto Rico, and the U.S. Virgin Islands.

† Totals might vary by <1% from summed components because of rounding.

- Foodborne disease outbreaks, cases and deaths
- 1993-1997
- *Salmonella* had the highest number

# History

# History

- Early 1900's
  - Contaminated food, milk and water caused many foodborne illnesses
- Sanitary revolution
  - Sewage and water treatment
  - Hand-washing, sanitation
  - Pasteurization of milk- 1908
  - Refrigeration in homes- 1913



# History

- Animals identified as a source of foodborne pathogens
  - Improved animal care and feeding
  - Improved carcass processing
- Surveillance and research
- Outbreak investigations
- Laws and policies regarding food handling

# Epidemiology



# Epidemiology

- Foodborne diseases each year in US
  - Affects 1 in 4 Americans
  - 76 million illnesses
  - 325,000 hospitalizations
  - 5,000 deaths
    - 1,500 of those deaths caused by *Salmonella*, *Listeria*, and *Toxoplasma*

# Epidemiology

- Many unrecognized or unreported
  - Mild disease undetected
  - Same pathogens in water and person to person
  - Emerging pathogens unidentifiable
- Greatest risk
  - Elderly
  - Children
  - Immunocompromised

# Surveillance/Regulation

- Surveillance
  - CDC
    - FoodNet and PulseNet
- Regulation
  - FDA
    - Domestic and imported food
  - USDA FSIS
    - Meat, eggs, poultry
  - National Marine Fisheries Service

# Surveillance

- FoodNet: Active surveillance
  - Established 1996
  - CDC, USDA, FDA, select state health departments
  - Nine sites in U.S. monitor 13% of U.S. population
    - California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New York, Oregon, Tennessee

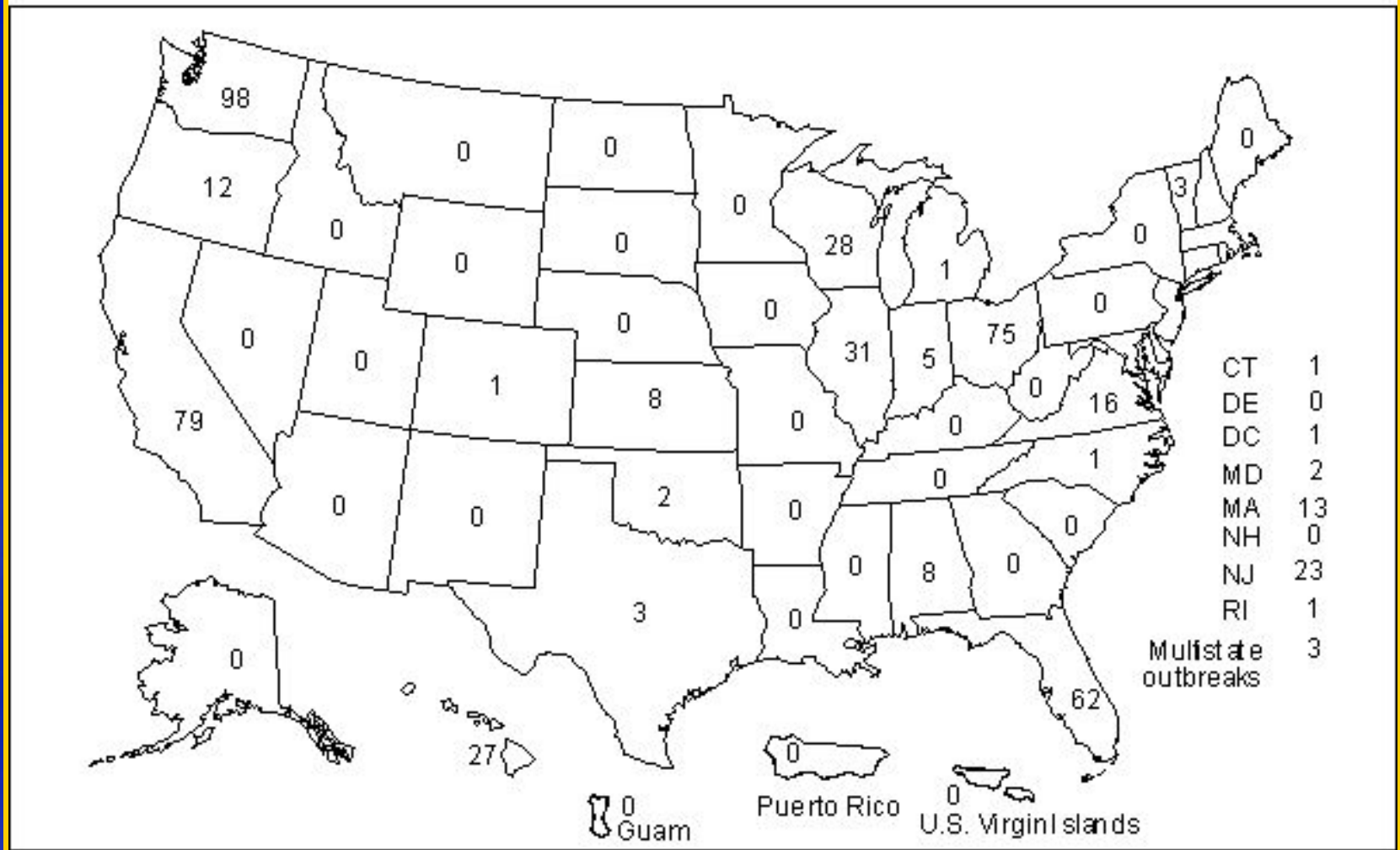
# Surveillance

- PulseNet: Identify cause
  - Molecular fingerprinting
  - 45 state public health labs certified
- Passive surveillance: Survey methods
  - Hospital discharges
  - Outpatient treatment facilities
- FoodBorne Disease Outbreak Surveillance System
  - All states submit outbreak data

# Estimated Cost

- Economic Research Service - USDA
  - Cost of top 5 foodborne pathogens
  - \$6.9 billion annually
    - Medical cost
    - Productivity losses (missed work)
    - Value estimate of premature death

**FIGURE 5. Number of reported foodborne-disease outbreaks, by state — United States,\* 1997**



\* Includes Guam, Puerto Rico, and the U.S. Virgin Islands.

