Food Safety: An International Public Health Issue

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Abstract

Foodborne disease caused by microbial pathogens remains a significant international public health problem in the 21st century. Worldwide there are thousands of millions of cases of foodborne illnesses annually. In developed nations, experts estimate that a third of the population has a foodborne illness event yearly accounting for about 20 million deaths. Although a natural fit in the health curriculum, traditionally, health education curricula, textbooks, and journals have given scant attention to the prevention of foodborne illness even though they often address prevention of other infectious diseases, such as common infections (e.g., colds and influenza) and sexually transmitted diseases. Thus, the purpose of this article is to review the most common infectious foodborne illnesses, describe disease prevention measures, and identify pertinent food safety educational materials.

Key Words: Food Safety, Foodborne Illness, Infectious Disease

Introduction

Foodborne disease caused by microbial pathogens remains a significant international public health problem in the 21st century, so much so that governments spanning the globe are intensifying their efforts to improve food safety (World Health Organization [WHO], 2000a). For example, in the U.S., one of the priorities in the *Healthy People 2010* initiative focuses on food safety (U.S. Department of Health and Human Services [USDHHS], 2001). In addition, a new guideline, 'keeping food safe to eat', was added to the 2000 edition of the *Dietary Guidelines for Americans* (U.S. Department of Agriculture [USDA] & USDHHS, 2000). The WHO recently announced a plan to expand its food safety program globally, regionally, and nationally (WHO, 2000b).

Headline news stories focusing on widespread outbreaks of foodborne illness on virtually every continent are vivid reminders that the food that nourishes and sustains us also can be debilitating, and in some cases, deadly (Brundtland, undated; Knabel, 1995). In fact, "food is the major source of exposure to pathogenic agents…from which no one in either developing or developed countries is spared" (WHO, undated-a, p.1). Although the incidence of foodborne illness is difficult to determine, the WHO estimates that worldwide there are thousands of millions cases of foodborne illnesses annually and over two million children die from these diseases each year (WHO, 1999; WHO, 2001). In developed nations, the WHO estimates that a third of the population has a foodborne illness event yearly accounting for about 20 million deaths (WHO, 2001). Recently, the Centers for Disease Control and Prevention estimated that 5,000 deaths and 325,000 hospitalizations each year in the United States are food-related (Mead, Slutsker, Dietz, et al, 1999). In the U.S., hospital costs for treating victims of foodborne illnesses likely top $3 billion and lost productivity costs amount to as much as $9 billion (Council for Agricultural Science and Technology Task Force [CASTTF], 1994). In England and Wales, the estimated medical costs and value of lives lost from just 5 foodborne illnesses are £300 to 700 million annually (WHO, 1999). None of the cost estimates include the total societal burden of chronic, long-term consequences of some foodborne illnesses (CASTTF, 1994). These estimates also do not account for the vast majority of foodborne disease cases caused by mishandling of food at home that go unreported (Mead, et al, 1999; CASTTF, 1994; Cliver, 1990; Shallow, Daily, Rothrock, et al, 1998) because consumers believe they have the 'flu' (American Dietetic Association [ADA], 1997). In addition, the costs do not reflect the devastating impact foodborne illness can have on a country's economy. For instance, the 1991 cholera epidemic in Peru resulted in the loss of $700 million in fish exports (WHO, 1999). FoodNet, a new active surveillance program, is helping to more accurately gather information about foodborne illness incidence and the actual burden of foodborne pathogens (Centers for Disease Control and Prevention [CDC], 2001a).

The importance of foodborne illness as a current public health concern is underscored by the increasing numbers of 'at risk' or highly susceptible populations (ADA, 1997; Neill, 2001). The number of people in the U.S. considered at increased risk for foodborne illness is now estimated to equal one-fourth of the population (USDHHS, 2001). In developing countries, the percent of the population at increased risk for foodborne illness may be even higher due to effects of malnutrition such as reduced immune system function. Those considered 'at risk' include persons with weakened immune systems due to disease (e.g., HIV/AIDS) or pharmaceutical or radiological treatments; pregnant women and their fetuses; lactating mothers; infants and young children; preschool children in day care; and elderly persons (ADA, 1997). Others who may be at a disproportionately greater risk include those living in institutional settings and financially disadvantaged individuals such as those who are homeless, migrants, displaced, or refugees (Food and Drug Administration

[FDA], USDA, United States Environmental Protection Agency [USEPA], & CDC, 1997). Many consumers are unaware that some people are at higher risk of foodborne disease than others are—and if they are aware of risk groups, they often fail to recognize when they belong to a risk group (Neill, 2001; Food Safety and Inspection Service [FSIS], 1998a; Woodburn & Raab, 1997).

The discovery of pathogenic microbes not previously known to cause foodborne illness (e.g., Norwalk virus, *Campylobacter jejuni, Escherichia Coli* 0157:H7) along with the emergence of antibiotic resistant strains of foodborne pathogens further highlights the importance of this public health concern (USDHHS, 2001; Knabel, 1995; USEPA, USDA, Center for Food Safety and Applied Nutrition, FDA, et al, 1999; WHO, 2000b). Today, we are aware of over 5 times more foodborne pathogens than we were just 50 years ago (USDHHS, 2001). These pathogenic microbes have made cooking and eating practices that were once consider safe, like eating rare ground beef or raw eggs, particularly dangerous because it's difficult to convince consumers that it's no longer safe to continue a behavior when they feel they have 'always done it and never gotten sick'. Medically treated cases of foodborne illnesses caused by new pathogens are frequently underreported and nearly half of all recorded foodborne illnesses are of unknown cause (ADA, 1997).

