TAKE-HOME POINTS FROM LECTURES BY CLEVELAND CLINIC AND VISITING FACULTY

The new American diet and the changing face of foodborne illness

ALAN J. TAEGE, MD
Department of Infectious Diseases, Cleveland Clinic

ABSTRACT

Pathogens responsible for foodborne illness are changing, owing to changes in the American diet as well as in food production and distribution. Microbial adaptations to heat, acid, cold, and antibiotics have made food safety a challenging task. This article reviews the common pathogens, their sources, and treatment.

FOODBORNE ILLNESS isn't just about bad potato salad any more. As the American diet and methods of food production and distribution have been transformed in recent decades, so have the patterns of foodborne illness and the pathogens that cause it.

Now we have to contend with *Cyclospora* contamination in imported raspberries and multistate distribution of deli meat contaminated with *Listeria*. Other pathogens are emerging or reemerging as well.

Fortunately, the US food supply is one of the safest in the world. However, much remains to be improved concerning methods of production, importation, processing, and storage.

Because consumers are the ultimate bioassay for food contamination, physicians often see the results of food safety problems in their offices. Certain pathogens may cause chronic sequelae (**TABLE 1**).[1] It is crucial to understand the scope and best treatment of the most common foodborne illnesses and to be alert to the potential sequelae.

TABLE 1

Chronic sequelae of some foodborne illnesses

Pathogen	Sequelae
Campylobacter	Guillain-Barré syndrome; Reactive arthritis
Escherichia coli O157:H7	Hemolytic uremic syndrome (especially in children)
Listeria monocytogenes	Encephalitis; Neurologic effects
Salmonella	Reactive arthritis
Shigella	Reactive arthritis
Yersinia enterocolitica	Reactive arthritis

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Consumers are the ultimate bioassay for food contamination

CHANGING CAUSES, PROMINENT PATHOGENS

An estimated 76 million cases of foodborne illness occur each year in the United States[1]; as many as 500,000 people are hospitalized and 9,000 may die. The economic impact is estimated to be as high as $25 billion per year.

These statistics may be gross underestimates because many cases of foodborne illness are never reported. Despite tracking by the US Public Health Service and investigations by local, state, and national agencies, the source of foodborne illness is determined in only 40% to 45% of cases. Sporadic outbreaks, which far outnumber large outbreaks, receive relatively little attention or investigation.

Several important shifts in the epidemiologic factors of foodborne illness have been noted in the last century.[1]

- Eighty percent of foodborne illnesses originate from sources outside the home, as opposed to early in the last century when home-preservation of foods with its inherent problems was much more common.
- Food poisoning is more likely to occur and be more severe at the extremes of age and in immunocompromised people. This becomes particularly important with our aging population and with increasing numbers of patients on immunosuppressive drugs.
- Two thirds of foodborne illnesses are thought to have a viral source and therefore are difficult to track. The remaining third are attributed to bacteria, with a small number derived from parasites, toxins, or chemicals.
- Foodborne illnesses caused by *Salmonella*, *Campylobacter*, and *Escherichia coli* O157:H7 have eclipsed those attributed to *Clostridium* and *Staphylococcus*.
- Heat-tolerant, acid-tolerant, and antibiotic-resistant pathogens are increasing. *Listeria* has the ability to multiply in a refrigerator; *E coli* O157:H7 has become significantly acid-tolerant. Strains of *Salmonella* have acquired multidrug resistance, likely as a result of the use of antibiotics in animal production.

80% of foodborne illnesses are from sources outside the home

WHY?

Health consciousness, demographic shifts, and consumption of ethnic foods have led to changes in the dietary habits of Americans during the last 20 to 30 years. Some of these changes had a positive impact on health, but others have resulted in greater consumption of foods likely to contain pathogens.

Preferences have changed

The demands of American consumers have resulted in new food demographics.[1]

- Consumption of red meat has decreased, while consumption of poultry has increased 90%.
- Cheese consumption has risen 120%.
- Fifteen percent to 20% more fruit and 25% to 30% more vegetables are being consumed.
- "Health foods," which typically have few preservatives and a short shelf life, have become very popular.
- The demand for exotic imported foods has increased. The US government has little control over the production and handling of imported foods. In addition, supermarket owners tend to leave these generally more expensive foods on the shelves for longer periods of time in order to recoup their costs.

Lack of education

When home economics classes were more popular in high schools, students were educated about food preparation and safety issues. These classes are currently less often selected. In addition, dining out has become much more common. As a result, children have fewer opportunities to learn proper food preparation, care, and storage in their homes.