# Transmission



# Transmission

- Oral route
- Contamination varies
  - Organism, reservoir, handling/processing, cross-contamination
- Human reservoir
  - Norwalk-like virus, *Campylobacter*, *Shigella*
- Animal reservoir
  - *Campylobacter*, *Salmonella*, *E. coli* 0157:H7, *Listeria*, and *Toxoplasma*

# Transmission

- Contamination can occur at several points along the food chain
  - On the farm or in the field
  - At the slaughter plant
  - During processing
  - At the point of sale
  - In the home



# Produce Processing

## Event

## Contamination sources

Production and harvest

Growing, picking,  
bundling

Irrigation water, manure,  
lack of field sanitation

Initial processing

Washing, waxing,  
sorting, boxing



Wash water, handling

Distribution

Trucking

Ice, dirty trucks

Final processing

Slicing, squeezing,  
shredding, peeling

Wash water, handling,  
cross-contamination

# Important Organisms

# Important Organisms

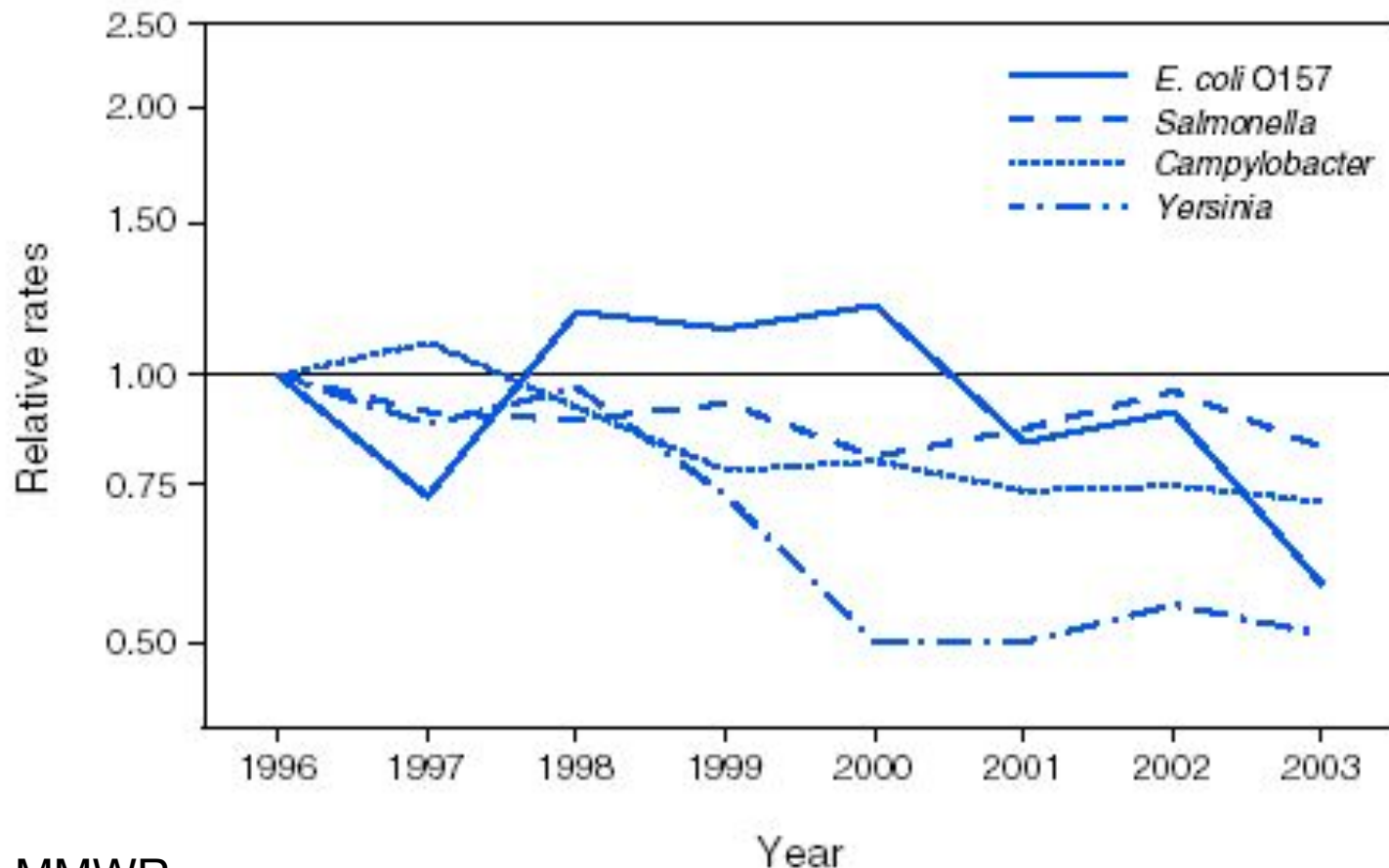
- Norwalk-like viruses
- *Campylobacter*
- *Salmonella*
- *E. coli* O157:H7
- *Clostridium botulinum*
- *Shigella* spp
- *Toxoplasma*
- Emerging organisms

Pathogen	No. of Cases
<i>Salmonella</i>	6,017
<i>Campylobacter</i>	5,215
<i>Shigella</i>	3,021
<i>Cryptosporidium</i>	480
<i>E. coli 0157</i>	443
<i>Yersinia</i>	161
<i>Listeria</i>	138
<i>Vibrio</i>	110
<i>Cyclospora</i>	15