Technological and societal changes over the last quarter century also have contributed to the opportunities for foodborne disease caused by mishandling of food and cross-contamination (ADA, 1997). Food today is more extensively processed, is handled at more steps between farm and table, and is stored and transported for longer periods than in the past, and these extra steps create opportunities for microbial contamination. In industrialized countries eating occasions have proliferated. Considering that each person in the U.S. eats, on average, at least four times daily, there could be a billion opportunities each day for someone to transmit and/or contract a foodborne disease (Coulston, 1999). The foods we eat and where we eat them have changed, too. Expanding urban migration and increased dependence on stored foods coupled with insufficient access to safe water and sanitary food preparation facilities present important food safety obstacles in many developing nations. The convenience-driven lives of many Westernized countries, which compels many to stash food unrefrigerated in the car, sports-bag, or desk drawer to be eaten on the run later presents other food safety hazards (Coulston, 1999).

Both the U.S. and U.K. educational systems once taught food safety in family and consumer sciences (home economics) classes in virtually every secondary school. Changes over the past decade have resulted in a reduction or even elimination of such courses (Beard, 1991; Kastner, 1995; FDA & USDA, 1998; Griffith, Mullan, & Price, 1995). Increasing numbers of working mothers and growing reliance on frozen meals, restaurant dining, and take-out foods have decreased opportunities for many children to learn safe food handling via observation. As a result, a large proportion of individuals have limited food preparation experience, have never learned basic principles of food safety, and, thus, lack the critical knowledge needed to help them proactively protect themselves and their families (Knabel, 1995; Williamson, Gravani, & Lawless, 1992; Beard, 1991; Partnership for Food Safety Education, 1998; USDA & FDA, 1991). Indeed, the National Academy of Sciences' report *Ensuring Safe Food: From Production to Consumption* (Committee to Ensure Safe Food From Production to Consumption, Institute of Medicine, National Research Council, 1998) identified major areas where the current U.S. food safety system falls short—one of these areas is limited consumer knowledge. Additionally, one of the seven food safety goals of the *Healthy People 2010* is to increase the proportion of consumers who follow key food safety practices (USDHHS, 2001). The WHO also has cited food safety education as a key health improving strategy for the entire world (WHO, undated-a).

Gro Harlem Brundtland, WHO Director-General stated that "more needs to be done globally to reverse the upward curve which represents escalating sickness and death from consumption of unsafe food" (WHO, 2000b). To help curtail the high rate and exorbitant cost of foodborne disease, both WHO and U.S. government agencies (i.e., USDA, FDA) have called for the integration of food safety concepts into health education programs for consumers and school age children (FDA & USDA, 1998; WHO, 2000c). Education is one of the most critical interventions in the prevention of foodborne illness (WHO, 2000a).

Although a natural fit in the health curriculum, traditionally, health education curricula, textbooks, and journals have given scant attention to the prevention of foodborne illness even though they often address prevention of other infectious diseases, such as common infections (e.g., colds and influenza) and sexually transmitted diseases (FDA & USDA, 1998; Griffith, 1995). Thus, the purpose of this article is to review the most common infectious foodborne illnesses, describe disease prevention measures, and identify pertinent food safety educational materials.

Major Foodborne Pathogens

A wide variety of agents are capable of causing infectious foodborne illness in humans including bacteria, viruses, molds, parasites, and infectious protein-containing particles that may be prions. Noninfectious causes of foodborne illnesses (e.g., heavy metals [e.g., copper, zinc, tin, cadmium, mercury], poison mushrooms [e.g., amatoxins, phallotoxins], chemicals [e.g., histamine, the causative agent in scombroid fish poisoning], and nonbacterial toxins [e.g., toxins produced by dinoflagellates that

cause paralytic shellfish poisoning and ciguatera] are relatively rare, accounting for less than two percent of all foodborne illnesses in the U.S. (Tauxe, Swerdlow, & Hughes, 2000) and beyond the scope of this article. Table 1 presents a synopsis of key features of each major foodborne pathogen.

Bacterial Foodborne Illnesses

Bacteria are everywhere in nature. They are found in the food we eat, the water we drink, and air we breathe. They live in our intestines, on our skin, in the refrigerator, and on kitchen countertops. Most are harmless, some have beneficial effects, as in the aging of cheeses, but a few are pathogenic and can cause illness. While bacteria are ubiquitous in the environment, most of the pathogenic bacteria that cause foodborne illness originate in an infected human or animal and reach food by one of three fairly well-defined routes.

- **Contamination by feces**
  Many foodborne illness bacteria are excreted abundantly in the feces of infected humans or animals. In countries with inadequate sanitation, the water used for drinking, cooking, washing produce and dishes, and fishing is frequently contaminated with sewage and is a major source of illness. Similarly, farmers in these countries may use untreated sewage or animal feces as fertilizer, thus contaminating crops in the field. In the U.S. and other industrialized countries, fecal contamination usually occurs when food is handled by a person who has come in contact with feces or sewage (as in using the bathroom or changing diapers) and has not thoroughly washed his or her hands. Just one gram of fecal matter from an infected person may contain a trillion bacteria (Cliver, 1997)—an infectious dose for *Salmonella* or *Vibrio Cholerae*. But, as few as 10 to 100 Shigella bacteria can produce infection (Butterton & Calderwood, 1998). Insects, such as houseflies, also may carry bacteria from sewage to food. Foodborne illnesses that are acquired from fecal matter in one of these ways are sometimes said to be transmitted by the fecal-oral route.
- **Contamination by an infected individual**
  Some pathogenic bacteria can be transferred to food directly by an infected individual. For example, a food handler who has an open wound or who coughs or sneezes onto food may contaminate the food. Pets also may be a source of foodborne pathogens that can contaminate food via the unwashed hands of food preparers.
- **Cross-contamination**
  Cross-contamination occurs when bacteria present in one food are transferred to another food. This may occur when an uncontaminated food touches a contaminated food or any object, such as a plate, knife, or cutting board, which came in contact with contaminated food. For instance, let's say a person sliced raw chicken contaminated with pathogenic bacteria and then sliced lettuce that was not contaminated. After slicing the chicken, the cutting board, knife, and his or her hands also were contaminated with bacteria that will spread to the lettuce if these items are not thoroughly washed before slicing the lettuce. While the bacteria on the chicken will be killed when it is cooked, the lettuce doesn't get cooked and the bacteria can grow if the lettuce is held at a suitable temperature. All bacteria can be transferred to food via cross-contamination.

