Chapter 7
Public Health Principles

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Learning Objectives

- Discuss foodborne illness.
- Discuss how pathogens can be transmitted.
- Discuss risk factors that contribute to foodborne illness.
- Discuss how public health agencies help prevent foodborne illness.

Introduction

Due to the ever-increasing level of complexity in our global food supply system, as well as the enormous costs and impacts associated with foodborne illness, every food protection professional (FPP) needs to understand the importance of food safety from a public health standpoint and the role that public health agencies play in preventing foodborne illness. This chapter provides a brief historical overview of food-related illness and the impact of foodborne illness, along with an overview of how foodborne pathogens are transmitted to individuals. Additionally, the chapter explores the numerous ways by which public health agencies help prevent foodborne illness outbreaks.

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Historical Overview

During the early twentieth century, contaminated food, milk, and water caused many foodborne illnesses such as typhoid fever, tuberculosis, botulism, and scarlet fever (CDC 1999). In fact, in 1900, diarrheal and other gastrointestinal illnesses were the third leading cause of death in the USA (CDC 2014a). Dense urban areas were especially prone to large illness outbreaks due to overcrowding and lack of sewer systems and water treatment facilities. Solid and liquid waste was often emptied directly onto streets, leading to frequent contamination of the water supply.

Thanks largely to Upton Sinclair's novel *The Jungle*, which exposed unsanitary conditions related to the food industry, public awareness—and public outrage—increased and led to passage of the Pure Food and Drug Act (Public Law 59-384, 34 Stat. 768) and the Federal Meat Inspection Act in 1906 (Public Law 59-242, 34 Stat. 674). These laws served as the foundation for the regulation of food safety in the US. A number of public health reforms were also implemented, including the development of modern sewage disposal systems, urban zoning laws which separated residential areas from industrial areas, refuse collection and management services, and drinking water filtration and chlorination.

Thanks to these initial forms of regulation, many of the sources of foodborne illness were soon identified; various control measures such as handwashing, sanitation, pasteurization, and refrigeration were incorporated; and the incidence of diseases decreased markedly. To illustrate, the incidence of typhoid fever in 1900 was about 100 per 100,000 people; by 1920, this decreased to 33.8, and by 1950, to just 1.7 (CDC 1999). Today, typhoid fever, cholera, and botulism, which were once ubiquitous in the USA, are relatively rare outside of the developing world.

Foodborne Illness

Despite technological advancements in the production and storage of food, the US Centers for Disease Control and Prevention (CDC www.cdc.gov) estimates that each year, one in six Americans will experience foodborne illness, which equates to roughly 48 million people each year nationwide. Additionally, foodborne illness causes 128,000 hospitalizations and 3,000 deaths annually in the USA (CDC 2014b, c). Worldwide, foodborne disease is a growing public health problem and encompasses a wide spectrum of illnesses caused by microbial, parasitic, or chemical contamination of food (World Health Organization 2014a).

In addition to the health implications caused by foodborne illness, there is also a substantial economic impact. A recent study estimated that foodborne illness poses a $77.7 billion economic burden in the US annually due to medical costs, pain, suffering, functional disability, and illness-related death. However, this figure does not take into account the costs to the food industry, including reduced consumer confidence in food products and companies, product recalls, and litigation.

The figure also does not consider the cost to public health agencies (federal, state, local) that respond to foodborne illnesses and outbreaks (Food Safety News 2014). Public confidence after a major foodborne outbreak may never be fully restored, and many establishments go out of business after just one outbreak incident.

Common symptoms of foodborne illness include diarrhea and/or vomiting, typically lasting 1–7 days. Other symptoms include abdominal cramps, nausea, fever, joint/back aches, and fatigue. What some people call the "stomach flu" may actually be a foodborne illness caused by a virus or bacteria in contaminated food or drink (Minnesota Department of Health 2010). Most individuals with foodborne illness will recover without any special treatment; however, certain types of foodborne illness require treatment with antibiotics, and severe types of foodborne illness can even lead to kidney failure, respiratory failure, premature delivery, and even death (FDA 2014a).

The length and duration of foodborne illness depend on the type of pathogen present, the amount of pathogen present, and an individual's susceptibility to the illness, i.e., the state of his or her immune system. When the immune system is strong and functioning properly, humans are generally less susceptible to disease. When a person with a healthy immune system becomes infected with a pathogen, the person's symptoms may be less severe or have a shorter duration. On the other hand, a person with a compromised or weak immune system is at a much higher risk of developing illness and may have more severe symptoms. Reasons for a weakened immune system include having an autoimmune disease, taking immunosuppressive drugs to treat cancer or other health conditions, having a chronic health condition, being very young or old, and being pregnant.