**Total in 2003**

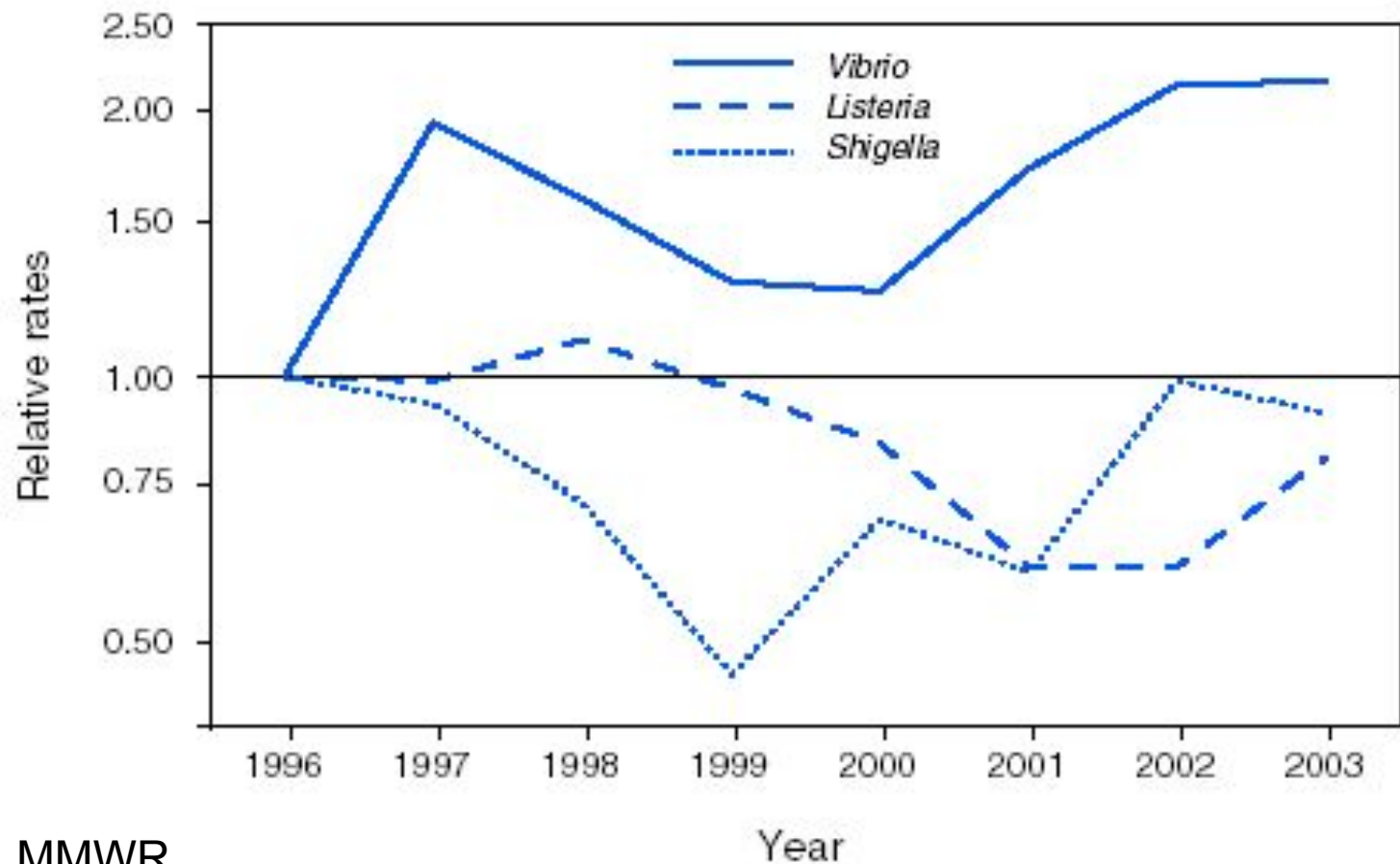
**15,600**

**FIGURE 1. Relative rates compared with 1996 of laboratory-confirmed cases of *Yersinia*, *Escherichia coli* 0157, *Campylobacter*, and *Salmonella*, by year — Foodborne Diseases Active Surveillance Network, United States, 1996–2003**



MMWR

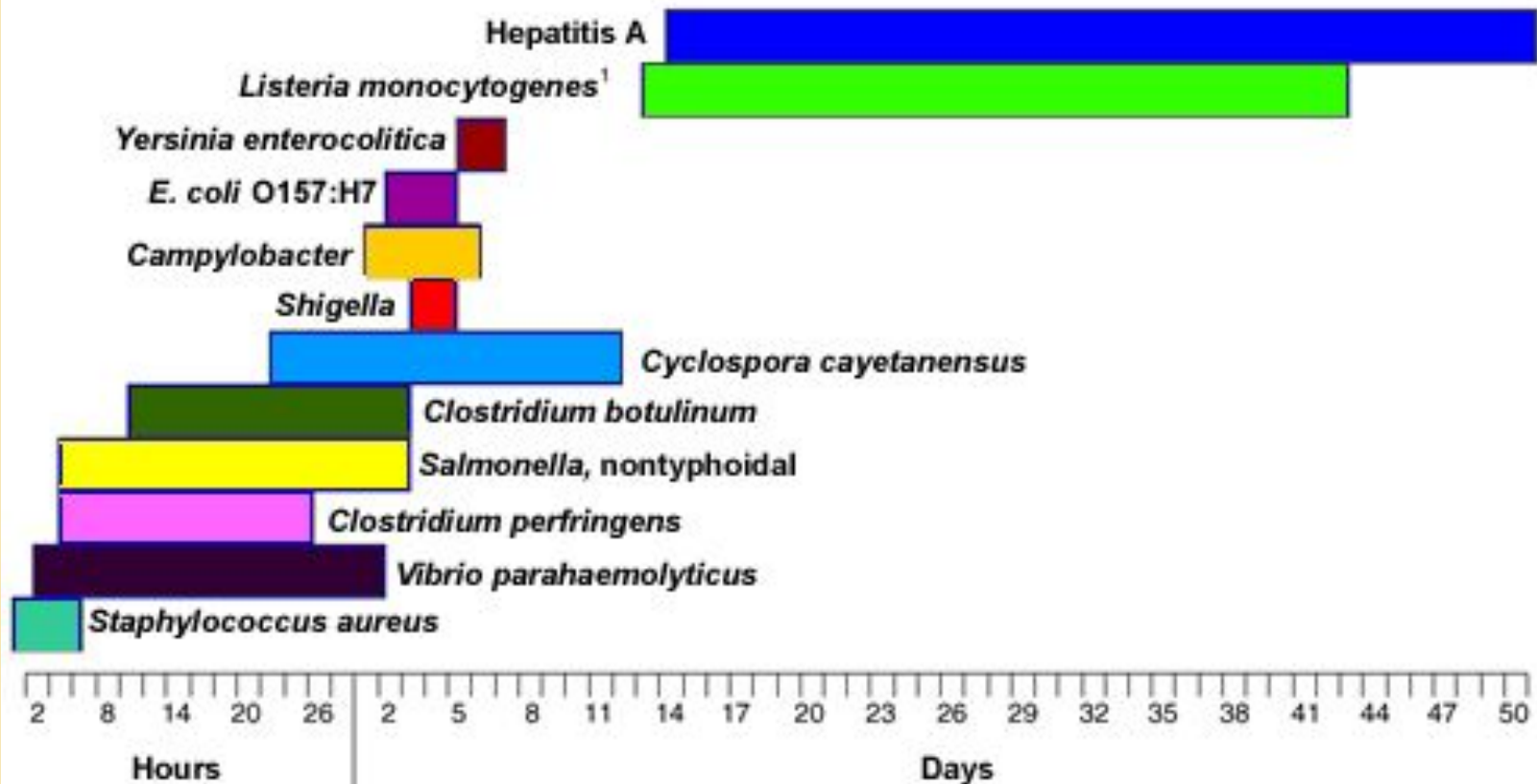
**FIGURE 2. Relative rates compared with 1996 of laboratory-confirmed cases of *Shigella*, *Listeria*, and *Vibrio*, by year — Foodborne Diseases Active Surveillance Network, United States, 1996–2003**