Handwashing is a frequently neglected aspect of disease prevention. This may become a significant issue at buffets and salad bars where many people share the same serving utensils.

The threat of bioterrorism

The September 11 terrorist attacks were a call to reflect on other avenues for vulnerability. Our food supply is one such potential avenue. Small attempts at contaminating food have already been made. Several hundred people became ill in 1984 when the Bhagwan Shree Rajneesh cult contaminated salad bars in The Dalles, Oregon, with *Salmonella typhimurium*, to decrease voter turnout on election day.

Authorities recognize the serious threat that could be posed by some foodborne pathogens. For example, 1 gram of botulinum toxin, derived from the bacterium *Clostridium botulinum*, would be enough to kill 1 million people.[2] This toxin can be easily procured and dispersed. The resulting illness may be difficult to quickly recognize and treat.

In response to recent threats, the US Food and Drug Administration (FDA) in January 2002 issued guidelines to food establishments to prevent food tampering and terrorist actions.[3] The guidelines highlight security measures in every facet of food preparation, from control of physical facilities to the hiring and monitoring of employees.

Increased international travel

Increasing international travel affords the opportunity to bring potentially contaminated foods home. Despite some degree of customs inspection, many travelers return with contaminated goods. Examples have included cholera-carrying crabs from Latin America and Bahamian barracudas with ciguatoxin.

Large-scale food production

In the last 100 years, mass production of food has been centralized to the point that one food-handling mistake can affect huge amounts of food. For example, a plant in Minnesota was temporarily closed in 1994 after 80 people became ill from eating ice cream contaminated with *Salmonella enteritidis*.[4] The ice cream had been distributed in three states.

Corporate farming operations have replaced the family farm as the source of most of the nation's meat and poultry. It is possible that a single pathogen may affect thousands of laying hens, cattle, or pigs simultaneously because of the proximity of the animals.

Widescale food distribution

Imported international foods are widely distributed throughout the United Sates and other countries. Mass-produced foods likewise reach diverse geographic regions. Contaminated alfalfa sprouts from the Netherlands were used to prepare sandwiches for an airline; these sandwiches were served on 219 flights, resulting in illness to people arriving in 24 states, Washington DC, and four countries. The difficulty tracking such an outbreak is obvious.[5]

More demand for nonseasonal foods

Nonseasonal demands by consumers have increased import pressures. Often these items are imported from areas that may have lax production standards, resulting in the potential for contamination by pathogens. Imported Mexican watermelons were found to have been washed in contaminated water prior to shipping, causing illness in American consumers.

The North American Free Trade Agreement has allowed the importation of less expensive products. To remain competitive, the US producers need to seek cost-cutting measures, some of which have the potential to compromise quality and safety of the products.

TABLE 2

Common pathogens and associated foods

Pathogen	Associated foods
Most common	
Campylobacter	Chicken Unpasteurized milk Water
Salmonella	Animal foods, eggs, fruits, vegetables
Shigella	Fruits and vegetables
Escherichia coli O157:H7	Alfalfa sprouts Hamburger, salami Unpasteurized milk and juice
Less common	
Clostridium botulinum	Home-canned foods
Cryptosporidia	Water
Cyclospora	Raspberries
Listeria monocytogenes	Deli meats Soft cheeses, unpasteurized milk Vegetables
Vibrio vulnificus	Shellfish
Yersinia enterocolitica	Raw pork Unpasteurized milk Water

On corporate farms, a single pathogen can affect thousands of animals

THE USUAL SUSPECTS

To determine the source of food poisoning, it is important to be familiar with foods associated with common foodborne organisms (TABLE 2), incubation periods, duration of the resulting illness, clinical symptoms, and the typical population involved in the outbreak.

Physicians who suspect foodborne illness should question patients carefully about their recent activities (TABLE 3).[1] If foodborne illness seems possible, specimens should be submitted for laboratory analysis, and the local or state health department should be alerted.

It is economically and logistically impossible to investigate every suspected food-relat-

TABLE 3

Questions to ask patients presenting with potential foodborne illness

Have you recently eaten raw or undercooked eggs, meats, shellfish, or fish; unpasteurized milk or juice; home-canned foods; fresh produce; or soft cheeses?

Are family members or close contacts experiencing similar symptoms?

Have you recently visited a foreign country, farm, day care center, coastal area, or campground with untreated water?

Have you recently attended a picnic?

Have you had recent contact with pets or other animals?