Pathogen Transmission

Pathogens are viruses, bacteria, and other microorganisms that cause disease in humans. Pathogen transmission refers to how a pathogen is passed from one body (the host or reservoir) to another (a susceptible host). Potential hosts or reservoirs include humans, animals, and environmental hosts such as plants, soil, and water. A pathogen leaves its host through a *portal of exit*, which can be the respiratory tract, urine, fecal matter, or bodily secretions, e.g., blood from a cut or wound, and enters another body through a *portal of entry* on a susceptible host (CDC 2012a). For example, a person ill with influenza coughs on a crowded bus, and the three people standing nearest inhale the influenza virus directly into their own respiratory tract. In this example, the portal of exit is the mouth of the ill person and the portal of entry is the nose/lungs of the nearby passengers, both functioning as part of the respiratory tract.

Pathogen transmission can either be *direct* or *indirect*. In direct transmission, the pathogen is transferred from a reservoir to a susceptible host through direct contact such as skin-to-skin contact or contact with soil or vegetation harboring pathogens. Indirect transmission, on the other hand, involves an intermediate step

between the portal of exit and the portal of entry, typically through air particles (e.g., coughing, sneezing, or air currents) or through an intermediate object called a *vector* or a *vehicle. Vectors* are living animals, most commonly biting insects such as mosquitoes, fleas, or ticks. *Vehicles* are inanimate objects and include water, biologic agents such as blood, and fomites, which are certain inanimate objects that are capable of carrying pathogens, such as clothing, bedding, and handkerchiefs (CDC 2012a).

Food is a common example of a vehicle for transmitting pathogens. In fact, virtually any type of food can be the source of foodborne illness (Fig. 7.1), especially when there is a lack or failure of a "kill step," typically a point in the food manufacturing process where pathogens are eradicated from the food product (usually by killing the pathogen). Traditional "kill steps" have included cooking, pasteurization, washing, and irradiation (Caywood 2009).

Risk Factors Contributing to Foodborne Illness

Knowing about portals of exit and entry and the ways that foodborne pathogens can be transmitted can help FPPs identify potential food safety risks and determine appropriate control or intervention measures. FDA has identified certain *risk factor categories* associated with foodborne illness outbreaks. Identification of these factors resulted from data collected during visits by FDA personnel to approximately 850 foodservice and retail food establishments conducted over a 10-year period. These risk factors include employee health and hygiene; inadequate cooking and holding temperatures; and contaminated equipment (FDA 2014b). Although the risk factors were identified through visits to retail and foodservice facilities, the factors can also be applied to food manufacturing facilities and other points along the food supply chain, such as growing areas, storage, distribution, and transportation.

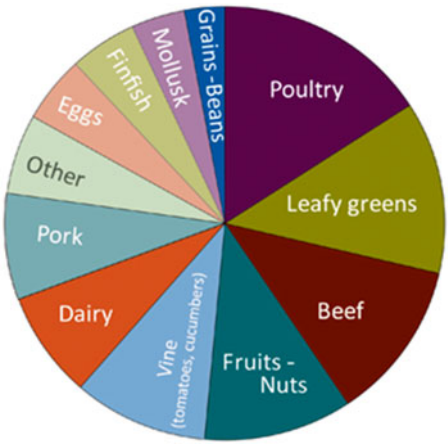

Fig. 7.1 Causes of illness in 1,565 single-food commodity outbreaks, 2003–2008 (CDC 2012b)

Employee Health and Hygiene

The cause of a foodborne outbreak can sometimes be traced to a sick or infected person handling a food product. As a result, public health agencies generally have regulations in place that prevent ill workers from continuing to work with food. Food products can also become contaminated when food handlers fail to wash their hands or wear gloves prior to handling the food.

Inadequate Cooking/Holding Temperatures

Bacteria grow best between certain temperatures, typically the "danger zone" between 40° and 140 °F (USDA 2013a). As a result, some food needs to be cooked at a temperature of 140 °F or above (or microwaved at 165 °F or above) (Foodsafety.gov 2014a), while other types of food such as meat, poultry, and casseroles need to be cooked at a higher temperature-such as 160 °F or 165 °F (Foodsafety.gov 2014b). Hot foods need to be held at a temperature of 135 °F or above, while cold foods need to be held at a temperature of 41 °F or below (San Bernardino County 2012) (Figs. 7.2 and 7.3).