MMWR



**Figure 1**  
**Usual incubation period ranges for select foodborne diseases**



<sup>1</sup> Invasive form, incubation period for diarrheal disease unknown.  
 Source: Data on the "usual" incubation period obtained from the Centers for Disease Control and Prevention, "Surveillance for Foodborne Disease Outbreaks--United States, 1988-1992." MMWR 45, SS-5 (Oct. 25, 1996):58-66

# Norwalk-like Viruses

- Norovirus; Caliciviridae family
  - Most common foodborne agent
  - 23 million cases annually
- Sources
  - Person-to-person
    - Shed in human feces, vomitus
    - Outbreaks in daycares, nursing homes, cruise ships
  - Contaminated shellfish



# Norwalk-like Viruses

- Small infectious dose
- Signs
  - 12-48 hours post-exposure
  - Nausea, vomiting, diarrhea, abdominal cramps
  - Headache, low-grade fever
  - Duration: 2 days
- Food handlers should not return to work for 3 days after symptoms subside

# *Campylobacter jejuni*

- Leading cause of bacterial diarrhea
- 2.4 million people each year
  - Children under 5 years old
  - Young adults (ages 15-29)
- Very few deaths
- Can lead to Guillain-Barré Syndrome
  - Leading cause of acute paralysis
  - Develops 2-4 weeks after *Campylobacter* infection (after diarrheal signs disappear)

# Campylobacteriosis

- Sources

- Raw or undercooked poultry
- Non-chlorinated water
- Raw milk
- Infected animal or human feces
  - Poultry, cattle, puppies, kittens, pet birds

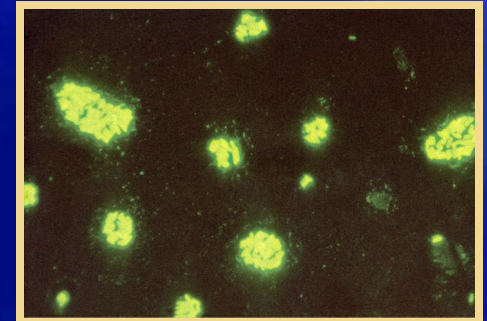


- Clinical signs

- Diarrhea, abdominal cramps, fever, nausea
- Duration: 2-5 days

# Salmonellosis

- Gram negative bacteria
- Many serotypes can cause disease
- *S. enteritidis* and *typhimurium*
  - 41% of all human cases
  - Most common species in U.S.
- 1.4 million cases annually
  - 580 deaths



# Salmonellosis

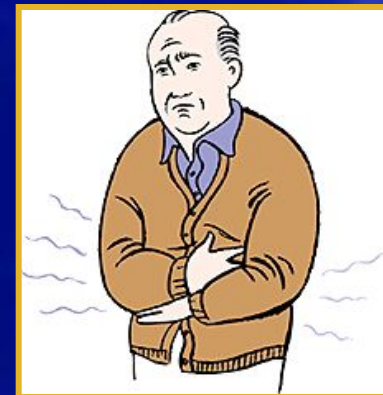
- Sources

- Raw poultry and eggs
- Raw milk
- Raw beef
- Unwashed fruit, alfalfa sprouts
- Reptile pets: Snakes, turtles, lizards