How bacteria cause foodborne illness. There are two ways in which pathogenic bacteria can cause disease. Some bacterial cells, such as *C. jejuni, Salmonella, Listeria monocytogenes,* and *E. coli*, injure the body directly by causing a foodborne infection. Others damage the body with a toxin that they produce and release. *Staphylococcus aureus, Clostridium perfringens, Clostridium botulinum,* and other toxin-producing bacteria cause foodborne intoxications. Unlike foodborne infections, live bacteria need not be present in food for a foodborne intoxication to occur. Toxin-producing bacteria need only to have, at some point, infused the food with their toxin.

Campylobacter jejuni. *C. jejuni* is a problem worldwide (WHO, 2000a). It is recognized as a major public health problem in northern European countries, North America, New Zealand, and Australia (Sharp & Reilly, 1994). In the U.S. and U.K., it is the most common cause of bacterial diarrhea with millions suffering infections yearly (Phillips, 1995; Foster, 1992). Raw or undercooked protein rich foods of animal origin, particularly poultry and raw milk, are the main vehicles that carry this pathogen into the human body (Wood, MacDonald, & Osterholm, 1992). Meat becomes infected with *C. jejuni* mainly when processing procedures or equipment rupture an animal's intestinal tract and cause fecal matter to contaminate the raw flesh. In the U.S., food safety laws require that animal flesh contaminated with fecal matter be trimmed away and discarded and/or cleansed, depending on the type of animal (FSIS, 1998b). Raw milk can become contaminated with *C. jejuni* either from feces that accidentally get into the milk or infected cow udders (Wood, et al, 1992). *C. jejuni* also can be spread to other foods by other routes of fecal contamination and cross-contamination. Temperatures below 32ºF (0ºC) or above 165ºF (74ºC) destroy *C. jejuni*. Thus, infection can be prevented by thoroughly cooking or freezing raw protein-rich foods of animal origin, and pasteurizing milk.

Salmonella. *Salmonella* has been recognized as a pathogen for humans and animals for more than a century. In the last decade, many countries throughout the world experienced an upsurge in the number of *Salmonella* infections (Sharp & Reilly, 1994). Although nontyphoidal *Salmonella* is a major problem in industrialized countries (WHO, 2000a), *Salmonella*

Table 1. Important Food-Borne Illness Causing Microorganisms

Pathogenic Microorganisms, Disease It Causes	Common Source of Transmission	Prevention Measures	Typical Symptoms	Usual Time of Onset/Usual Duration
BACTERIA				
Campylobacter jejuni, Campylobacteriosis	undercooked animal flesh, raw milk	freeze, heat to >165° F (74° C), wash produce thoroughly, handle food safely	fever, muscle pain, headaches, stomach cramps, nausea, diarrhea, severe cases may lead to inflammation of the brain or spinal cord, urinary tract infections, and inflamed joints	2-5 days/7-10 days
Salmonella, Salmonellosis	undercooked poultry and eggs, raw milk, and unwashed produce	heat to >180° F (82° C), wash produce thoroughly, handle food safely	severe headache, chills, fever, nausea, sometimes vomiting, abdominal cramps, diarrhea	6-48 hours/1-4 days
Escherichia coli, *E. Coli* Infection	undercooked ground beef, raw milk, unwashed produce, fecal-oral route	heat to >160° F (70°C); wash produce thoroughly	nausea, vomiting, stomachache, gas, severe abdominal cramps, diarrhea, death	4-9 days/4-10 days
Listeria monocytogenes, Listeriosis	raw milk, soft cheese, blue-veined cheeses, processed meats and seafood, unwashed produce	freeze, heat to >140° F (60° C), wash produce thoroughly, avoid soft cheeses	headaches, nausea, vomiting, fever, chills, death, spontaneous abortion in pregnant women	48-72 hours/1-6 weeks
Staphylococcus, Staphylococcal Food Poisoning (toxin producing bacteria; toxin not inactivated by heat)	protein-rich foods of animal origin, infected food handler	handle food safely, cook food thoroughly and refrigerate promptly	headache, severe nausea, violent vomiting, abdominal cramps, diarrhea	30 minutes-8 hours/1-2 days
Clostridium perfringens, Perfringens food poisoning (toxin producing bacteria; endospore forming anaerobe)	protein-rich food kept at danger zone temperatures	handle food safely, cook food thoroughly and refrigerate promptly	severe abdominal cramps, diarrhea	8-12 hours/24 hours
Clostridium botulinum, Botulism (toxin producing bacteria; endospore forming anaerobe; requires prompt medical intervention)	home-canned non-acid foods; non-acid, moderately anaerobic food; honey for infants	discard suspect foods, use correct procedures for canning foods at home, boil home-canned foods 15 minutes before tasting	muscle weakness, paralysis progressing downward from head	4-36 hours/24 hours-many years for complete recovery
Yersinia enterocolitica, Yersinia Infection	undercooked meats, raw milk, contaminated water	cook thoroughly, pasteurize milk	fever, headache, abdominal pain, bloody diarrhea	24-36 hours/2 weeks or longer
Vibrio cholerae, Cholera	fecal-oral route	handle food safely, improve sewage treatment methods	diarrhea, vomiting	1-3 days/3-6 days with fluid and electrolyte treatment
Shigella, Shigellosis	fecal-oral route	handle food safely, improve sewage treatment methods	fever, anorexia, nausea or vomiting, bloating, gripping abdominal cramps, diarrhea	1-7 days/up to 6 weeks
VIRUSES				
Hepatitis A, Hepatitis A Viral Infection	undercooked contaminated shellfish, produce, infected food handler	cook shellfish thoroughly, handle food safely, improve sewage treatment methods	anorexia, fatigue, sweats, chills, nausea, vomiting, dark urine, jaundice, liver damage	average is 28 days/2-3 weeks
Rotaviruses	contaminated food and water	handle food safely	vomiting, watery diarrhea, low grade fever	1-2 days/4-8 days
Norwalk viruses	contaminated food and water	handle food safely, cook food thoroughly, improve sewage treatment methods	nausea, vomiting, diarrhea, abdominal pain	1-2 days/1-3 days
MYCOTOXINS	handle foods safely, wrap foods, discard molded foods, eat foods soon after purchasing, carve away at least an inch around moldy areas of firm foods	varies with mycotoxin	varies with mycotoxin	varies with mycotoxin
PARASITES				
Tapeworm, Tapeworm Infection (helminth, cysts cause infection)	undercooked beef, fish, and pork	cook thoroughly	fatigue, weight loss, cramps, diarrhea	few days to months/in serious cases, until medical treatment
Trichinella spiralis, Trichinosis (helminth, larvae cause infection)	undercooked pork and wild game	cook thoroughly	thirst, fever, chills, edema, nausea, vomiting, diarrhea, swollen, sore muscles, difficulty talking, swallowing, and breathing	few days to weeks/in serious cases, until medical treatment
Anisakids, Anisakiasis (helminth, larvae cause infection)	raw fish dishes	freeze for 72 hours or more, cook to 140° F (60° C)	none to severe stomach pain, nausea, vomiting	within 12 hours/in serious cases, until medical treatment
Toxoplasma gondii, Toxoplasmosis (protozoa)	undercooked meat, unwashed produce	handle food safely, cook thoroughly, wash produce thoroughly, wash hands after cleaning a cat's litter box	fetus: jaundice, enlarged liver, rashes, brain damage, blindness, death; susceptible individuals: fatigue, muscle pain, fever, chills, rashes, anemia, hypotension, liver malfunction, diarrhea, headaches	few days/days to weeks
Giardia lamblia, Giardiasis (protozoa)	contaminated water, infected food handler, raw foods	handle food safely, cook thoroughly	nausea, fatigue, weight loss, bloating, gas, abdominal cramps, diarrhea (sometimes constipation) lactose intolerance	7-14 days/2weeks
Cryptosporidium parvum, Cryptosporidiosis (protozoa)	infected handler, contaminated water	handle food safely, cook thoroughly	nausea, fever, abdominal cramping, explosive watery diarrhea	4-14 days/5-11 days
Infectious protein-containing particles	infected ruminants and compounds from ruminants	do not eat or use infected meat or compounds	Loss of muscular coordination, paralysis, dementia, muscle wasting, death	5-10 years/average is 13 months between onset and death