Contaminated Equipment

Pathogens can be spread via contaminated surfaces that contact food, such as utensils, tables, blades, conveyors, and other equipment used in processing. As a result, all equipment needs to be cleaned and sanitized on a regular basis (San Bernardino County 2012). Pathogens can live (or remain in an active state) on inanimate objects long enough to be transmitted to a food product.

Fig. 7.2 Approximately 900 pounds of the dairy product to the right were sent to a landfill for disposal due to improper storage temperatures on a truck (Source: Indiana State Department of Health, Food Defense Program)

Fig. 7.3 Taking thermal readings of refrigerator contents using a digital thermometer (Source: CDC Public Health Image Library image # 13851/CDC/Amanda Mills)

How Public Health Agencies Help Prevent Foodborne Illness

There are approximately 2,565 local public health agencies/departments in the USA and 50 state health departments, along with state departments of agriculture and public health agencies at the tribal and territorial levels. Federal public health departments, such as CDC and FDA, help ensure that all levels of government are able to provide essential public health services, act when health threats span more than one state, and help states that lack certain expertise or resources to respond to a public health emergency (CDC 2013).

In the vast majority of states, local health departments are led by local government, which makes most fiscal decisions. In some states, however, some local health departments are governed at the state level, while in the remaining states, local health departments are led by *both* state and local authorities (CDC 2013).

Local and state health and state agriculture agencies play key roles in preventing foodborne illness outbreaks. These agencies inspect food manufacturing and food retail establishments, maintain a trained and educated staff of FPPs, educate the public about food safety, collect information about potential cases of foodborne illness (surveillance), conduct enforcement activities (recalls, embargoes, seizures), and investigate cases of suspected foodborne illness.

Inspections

Inspections of facilities involved in *all* points of the food chain (processing, distribution, retail, etc.) play a key role in ensuring a safe food supply. During an inspection, FPPs identify critical food safety issues, help confirm a link between foodborne illness disease and unhygienic conditions, and take appropriate steps to control or remedy these issues. Today, inspections focus on events that are most likely to cause a foodborne illness or outbreak, which is a more effective approach than the traditional "floors/walls/ceilings" inspections, where the FPP based the inspection merely on observable evidence of violations, typically related to cleanliness, housekeeping issues, and pest control. Nobody likes to eat in a dining area with a dirty carpet, but dirty carpets are not likely to make anyone sick. However, a plate that looks clean but was not properly sanitized could make someone sick. Inspections are covered in greater detail in Chap. 12.

Trained and Educated Staff

The world of food safety is constantly changing. New technologies emerge that assist in detecting and minimizing the effect of harmful organisms before the organisms have a chance to cause a foodborne illness. Likewise, new sources of foodborne illness are emerging and evolving. For example, in the past, peanut butter and cantaloupe were not considered sources of widespread foodborne outbreaks. However, in recent years, both have been involved in major outbreaks (CDC 2012c, d).

Because the FPP can help keep both industry and the public informed of food safety issues, he or she must stay up-to-date on the latest food safety information available, be adequately trained in food safety principles, and be well-versed in the regulations and policies for the jurisdiction where he or she is employed. Most agencies have specific training requirements before an inspector is assigned to conduct inspections. Typically, this preparation includes training courses, both online and instructor-led, as well as accompanying veteran FPPs during inspections. Some jurisdictions, in fact, require a certain number of contact hours or continuing education units throughout the FPP's career.

Consumer Education

Public awareness is another useful tool in helping prevent the spread of foodborne illness. Many public awareness campaigns are carried out with the help of the Partnership for Food Safety Education (PFSE, www.fightbac.org), which brings together public and private sectors to support the work of health and food

safety educators. One of PFSE's public awareness campaigns is Be Food Safe (www.befoodsafe.gov), developed in cooperation with USDA. The campaign provides educators with the tools to inform consumers about foodborne illness and raise the level of awareness of the dangers associated with improper handling and undercooking of food (USDA 2013b).

Surveillance Activities

Public health agencies monitor foodborne illness through a variety of mechanisms, but primarily through two types of surveillance systems: complaint-based systems and pathogen-specific systems. (Surveillance is discussed in greater detail in Chap. 8.) Complaint-based surveillance systems involve reports of foodborne illness symptoms to the local public health agency by an individual or a group of individuals experiencing symptoms believed to be caused by ingestion of contaminated food or water. Complaint-based systems can allow agencies to respond quickly to potential outbreaks. However, complaint data are not typically shared between jurisdictions, so identifying outbreaks that occur across jurisdictional lines can be difficult.