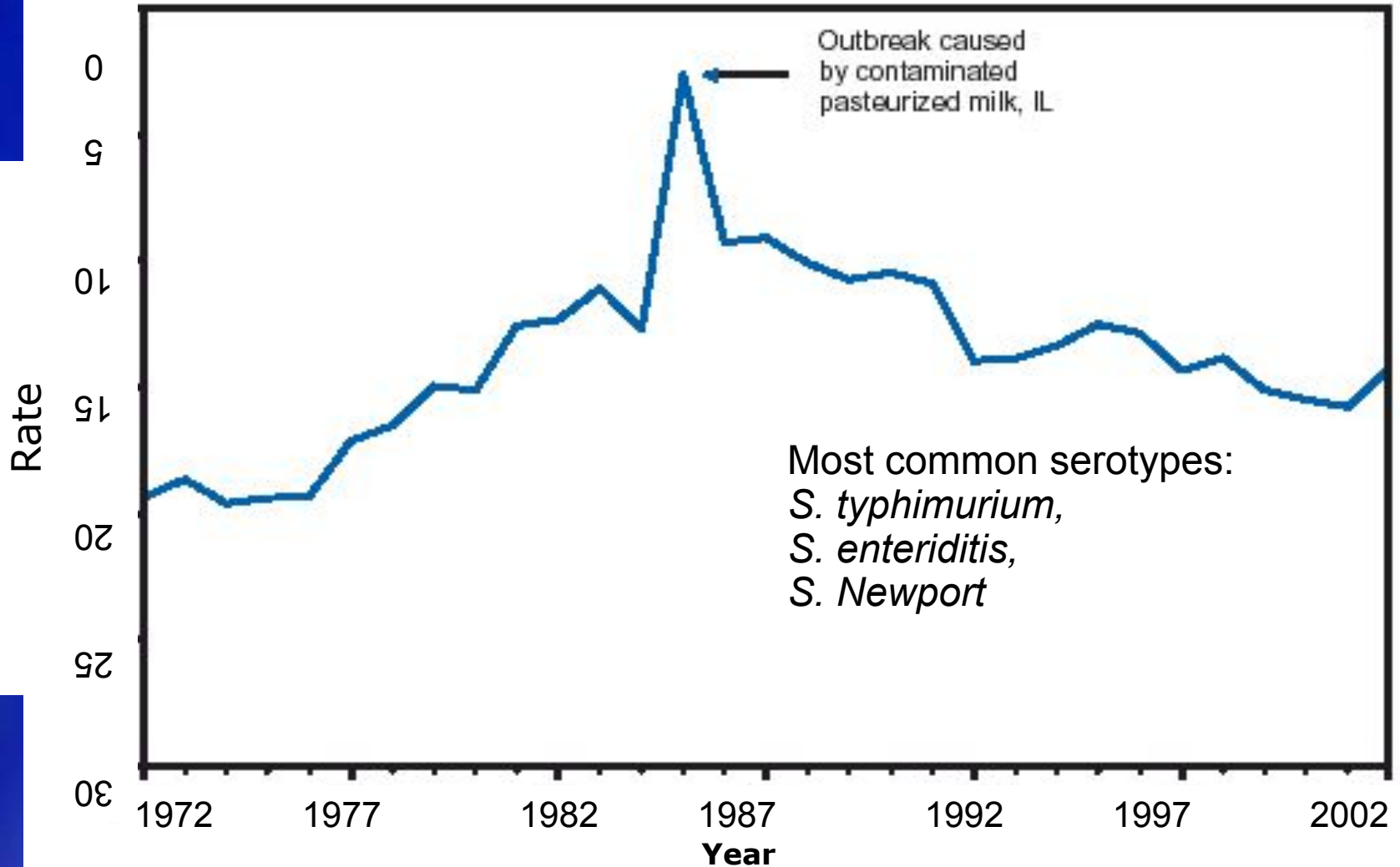


- Signs

- Onset: 12-72 hours
- Diarrhea, fever, cramps
- Duration: 4-7 days



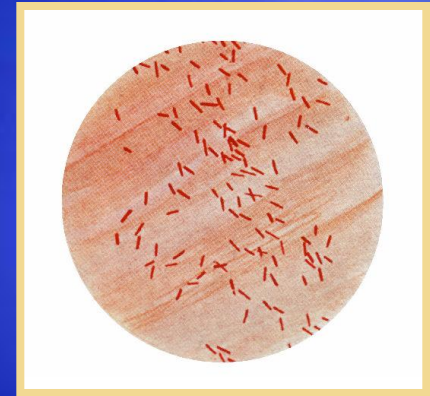
## Salmonellosis. Reported cases per 100,000 population, by year – U.S., 1972-2002





# *E. coli* O157:H7

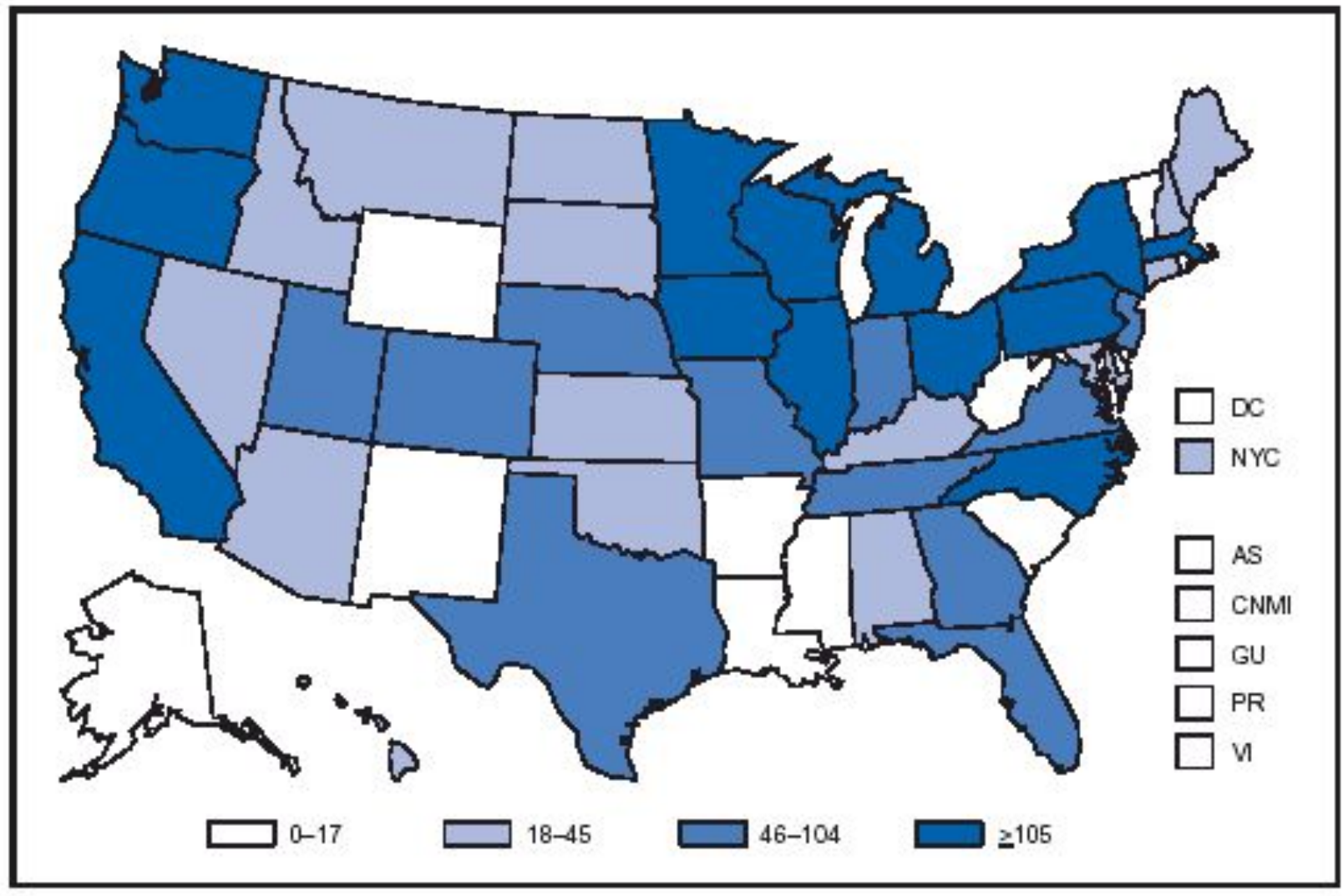
- Enterohemorrhagic *Escherichia coli* (EHEC)
  - Surface proteins; toxin
- Sources
  - Undercooked or raw hamburger; salami
  - Alfalfa sprouts; lettuce
  - Unpasteurized milk, apple juice or cider
  - Well water
  - Animals: Cattle, other mammals