Typhi (the bacterium that causes typhoid fever) is uncommon (Neill, 2001). *Salmonella* infection is often traced to raw or undercooked poultry and eggs, raw milk, and produce, particularly melons that came in contact with contaminated soil or water (Foster, 1992; Anonymous, 1993; UDSHHS Public Health Service, 1988; Wood, et al, 1992; CDC, 1993). *Salmonella* bacteria, like *C. jejuni*, are commonly found in animal

fecal matter and can be spread to animal flesh during processing as well as to raw milk. A strain of *Salmonella* appearing in chickens can infect the hen's internal organs and be present in the yolk when the egg is laid (Foster, 1992; Williams, 1991). *Salmonella* can grow rapidly on the surface of produce and when a knife cuts through the skin or rind, it can transfer some of the bacteria from the outside to the part we eat (Anonymous, 1993; Golden, Rhodehamel, & Kautter, 1993). *Salmonella* also spreads via other routes of fecal contamination and cross-contamination.

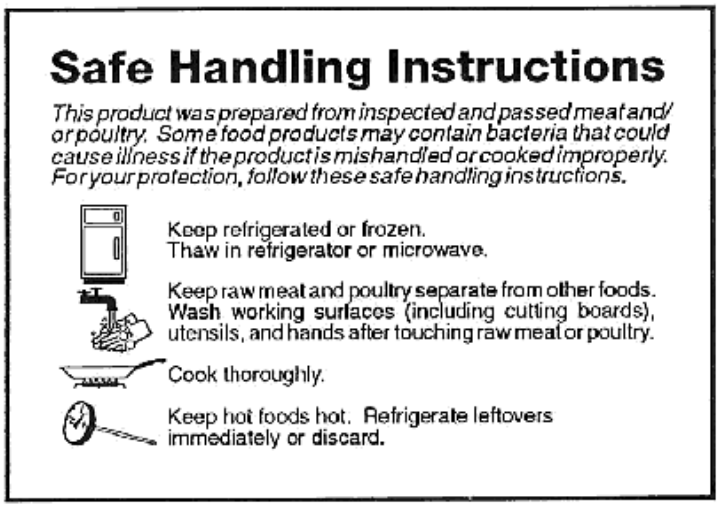
All of the over 2200 types of *Salmonella* bacteria can be killed by thoroughly cooking animal flesh and eggs and pasteurizing milk. The risk of infection from raw produce can be minimized by sanitary food handling procedures including thoroughly washing produce before preparing or eating it. Once produce is sliced, it should be eaten immediately or refrigerated (Anonymous, 1993). In just four hours, bacteria on a sliced melon left at room temperature can multiply to dangerous levels.

Escherichia coli. Although most types of *E. coli* bacteria are harmless inhabitants of the human intestinal tract, some types are major causes of diarrhea worldwide (Neill, 2001) and at least six types are known to cause serious illness. Fortunately, the rate of serious *E. coli* infections is relatively low (WHO, 2000a). However, in 1993, one of the dangerous types, *E. coli* 0157:H7 caused one of the most serious outbreaks of foodborne illness in the U.S. This bacterium infected more than 500 people and killed four children in western states, most of whom had eaten undercooked hamburgers at local fast food restaurants. It was this outbreak that led to the food safety handling instructions labels now required on fresh meats (see Figure 1). This bacterium causes illness by attaching itself to the intestinal wall and then producing a toxin. In severe cases, the intestinal wall becomes so damaged that the toxin can leak into the person's bloodstream, spread to vital organs and damage them so severely that death results.