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ed illness. Most are not reported, the majority are viral in origin, and those affected usually experience a short illness with no consequences. Health care providers need to be vigilant for foodborne illness in the very young and old, the immunocompromised, and in pregnant patients, as they often experience the most severe disease and serious outcomes.

Clinicians need to be alert for unusual illness as a clue to food contamination; hemolytic uremic syndrome as a sequela to *E coli* O157:H7, bullous cellulitis and sepsis from *Vibrio vulnificus*, or a flaccid descending paralysis suggestive of botulism (TABLE 4).

The US government has limited control over the growing or handling of imported foods

C botulinum

Twelve to 72 hours after ingestion, botulism manifests as symmetric descending flaccid paralysis with bulbar palsies (ie, diplopia, dysarthria, dysphonia, dysphagia). It can cause nausea, vomiting, diarrhea, and cramps.

Differential diagnostic considerations include tick-borne paralysis, myasthenia gravis, the Miller Fisher variant of Guillain-Barré syndrome, and the Lambert-Eaton syndrome. If botulism is suspected, physicians should perform blood assays for the toxin and send stool, vomitus, gastric aspirate, or suspected foods for analysis to state or federal facilities.

Laboratory confirmation is low; therefore, botulism requires a rapid clinical diagnosis. An antitoxin is available. However, it must be administered quickly to be effective, and it only prevents further paralysis rather than reversing already existent paralysis. In addition, serum sickness develops in 9% of patients who receive the antitoxin, and 2% experience anaphylaxis. Treatment is otherwise supportive.

Campylobacter

Chicken, unpasteurized milk, and untreated water are the most common sources of *Campylobacter*. One to 7 days after ingestion, approximately two thirds of affected people have fever, and about half have bloody diarrhea. The duration of illness is usually only 1 week in healthy people. Immunocompromised or otherwise unhealthy people may benefit from erythromycin or a quinolone.

Cryptosporidia

In 1993, more than 400,000 people in Milwaukee became ill after drinking water containing cryptosporidia. Chlorine does not kill this organism; a special filter is required to protect water supplies. After an incubation of 2 to 10 days, symptoms including diarrhea, headache, cramping, nausea, vomiting, and low-grade fever may last 1 or 2 weeks. Treatment is supportive. Spread by fecal contamination, this parasite can be transmitted from person to person in a fecal-oral manner.

Cyclospora

Cyclospora emerged as a food-related illness after its association with imported raspberries. It has also been found on lettuce, basil, and other foods after fecal contamination. Two to 10 days after ingestion, it manifests as cramping, bloating, flatulence, and nonbloody diarrhea lasting for a few days to a month. An acid-fast stain of a stool sample is required for diagnosis. Treatment with trimethoprim-sulfamethoxazole may assist in recovery, particularly in prolonged cases.

E coli O157:H7

Hamburger, unpasteurized apple cider, milk, lettuce, and water have been associated with outbreaks of *E coli* O157:H7.[6] In 1993, four children died and hundreds of people became ill after eating *E coli*-tainted hamburger from Jack-in-the-Box restaurants in the Pacific Northwest, which occurred because of inadequate cooking. An estimated 20,000 cases occur annually, resulting in approximately 250 deaths.

E coli O157:H7 has an incubation period of 4 to 8 days and causes abdominal pain and bloody diarrhea, but not usually fever. The illness is caused by a toxin produced from a *Shigella*-derived gene.

Antibiotics appear to have no role in the treatment, leaving supportive care as the mainstay.

The hemolytic uremic syndrome that can follow this illness usually occurs 5 to 10 days after the diarrhea has abated. Children are most commonly afflicted.

Listeria

This organism has been associated with deli meats, soft cheeses, and coleslaw. In 1999, Bosell Foods in Cleveland, Ohio, recalled 350 pounds of sliced ham contaminated with *Listeria*. That same month, the Oscar Mayer company recalled 28,313 pounds of deli meat for the same reason. Not only is *Listeria* cold-tolerant, it has also developed some degree of heat tolerance.

After an incubation of 1 or 2 days, fever, gastrointestinal upset, and nonbloody diarrhea develop. Pregnant women, newborns, and people with weakened immune systems are most susceptible. *Listeria*, along with *Vibrio vulnificus*, has the highest hospitalization and mortality rate of all food-related pathogens. Ampicillin appears to be the most effective antibiotic for listerial illness.

Salmonella

Salmonella species are commonly found in contaminated fruits, vegetables, eggs, and animal foods. *S enteritidis* can be transmitted transovarially from one generation to the next through a poultry population. Despite a reduction in recent years, there may be an evolving trend of resurgence of *Salmonella* cases associated with animal foods.