# *E. coli* O157:H7

- Signs
  - Watery or bloody diarrhea, nausea, cramps
  - Onset: 2-5 days
  - Duration: 5-10 days
- Sequela
  - Hemolytic Uremic Syndrome (HUS)
    - Acute kidney failure in children
    - Life threatening

*ESCHERICHIA COLI*, ENTEROHEMORRHAGIC O157:H7. Reported cases — United States and U.S. territories, 2002

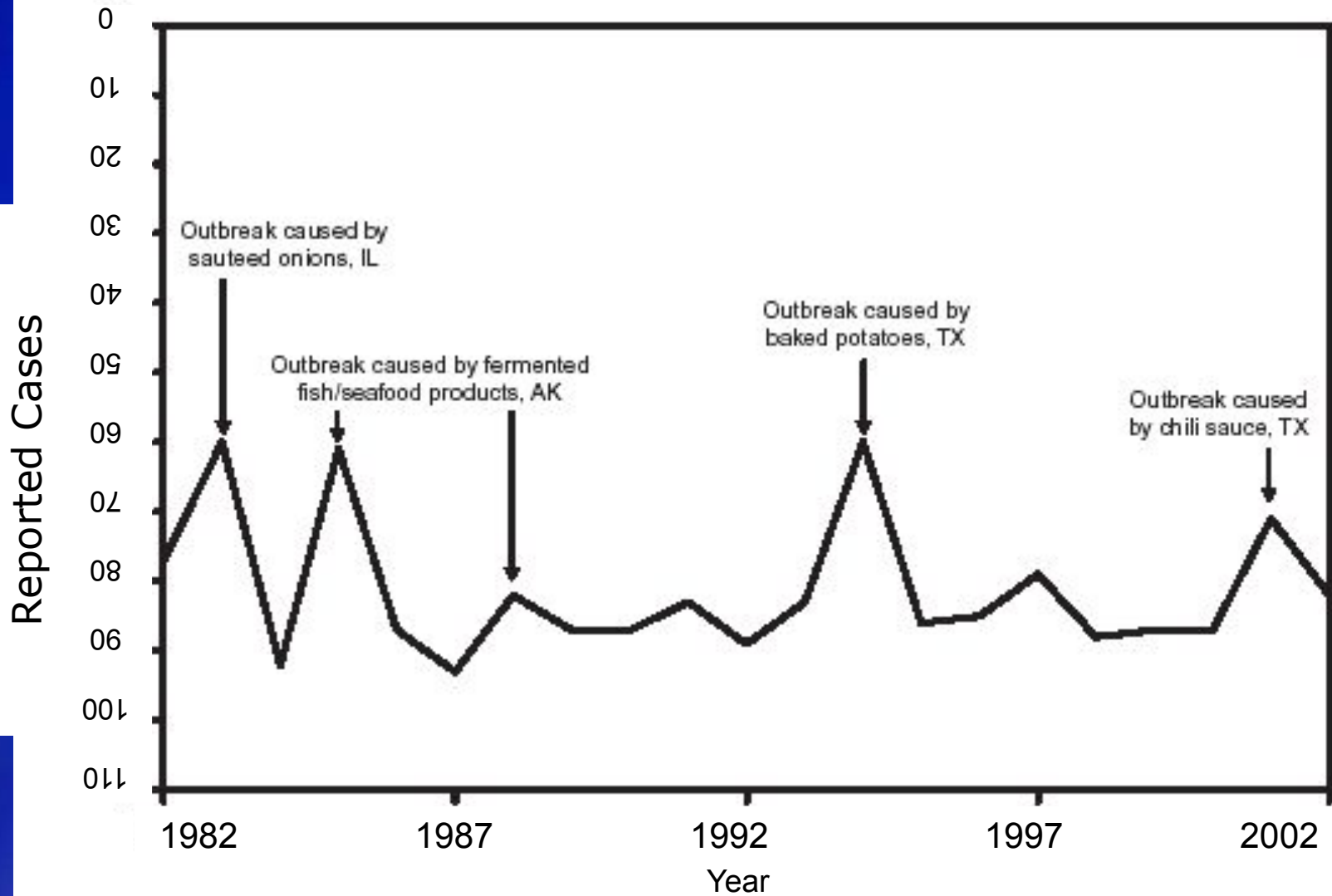


# Botulism

- *Clostridium botulinum*
  - Neurotoxin leads to flaccid paralysis
  - Infants at greatest risk
  - Annually: 10-30 outbreaks; ~110 cases
- Sources: Home-canned foods, honey
- Signs
  - Double vision, drooping eyelids, difficulty speaking and swallowing
  - Onset: 18-36 hours