Undercooked meat is the most frequent cause of this infection. Raw milk, unwashed produce, and unpasteurized, unpreserved apple cider are other common culprits (Wood, et al, 1992; Besser, Lett, Weber, et al, 1993). *E. coli* 0157:H7 is found in the intestinal tracts of cattle and is harmless to the animals. Like *C. jejuni* and *Salmonella*, it contaminates meat if, during slaughter, fecal matter spills onto the carcass. *E. coli* 0157:H7 can be transmitted to other foods by other sources of fecal contamination as well as by cross-contamination (Besser, et al, 1993; Foulke, 1994).

E. coli 0157:H7 can survive freezer temperatures and can multiply slowly at temperatures as low as 44ºF (7ºC). Thoroughly cooking meat to 160ºF (70ºC) and pasteurization are the best safeguards against infection (Foulke, 1994). Illness can be minimized by thoroughly washing fresh produce prior to preparing or eating it.

Figure 1: This label is placed on fresh meat and poultry packages (FSIS, 2001b).



Listeria monocytogenes. *L. monocytogenes* occurs widely in nature. Since the early 1900s, scientists have known that this pathogen causes infection in animals and humans. But, it wasn't until around 1980 that scientists realized that this bacterium could be conveyed by food. In fact, one of the most tragic foodborne infection outbreaks in the U.S. confirmed that food is an important source of *L. monocytogenes* infection. In 1985, contaminated soft cheese was linked with 142 cases of listeriosis (the disease caused by *L. monocytogenes*) that resulted in 47 fatalities, including 29 infants infected during fetal life. In actuality, this organism rarely causes disease in healthy persons. However, it can be devastating for vulnerable individuals--notably those with underdeveloped immune systems (e.g., fetuses, neonates), and persons with weakened immune systems. About one-fourth of the 1600 or so Americans who develop listeriosis each year die from it (Skinner, 1988).

L. monocytogenes is mostly associated with raw milk, but in most developed countries, milk is rarely the cause of listeriosis because pasteurization kills this microorganism. However, a few soft cheeses such as Brie, Camembert, and Mexican-style cheeses (e.g., Queso Blanco and Queso Fresco) are made with milk that is not pasteurized. Although soft cheeses are the primary cause of listeriosis, infections also have resulted from blue-veined cheeses, unwashed produce, and processed meats and seafood (e.g. luncheon meats, shrimp salad). *L. monocytogenes* also can be spread by the fecal-oral route and cross-contamination.

L. monocytogenes is described as being a 'tough bug' or 'macho microbe' because it is able to survive typical cooking temperatures and the effects of food processing much better than many microorganisms. It can even continue multiplying at refrigerator temperatures. However, temperatures of 0ºF (-18ºC)

will stop it from multiplying and temperatures above 140ºF (60ºC) will kill it (Skinner, 1988). Because foods associated with *L. monocytogenes* are not always heated before serving and because this bacterium can thrive under conditions where other bacteria have a hard time surviving, the best defense against this organism is to avoid contamination in the first place. To accomplish this in the U.S., the FDA, dairy food producers, and seafood distributors have stepped up efforts to identify potential food safety problems, recall contaminated products, and eliminate sources of contamination. The low percentage of products found to be contaminated indicates that these efforts are paying off (Skinner, 1988). An additional precautionary measure for individuals vulnerable to listeriosis is to avoid foods and food preparation techniques associated with listeriosis.

Staphylococcus aureus. *S. aureus*, also known as 'staph', is the most common type of bacterium that causes foodborne intoxication. As many as two in five cases of foodborne illness are caused by *S. aureus* toxin. The usual source of *S. aureus* contamination is a food handler who harbors the bacterium. *S. aureus* live in many people's respiratory tracts and can be transmitted to food by sneezing or coughing. These bacteria also can enter food from open cuts, sores, and pimples. It is not surprising, then, that the most 'risky' foods for staph intoxication include those that are extensively handled, such as sliced meats and salads made with chopped ingredients (e.g., potato salad or egg salad). Like most bacteria, *S. aureus* grow readily in protein-rich, moist foods of animal origin.

Cooking will kill the bacteria, but unlike most bacterial toxins heat will not destroy the staph toxin. So, the only way to prevent staph intoxication is to prevent contamination by using safe food-handling procedures and prevent the growth of the bacteria. Bacterial growth can be prevented by thoroughly cooking food and then refrigerating it immediately.

Clostridium perfringens. *C. perfringens* is known as the 'café germ' or 'banquet germ' because the source of most outbreaks is food served in restaurants or events such as picnics or banquets. The culprit food is typically a protein-rich dish in a deep pan, such as a casserole, gravy, or stew, which is made well ahead of serving, kept at temperatures in the danger zone (40 to 140° F or 5 to 60° C), and not thoroughly reheated before serving. *C. perfringens* thrives under these conditions because it is endospore-forming and requires at least moderately anaerobic (oxygen-free) conditions for growth. The endospores survive the initial cooking of the food, and as the temperature drops into the danger zone they germinate and grow in the food's anaerobic center. (Endospores are a dormant form certain bacteria can take that can survive stresses that would kill active bacterial cells, such as dryness and heat. When conditions favor growth, the spores become active [germinate] and bacteria multiply.)

Intoxication thus can be prevented by refrigerating foods immediately after cooking. If necessary, the food can be divided into shallow pans so that it chills rapidly. The toxin produced by *C. perfringens* can be inactivated by heat (unlike staph toxin), so thoroughly reheating a food before serving will prevent intoxication. *C. perfringens* is ubiquitous, occurring naturally in soil, water, dust, and sewage--it can contaminate food when any of these come in contact with food. It also can be spread by cross-contamination from one food to another.