A pathogen-specific surveillance system tracks cases of foodborne illness that have been confirmed through laboratory testing and then reported back to a local or state public health agency. When an ill individual seeks medical care, his or her healthcare provider may take a sample from that patient and send the sample to a laboratory, which can identify the genetic code, or DNA fingerprinting, of illness-causing pathogens. Laboratories can also identify linkages between cases when two samples have the same DNA fingerprint, even if the cases occur in different states at different times. One limitation to pathogen-specific surveillance, however, is the potential length of time for agencies to receive laboratory results. Such a delay can occur because individuals often do not visit their healthcare provider until days after the onset of symptoms, and laboratories may need days to confirm a diagnosis, depending on the pathogen(s). In fact, the average time from onset of symptoms to outbreak confirmation is estimated to be 2–3 weeks (Council to Improve Foodborne Outbreak Response 2009).

Other, less frequently used surveillance systems include syndromic and sentinel systems. The objective of syndromic surveillance is to identify illness clusters early, before diagnoses are confirmed, and to mobilize a rapid response. An example of syndromic surveillance would involve a greater-than-expected number of emergency department visits for specific symptoms. Syndromic surveillance was primarily developed for early detection of a large-scale release of a biologic agent (CDC 2004). In a sentinel surveillance system, a network of carefully-selected health facility sites serving a relatively large population (e.g., a network of large hospitals) share data and information regarding day-to-day experiences, which can serve as an early warning for outbreaks (World Health Organization 2014b).

The Internet is also emerging as a tool for detecting potential foodborne illness outbreaks and diseases. To illustrate, researchers at the New York City Department of Health and Mental Hygiene, Columbia University, and Yelp analyzed close to 300,000 food review posts on Yelp, looking for keywords such as "diarrhea," "sick," and "vomit." Health officials ultimately used the results of the analysis to investigate more than 100 possible foodborne outbreaks. This led to follow-up interviews and health inspections at a handful of restaurants (Advisory Board Company, The 2014a). Another team of researchers concluded that an online tool called Google Flu Trends could predict surges in hospital flu visits more than a week before the CDC could make such a prediction, while another study found that using Twitter could help track cholera outbreaks in Haiti quicker than traditional methods (Advisory Board Company, The 2014b).

Enforcement Activities

If a food product is found to pose a health risk to consumers, the product may be *recalled*, i.e., removed from warehouses and stores and from customers after purchase. Manufacturers or distributors may voluntarily initiate a recall; however, recalls can be requested or mandated by the FDA or USDA if the product is regulated by the federal agency. Recalls can also be requested by state food protection regulatory agencies, such as agriculture and health departments. Recalls are classified into three categories based on the severity and relative health risk related to the product. A Class I recall is a situation where there is a reasonable probability that a product will cause serious adverse health consequences or death; a Class II recall is a situation where a product may cause temporary or medically-reversible adverse health consequences, or where the probability of serious adverse health consequences is remote; a Class III recall involves a situation where a product is not likely to cause adverse health consequences (FDA 2014c). State food protection agencies may check food establishments, grocery stores, warehouses, etc., to verify that a recalled product has been removed from commerce.

If the soundness or safety of a product is in question, state food protection agencies may sometimes place an *embargo* or "hold order" on a product until the product has been determined safe for human consumption. If the product is not deemed safe to consume, the product can be destroyed or returned for reconditioning. The embargo process is especially common for imported goods. Every jurisdiction has different regulations and procedures for placing an embargo on food, and the FPP needs to be aware of the requirements in the area he or she inspects or regulates.

Sometimes the forced removal or *seizure* of a product from a store, warehouse, or port may be necessary to ensure the product does not reach the consumer. This removal is typically done when cooperation with the holder of the product is not possible. Most jurisdictions are required to obtain a court order before seizing products, and plans must be made regarding how the food is to be destroyed or stored prior to the product being seized.

Investigation

Once a case of foodborne illness is reported to a health agency, the case may be investigated by agency staff. Not every case of foodborne illness will be investigated due to the number of reported cases and the limited funding and staffing faced by many state and local health agencies. However, the chance of an investigation being conducted is greater if any of the following situations are involved:

- Severe illness and/or death.
- Illness affecting a more vulnerable segment of the population (e.g., elderly individuals, pregnant women, or children).
- Widespread illness, suggesting a commercially distributed product.
- Illness that suggests potential bioterrorism or intentional contamination.
- Political pressure applied from inside or outside the responding agency.

When a public health agency receives a foodborne illness complaint, an interview is typically initiated with affected individuals or their friends or family members. The goal of the interview is to assess the symptoms of the illness, establish a timeline of events, and identify all the foods and beverages that the person consumed within a given timeframe (i.e., a food history). The information gathered in an interview is collected according to a prescribed methodology, i.e., interviewers ask the same questions in the same manner and record the information in the same format. Consistency is highly important when interviewing potential cases, because variations in interviewing technique can introduce errors that can confound an investigation.