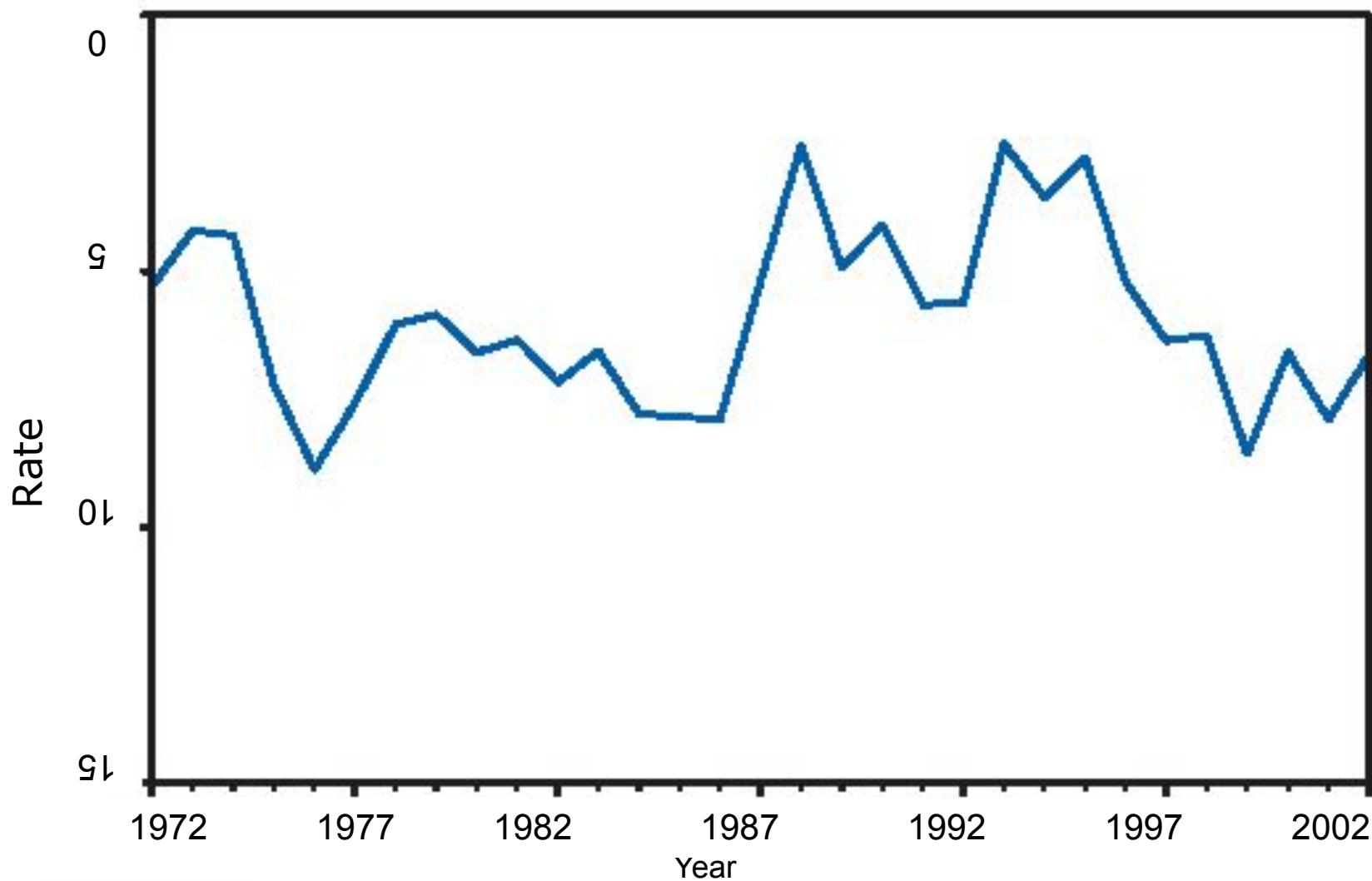
**BOTULISM, FOODBORNE. Reported cases, by year — United States, 1982–2002**



# Shigellosis

- Bacillary dysentery
  - Most cases *Shigella sonnei*
  - 90,000 cases every year in U.S.
- Sources:
  - Human fecal contamination of food, beverages, vegetables, water
- Signs:
  - Watery or bloody diarrhea, nausea, vomiting, cramps, fever
  - Onset: 2 days
  - Duration: 5-7 days

SHIGELLOSIS. Reported cases per 100,000 population, by year — United States, 1972–2002



# Toxoplasmosis

- *Toxoplasma gondii*- intracellular protozoan
  - 112,500 cases annually
  - Pregnant women/immunocompromised at greatest risk
- Sources
  - Infected cats, soil, undercooked meat
- Signs
  - Fever, headache, swollen lymph nodes



# Emerging Pathogens

- *Cyclospora* (Protozoan)
  - 1996, imported raspberries
- *Listeria monocytogenes*
  - Sources
    - Ready-to-eat meats, soft cheeses
  - Signs
    - Human abortions and stillbirths
    - Septicemia in young or low-immune



### Common food vehicles for pathogens

<b>Pathogen</b>	<b>Food sources</b>
<i>Campylobacter jejuni</i> or <i>coli</i>	Major: poultry. Minor: milk, mushrooms, clams, hamburger, water, cheese, pork, shellfish, eggs, cake icing.
<i>Clostridium perfringens</i>	Major: meat, meat stews, meat pies, and beef, turkey, and chicken gravies. Minor: beans, seafood.
<i>Escherichia coli</i> O157:H7	Major: beef particularly ground beef. Minor: poultry, apple cider, raw milk, vegetables, cantaloupe, hot dogs, mayonnaise, salad bar items.
<i>Listeria monocytogenes</i>	Major: soft cheese, pâté, ground meat. Minor: poultry, dairy products, hot dogs, potato salad, chicken, seafood, vegetables.
<i>Salmonella</i> (non-typhoid)	Major: poultry, meat, eggs, milk, and their products. Minor: vegetables, fruits, chocolate, peanuts, shellfish.
<i>Staphylococcus aureus</i>	Major: workers handling foods: meat (especially sliced meat) poultry, fish, canned mushrooms. Minor: dairy products, prepared salad dressing, ham, salami, bakery items, custards, cheese.
<i>Vibrio</i> sp.	Major: oysters. Minor: other seafood.