Clostridium botulinum. The toxin produced by *C. botulinum*, called botulin, is the single most deadly poison known. An amount equal in size to a grain of salt can kill several people in less than an hour. Ten pounds could kill everyone on earth. It is fortunate that this type of foodborne intoxication, known as botulism, is rare because two out of three cases result in death.

Like its relative *C. perfringens, C. botulinum* is an endospore-forming anaerobe that is ubiquitously present in soil and probably contaminates virtually all foods. This bacterium is fairly sensitive to acid conditions and generally will not grow in acid food, but it can germinate, grow, and produce its deadly toxin in any non-acid, moderately anaerobic food. That is why the classic source of botulin is canned or bottled non-acid foods, such as mushrooms, corn, peas, and meats that have been incorrectly processed. Correct processing of such foods involves heating them to a temperature that will destroy the *C. botulinum* endospores as well as the bacteria and toxin. Virtually all commercially canned and bottled foods have been correctly processed and are safe. Home-canned non-acid foods may be risky. A few cases of botulism have been associated with the kinds of foods that typically cause *C. perfringens* outbreaks -- that is, foods with anaerobic centers such as macaroni salad, casseroles, and stew. Smoked fish have been a culprit, too.

It is important to know that honey poses a botulism risk to infants, although not to adults. Honey contains *C. botulinum* endospores, and these spores can germinate and multiply in the gastrointestinal tracts of infants less than one year old. Infants should never be fed honey (Mirkin, 1991).

The botulin toxin injures the body by irreversibly attaching itself to nerve endings and blocking nerve impulses thereby causing muscle weakness and paralysis. Botulin tends to start with the cranial nerves and then work its way symmetrically down the body. When the cranial nerves are affected the eyelids droop, the individual has difficulty swallowing, chewing, and talking, and experiences dizziness and double vision---victims often are mistakenly thought to be inebriated. As the toxin moves downward, the arms and legs become paralyzed. Once the toxin attaches itself to the nerves that control the muscles in the chest and diaphragm, respiration is inhibited and the victim dies of asphyxiation.

Victims are treated with an antitoxin that destroys the botulin toxin that has not yet attached itself to nerve endings. Unfortunately, the antitoxin has no effect on the toxin that is already attached to nerve endings. So, the key to recovery is a quick diagnosis and immediate administration of antitoxin. The longer it takes to administer the antitoxin, the more nerve endings will be damaged by the toxin and the greater the recovery time will be. Respiratory support is essential if the nerves that control the muscles in the chest and diaphragm have been affected by the toxin. Generally, recovery is a slow process because damaged nerves take months or even years to fully regenerate (Segal, 1992).

The biggest problem with getting a quick diagnosis is that botulism is so rare that many physicians have never seen a case. By the time the correct diagnosis is made and the antitoxin is administered, significant nerve damage, or even death, may have occurred. Thus, prevention is the only good way to deal with this disease. Botulism can be prevented by checking food cans and jars closely and discarding any that leak, bulge, have holes, are rusted, or contain food that looks or smells odd or spurts out when the container is opened. If food is suspected of containing the botulin, don't take any chances--discard the food so that no person or animal can eat it. Tasting just one corn kernel contaminated with botulin can be fatal. Also, avoid smelling or touching the food because the toxin also can enter the body through the lungs or a cut in the skin. When serving low-acid home canned foods (e.g., meats and most vegetables), many food scientists recommend that these foods be boiled for 15 minutes before they are tasted because heat will destroy any *C. botulinum* and botulin toxin they might contain.

Yersinia enterocolitica. *Y. enterocolitica* is a relatively rare cause of foodborne infection, but the resulting disease can be severe and linger for a year or longer. Victims may experience abdominal pain so severe that it mimics appendicitis. In fact, this bacterium has caused several individuals to undergo unnecessary appendectomies. The foods most frequently implicated as the source of *Y. enterocolitica* are undercooked meats, raw milk, and foods prepared with contaminated water (Doyle, 1991). This bacterium multiplies slowly at refrigerator temperatures, but thorough cooking and pasteurization destroy it and prevent infection.

Vibrio. *Vibrio cholerae* causes the deadly foodborne infection cholera, a disease characterized by relentless diarrhea and often by vomiting. Cholera, a major public health problem in developing countries (WHO, 2000a), is spread by the feces of infected individuals. Raw shellfish are the primary food source of this illness. With medical treatment, victims recover in a few days, however without treatment, more than 60 percent die. Death results from dehydration caused by diarrhea, which leads to circulatory collapse. Safe food-handling procedures and improved sewage treatment methods can prevent cholera. Cholera currently causes epidemics only in countries where sanitation is poor. A cholera epidemic raged throughout South America in the early 1990s infecting more than a million people and killing over 5,000 (Community Nutrition Institute [CNI], 1993a)

Two other *Vibrio* species that cause foodborne disease are associated mainly with inadequately cooked shellfish, particularly oysters and shrimp. *Vibrio vulnificus* is found in warm seawaters and causes only about 100 illnesses in the U.S. each year, but 40 to 65 percent of the victims die (CNI, 1993b). *Vibrio parahaemolyticus* is the main cause of foodborne illness in Japan; very few cases have been identified in the U.S. (Tauxe, et al, 2000).

Shigella. *Shigella* shares many similarities with *V. cholerae*. That is, it too is spread by the feces of infected individuals, is most common in areas with inadequate sanitation, and can be prevented by safe food-handling procedures and improved sewage treatment. And like cholera, death from *Shigella* infection results from dehydration caused by diarrhea.