Salmonellosis has an incubation period of 1 to 2 days, usually lasts less than 10 days, and presents as a gastroenteritis with vomiting and diarrhea. No treatment is required in most cases, but newborns, immunocompromised people, people with inflammatory bowel disease or hemoglobinopathy, and those with endovascular prosthetic devices may benefit from antibiotic treatment with ampicillin, gentamicin, trimethoprim-sulfamethoxazole, or ciprofloxacin.

TABLE 4

Signs of serious foodborne illness that should lead to submission of laboratory specimens

- Bloody diarrhea
- Diarrhea leading to dehydration
- Fever
- Neurologic involvement (eg, paresthesias, motor weakness, cranial nerve palsies)
- Prolonged diarrhea (ie, three or more unformed stools daily for several days)
- Severe abdominal pain
- Sudden onset of nausea, vomiting, diarrhea
- Weight loss

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Shigella

Much less common than *Campylobacter* and *Salmonella*, *Shigella* is associated with fecal contamination of fruits, vegetables, and shellfish. It has an incubation period of 2 to 4 days and manifests as fever, abdominal cramping, and bloody diarrhea for 5 to 7 days.

Shigella is usually treated with third-generation cephalosporins and quinolones. Multidrug-resistant species occur.

E coli O157:H7 causes abdominal pain and bloody diarrhea, but not usually fever

Vibrio

This organism is often associated with raw seafood from the southern US seacoast. The highest risk is in late summer or early autumn, when warm waters encourage bacterial growth. *V parahaemolyticus* has the ability to tolerate and proliferate in a cold environment.

One to 4 days after ingestion, *Vibrio* may cause vomiting, diarrhea, and abdominal pain. In immunocompromised people—particularly in those with underlying liver disease—*V vulnificus* may manifest as a sepsis-like syndrome or bullous cellulitis.

Treatment consists of tetracycline or ceftriaxone.

Yersinia enterocolitica

Illness caused by this organism is rare in the United States and affects mostly young children. It is typically acquired by eating raw pork or drinking unpasteurized milk or water. An ethnic food, chitterlings, has been associate with cases of yersiniosis.

Yersinia has an incubation period of 4 to 7 days. Symptoms include fever, abdominal pain, and diarrhea that is often bloody. Right-sided abdominal pain and fever may be confused with appendicitis. Carditis, joint pain, or sepsis may occur. The illness usually resolves without antibiotic therapy, but severe illness or complications may require the use of antibiotics such as aminoglycosides, doxycycline, trimethoprim/sulfamethoxazole, or fluoroquinolones.

EFFORTS TO ENSURE SAFETY

In addition to technical advances in food preparation, handling, and storage, strides have been made to improve surveillance.

In 1995, the Centers for Disease Control and Prevention (CDC), the FDA, the US Department of Agriculture (USDA), and five states unveiled the Foodborne Diseases Active Surveillance Network (FoodNet at **www.cdc.gov/foodnet/**).[7] FoodNet now includes monitoring sites in eight states. The goal of this network is to survey, characterize, and respond to foodborne illness in a timely fashion.

***Listeria* and *Vibrio* can tolerate and proliferate in cold environments**

PulseNet is a nationwide computer network designed to track and link foodborne outbreaks by DNA fingerprinting with pulse-field gel electrophoresis, thereby rapidly identifying clusters of similar cases. See **www.cdc.gov/ncidod/dbmd/pulsenet/pulsenet.htm.**

HACCP

Established in 1996, the Hazard Analysis Critical Control Point (HACCP) system[6] is an effort to increase the safety of meat and poultry processing. It is a preventive effort targeting the production industry in a preemptive fashion by establishing sanitation standards and monitoring critical points in the production process.

Irradiation

By slowing cell division, irradiation of food can delay ripening and sprouting, eliminate insect infestations, maintain food freshness, and attempt to sterilize the foods. In 1992, the FDA approved the use of irradiation in the poultry industry. In 2000, it was put into effect through federal enactment to be used in grains and fresh produce.

However, irradiation systems are expensive to install, and the public remains skeptical about irradiation. It is important to understand that ionizing irradiation is used and that it is not radioactive. More public education about the safety of this method is necessary before it will be widely accepted.

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SUGGESTED READING

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ADDRESS: Alan J. Taege, MD, Department of Infectious Diseases, The Cleveland Clinic Foundation, 9500 Euclid Avenue, Cleveland, OH 44195; e-mail taegea@ccf.org.