Foodborne illness investigation may involve multiple individuals, including, but not limited to, a public health nurse and/or an epidemiologist to interview persons who became ill and to collect stool samples, a microbiologist to detect the presence of a pathogen, an environmental sanitarian, a food inspector or investigator, a veterinarian if animals are involved, laboratory personnel to prepare and test samples, specialists in food manufacturing processes, and public relations personnel to make sure that accurate and consistent information is provided to the media and to the public.

A foodborne illness investigation can also involve multiple agencies, especially where the outbreak involves a large geographic area. To illustrate, a recent outbreak of a rare illness known as Haff disease in Mississippi resulted in multiple state agencies being in constant communication due to jurisdictional issues. (Haff disease is associated with the consumption of buffalo fish, though no exact cause or toxin has ever been isolated.) The State Department of Health had jurisdiction over the fish processing and epidemiological aspects. The Department of Agriculture regulated the sale of buffalo fish in retail establishments. Because buffalo fish is wild-caught, the Department of Wildlife had the authority to stop the harvest of the fish. The Department of Marine Resources was involved because buffalo fish is an aquatic animal. Finally, the Department of Environmental Quality had to determine when the waters were safe to fish. Clearly, different agencies offer specific areas of expertise, which can prove to be a tremendous asset during an investigation. (Note: all victims of the Haff disease outbreak survived, though most were hospitalized for several days.)

The primary goals of a foodborne illness outbreak investigation are to identify the cause of the outbreak, minimize the impact of the outbreak, and prevent such an incident from recurring. An outbreak investigation may reveal that a basic piece of information had been overlooked, or the investigation may identify a gap in the food supply chain that warrants a corrective action, such as replacing a certain piece of equipment or training certain employees on personal hygiene.

Conclusion

Foodborne (and water-related) illness can occur and spread in a variety of ways and can have tremendous impact on public health. Public health agencies at all levels of jurisdiction serve an important role in the detection and prevention of foodborne outbreaks along with state departments of agriculture. Agencies license and inspect foodservice and production operations, investigate cases of foodborne illness, conduct surveillance of potential outbreaks, create educational and training materials, and conduct public awareness campaigns related to food safety.

Take-Home Message

Public health agencies at all levels (federal, state, local, tribal, and territorial) play a crucial role in monitoring and mitigating foodborne illness outbreaks, as well as investigating the source of the illness and educating the public about preventive and protective measures. The FPP needs to understand that preventing food- and water-related illness is one of the primary objectives of his or her job and can help educate others on methods and practices that can detect, monitor, prevent, and contain the spread of such diseases.

Activity

Chapter review questions.

1. Contracting *Salmonella* from eating a contaminated food item is an example of:
   (a) Direct transmission.
   (b) Indirect transmission.
2. When comparing surveillance systems, match the following characteristics to the correct surveillance system—complaint-based or pathogen-specific.
   (a) Usually initiated by a citizen phone call to a state or local health agency.
   (b) Usually initiated by a laboratory notification to a state or local health agency.

(c) Is usually based on an individual or group of individuals experiencing gastrointestinal illness who have not sought medical care.
(d) Is based upon a clinical sample collected by a healthcare worker.
(e) The pathogen causing illness has been identified by a laboratory.
(f) The cause of illness has not yet been determined.
(g) Can lead to DNA fingerprint analysis.
(h) Allows for a faster response to a potential outbreak.

3. Why might a local health agency *not* investigate a case of foodborne illness?
4. What major risk factors contribute to foodborne illness, according to FDA research conducted at foodservice and retail food establishments?

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Answer Key

1. B—Indirect, because food is the intermediate vehicle
2. Complaint-based surveillance—a, c, f, h
   Pathogen-specific surveillance—b, d, e, g
3. There are many potential reasons. Examples include:
   (a) The case is found to be sporadic (not part of an outbreak).
   (b) The illness is not severe.
   (c) There is minimal risk that transmission is ongoing.
   (d) The illness is not affecting a vulnerable segment of the population (such as the young, elderly, and/or immunocompromised).

(e) The health department is lacking resources to pursue the individual cases of foodborne illness (focusing on outbreaks).
(f) There is nothing unusual about the pathogen, the illness, or the mode of transmission.

4. Major risk factors contributing to foodborne illness include:

(a) Employee health and hygiene.
(b) Inadequate cooking/holding temperatures.
(c) Contaminated equipment.