Viral Foodborne Illnesses

Viruses, like bacteria, are widely dispersed in nature and injure the body directly or by making a toxin. Several viruses, such as hepatitis A virus, Norwalk virus, and rotaviruses, are known to cause foodborne infections. These viruses are spread just as bacteria are: by the fecal-oral route, cross-contamination, and infected food handlers. Unlike bacteria, viruses can reproduce only after invading the body's cells. Thus, the key to preventing foodborne viral illnesses is to use sanitary food preparation practices to keep viruses from contaminating food and to cook food thoroughly to kill any that found their way into food.

Hepatitis A. Hepatitis A is a contagious liver infection that can be a very serious, sometimes fatal illness that may be food or waterborne. Hepatitis A attacks the liver causing jaundice, very yellow urine, and liver damage. In industrialized countries, the number of reported cases ranges from about 10 to 50 per 100,000 people each year. It is one of the most commonly reported infectious diseases in the U.S. In developing and Eastern European countries, 50 to 300 cases per 100,000 people are reported annually (WHO, undated-b). Although the overall incidence of this illness is low, it is particularly common among those who live in crowded quarters, lack running water, and have poor sanitation. For instance, researchers reported that individuals living in some poverty stricken areas are so susceptible to hepatitis A infection that more than 80 percent of the adults and a third of the children have suffered from this illness (Shaw, Shapiro, Welty, et al, 1990).

Undercooked shellfish harvested from sewage contaminated waterways and inadequately washed produce are the most common sources of hepatitis A (Rosenblum, Mirkin, Allen, et al, 1990). Consuming contaminated water or ice also can lead to this viral infection (Association of State and Territorial Directors

of Health Promotion and Public Health Education [ASTDHPPE], 2001a). This virus can survive for a long time at room temperature and is not affected by freezing (ASTDHPPE, 2001a). Heat destroys the hepatitis A virus, so this disease can be avoided by cooking foods thoroughly. Safe food-handling procedures will minimize its spread via infected food handlers. Chlorination of water supplies also kills this virus and halts its spread (ASTDHPPHE, 2001a).

A vaccination also is available to prevent hepatitis A. Universal immunization is highly recommended because vaccination could successfully control hepatitis A. However, currently vaccine cost and availability preclude such a recommendation (WHO, Department of Communicable Disease Surveillance and Response, undated). Nonetheless, those at high risk of this disease should get a hepatitis A vaccine. Persons who should get the hepatitis A vaccine include anyone age 2 and over who will be traveling or working in countries with high rates of this disease, particularly Central and South America, the Caribbean, Mexico, Africa, southern or eastern Europe, and Asia (except Japan). Others who should get this vaccine are those living in communities with prolonged outbreaks or high rates of hepatitis A, homosexual men, those who use intravenous street drugs, chronic liver disease patients, and people receiving blood clotting factor concentrates such as hemophilia patients (CDC, 1998).

Rotaviruses. Although anyone at any age is susceptible to rotavirus infection, this infection is particularly common in children. In fact, experts believe that nearly every child on earth will experience a rotavirus infection at least once before they reach age five (CDC, 1999). Each year in the U.S., severe rotavirus infections cause thousands of children between the ages of 3 and 35 months to be hospitalized or need emergency room treatment. Foods are usually contaminated with rotaviruses by infected food handlers and sewage contaminated water. Safe food-handling procedures will minimize its spread via infected food handlers. Although a vaccine is available to help prevent rotavirus infections, it is not recommended for routine use in infants because of a strong association between it and bowl obstruction (CDC, 2001b).

Norwalk Viruses. In the U.S., only the common cold is more frequent than viral gastroenteritis—fully one-third of the cases among those over the age of two are attributed to Norwalk viruses. This virus was first identified after an outbreak of gastrointestinal disease in Norwalk, Ohio in 1972. Since that incident, other similar viruses have been identified and are sometimes termed 'Norwalk-like viruses' (ASTDHPPHE, 2001b). In developing countries, Norwalk viruses are so common that a very high percentage of children develop immunity at an early age. In the U.S., the percentage having immunity rises with age, reaching approximately half the population by age 18 (FDA, 2002). Unfortunately, immunity is not permanent and re-infection can occur. But, generally the illness that results from Norwalk viruses is mild and brief (FDA, 2002). Foods are contaminated with Norwalk viruses via the fecal-oral route and contaminated water. Salads, insufficiently cooked clams and oysters, ice, and water are the most commonly implicated foods. Safe food handling procedures, thorough washing of fresh produce with clean water, thorough cooking of shellfish, and sanitary disposal of sewage helps to prevent this disease (ASTDHPPHE, 2001b).

Foodborne Illnesses Caused by Molds

Molds are a type of fungus that spread from place to place through the air like dandelion seeds. They grow best in humid, dark places where air circulates. When conditions are right, the mold grows by sending root-like 'threads' deep into the food it lives on and forming endospores on the outside of food. These endospores give mold the fuzzy, colorful look you see and are the form in which the mold travels to new locations. The foods most likely to mold in U.S. homes are cheese, breads, and fresh produce.

Thousands of types of molds grow on foods. Most just alter the color, texture, taste, and/or odor of foods, making them unpalatable and inedible. Some destroy crops and shorten storage times. Others cause allergies or respiratory problems. A few fungi produce toxins known as mycotoxins ('myco' is the prefix meaning 'mold') which cause blood diseases, nervous system disorders, and kidney and liver damage. The most important mycotoxins are aflatoxin, ergot, and those produced by the *Fusaria* fungi. Aflatoxin is produced by a mold that attacks peanuts, tree nuts, corn, and oilseeds and is a known carcinogen. Ergot is produced by a dark purple mold that grows on improperly stored grains, especially rye. It is a natural source of lysergic acid diethylamide (LSD) and is a powerful hallucinogen. Ergot poisoning can cause spontaneous abortion and constrict blood flow to the arms and legs so severely that gangrene develops. Several types of *Fusaria* fungi can grow on grains stored for long periods, and produce deadly mycotoxins. Mycotoxins are rarely a problem in most industrial nations because food production practices are designed to minimize mold growth. In addition, food producers and government inspectors closely monitor foods to detect molds and destroy any foods found to contain them. Unfortunately, mycotoxin poisonings are frequent in other parts of the world. For example, in India in 1975 an outbreak of aflatoxin poisoning caused liver damage in many people and killed some. Mycotoxins, from *Fusaria* involving mainly millet and other cereal grains stored for long periods, are a public health problem in the countries that once formed the Soviet Union.