Pathogens causing outbreaks and the foods associated with them are reported by CDC. For more information see: [Surveillance for Foodborne Disease Outbreaks --United States, 1993-1997](#) Vol. 49, No SS01;1 03/17/2000

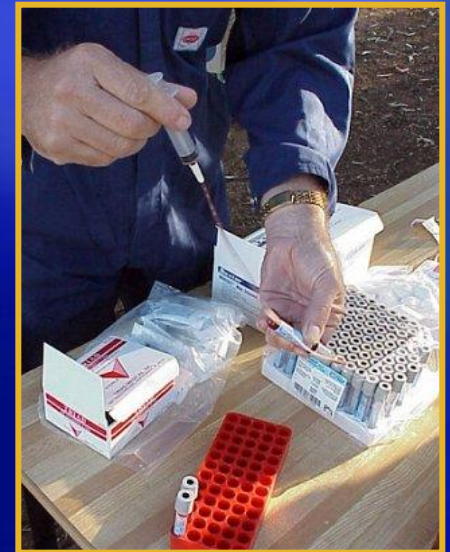
# Prevention and Control

# HACCP

- Hazard Analysis Critical Control Point
- To monitor and control production processes
- Identify food safety hazards and critical control points
  - Production, processing and marketing
  - Establish limits
  - Monitor
- Applied to meat, poultry, and eggs

# On Farm Strategies

- Testing and removal for *Salmonella*
  - Serologic, fecal culture, hide culture
- Vaccinating
  - Many serotypes
  - Varying effectiveness
- Minimize rodents, wild birds
- Isolation of new animals



# At the Slaughter Plant

- FSIS target organisms
  - *Salmonella* and *E. coli*
- Control points
  - Removal of internal organs
  - Minimize contact between carcasses
  - Proper movement through facilities
  - Chilling
  - Cooking processes (time, temperature)



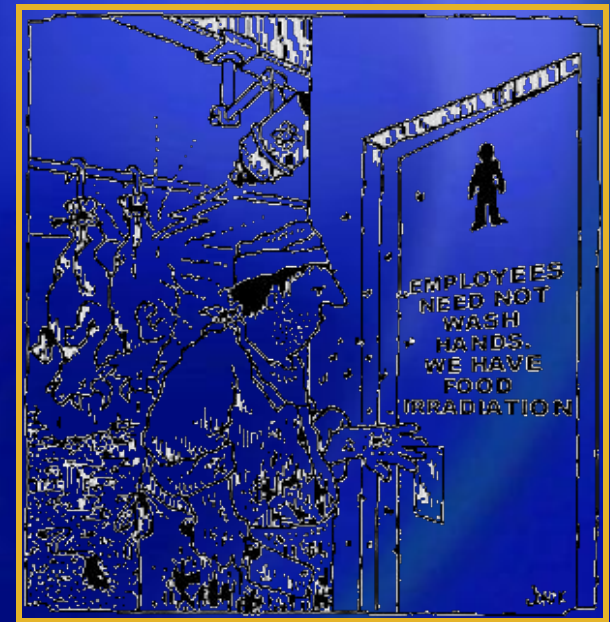
# Irradiation

- Used since 1986 for *Trichina* control in pork
- Gamma rays
  - Poultry in 1990/1992
  - Meat in 1997/1999
  - Reduction of bacterial pathogens
- Kills living cells of organisms
  - Damaged and cannot survive



# Irradiation

- Identified with radura.....
- Does not affect taste quality
- Nutrients remain the same
- Handle foods appropriately afterwards
  - Does not sterilize
  - Contamination can still occur





# USDA Recall Classification

Class I	Health hazard situation; <i>reasonable</i> probability that the use of the product will cause serious, adverse health consequences or death.
Class II	Health hazard situation; <i>remote</i> probability of adverse health consequences from the use of the product.
Class III	Use of the product will <i>not</i> cause adverse health consequences.

# In the Home

- Drink pasteurized milk and juices
- Wash hands carefully and frequently
  - After using the bathroom
  - Changing infant's diapers
  - Cleaning up animal feces
- Wash hands before preparing food



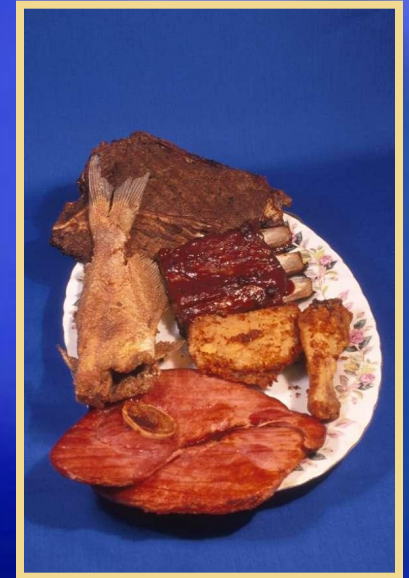
# In the Home

- Wash raw fruits and vegetables before eating
- After contact with raw meat or poultry
  - Wash hands, utensils and kitchen surfaces
  - Hot soapy water
- Defrost meats in the refrigerator



# In the Home

- Cook beef/beef products thoroughly
  - Internal temperature of 160°F
- Cook poultry and eggs thoroughly
  - Internal temperature of 170-180°F
- Eat cooked food promptly
- Refrigerate leftovers within 2 hours after cooking
- Store in shallow containers



# Additional Resources

- Centers for Disease Control and Prevention
  - <http://www.cdc.gov/foodsafety/>
- U.S. Department of Agriculture
  - <http://www.foodsafety.gov>
  - <http://www.nal.usda.gov/fnic/foodborne/statemen.html>

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# Acknowledgments

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