To prevent molds from invading food, keep foods covered to prevent them from becoming home to airborne mold endospores. Another way to prevent the spread of mold is to scrub mold off refrigerator walls and door seals. Also, launder dish cloths and sponges often; a musty smell means they are spreading mold. It also is important to inspect foods carefully for signs of

mold growth when grocery shopping and just before preparing them. Yet another prevention method is to eat foods as soon after purchasing as possible--the longer they are stored, the more likely they are to mold (Parmley, 1993).

Despite all precautions, mold still invades many foods. Food covered with mold should be wrapped and thrown away so that no person or animal can eat it. Avoid sniffing the food because mold spores can enter the lungs and cause respiratory difficulties. Next, clean the area where the moldy food was sitting and check nearby foods for mold (mold spreads fast, especially in fruits and vegetables). If a piece of food has only a small spot of mold and is of a firm type (e.g., hard cheeses, carrots, cabbage, potatoes) part of the food may be salvaged by carving away at least an inch around and below the moldy area. Foods that are soft or liquid (e.g., lettuce, tomatoes, jam, cottage cheese, syrup, juice) should be discarded even if they only have a trace of mold. Don't try to salvage moldy bread, baked goods, flour, grains, legumes, nuts, and peanut butter; they may contain harmful toxins.

Figure 2: The WHO Golden Rules for Safe Food Preparation (WHO, undated-c)
1. Choose foods processed for safety (e.g., pasteurized milk, thoroughly washed produce).
2. Cook food thoroughly.
3. Eat cooked foods immediately.
4. Store cooked foods carefully.
5. Reheat cooked foods thoroughly.
6. Avoid contact between raw foods and cooked foods.
7. Wash hands repeatedly.
8. Keep all kitchen surfaces meticulously clean.
9. Protect foods from insects, rodents, and other animals.
10. Use safe water.

Parasitic Foodborne Illnesses

Parasites live in or on another organism, known as the host, from which they absorb nutrients. Humans may serve as the host to parasites. These tiny ravagers rob millions of people around the globe of their health and, in some cases, their lives (Segal, 1993). Those hardest hit live in tropical countries where poor sanitation fosters the growth of parasites. However, epidemiologists report that parasitic infections seem to be on the increase in the U.S. and other industrialized countries. Parasitic infections may be transmitted in many ways, including contaminated foods.

The more than 80 foodborne parasites known to affect humans include mainly two types: helminths (worms) and protozoa (one-celled animals). The most common foodborne helminths in the U.S. are tapeworms, *Trichinella spiralis*, and anisakids.

Tapeworms. These long, flat worms have heads equipped with suckers and hooks that lock the worms onto the host's intestinal tract. Tapeworm cysts or 'eggs' are found in raw and undercooked beef, fish, and pork. Within a few days of being eaten, the tapeworm cysts germinate and the worms begin growing. Most who have tapeworms don't realize it until they excrete tapeworm segments or a living tapeworm in their feces (Zamula, 1987). In cases where the tapeworms grow excessively long (i.e., several yards), they may cause intestinal blockage and steal enough nutrients from their host to cause nutrient deficiencies. Tapeworms are easy to avoid because thorough cooking kills the cysts. A cyst is a structure formed by certain microorganisms that encases them, puts them in a dormant state, and enables them to survive harsh environmental conditions.

***Trichinella spiralis*.** This parasite infects some pigs and wild game. Humans may develop the disease trichinosis if they eat undercooked pork or game meat containing the larvae of this parasitic roundworm. Ingested larvae mature and reproduce in the human intestinal tract, and then they die and leave the body in the feces. Their larvae, however, are left behind. The larvae may bore through the intestinal tract and travel via the blood or lymph vessels to muscles where they embed themselves, mature, and live. The severity of trichinosis symptoms depends on the number of larvae consumed. People who eat a few larvae usually don't know it, but if they eat a large amount, they will often experience intestinal upset, sore muscles, and difficulty talking, swallowing and breathing. The problem with trichinosis is that once symptoms develop, a great deal of damage has already been done to the muscles. Fortunately, there are less than 100 cases of trichinosis in the U.S. yearly mainly because most people know that pork must be cooked thoroughly and because legislation now requires that any garbage fed to pigs must be cooked, which kills any larvae (Segal, 1993).

Trichinosis may be on the down swing in the U.S., but fish-borne parasitic illnesses, such as anisakiasis, are on rise. This increase corresponds to the growing popularity of raw fish dishes, like sushi, sashimi, ceviche, and gravlax. Anisakiasis is caused by the larvae of anisakids worms boring into the stomach or intestinal lining. Usually these roundworms die or do not stay long because humans are not their usual host. They may be coughed or vomited up. Some infected individuals may pull this spaghetti-shaped worn out of their throats after feel a tickling at the back of their throats (Segal, 1993). In some cases, anisakiasis causes severe stomach pain that persists until the larvae are removed surgically. To help prevent parasite ridden fish from reaching consumers, fish processors thoroughly inspect species that are likely to carry parasites. However, to be completely safe, it is important to thoroughly cook fish or freeze it at 0ºF (-18ºC) for 72 hours or more before preparing it.

Toxoplasma gondii. Another common parasitic disease, toxoplasmosis, is caused by a protozoan parasite known as *Toxoplasma gondii*. When this parasite infects a human or other animal, it enters their tissues where it forms parasite-filled cysts. These cysts typically cause few or no symptoms in healthy adults unless they are numerous or happen to be located in a sensitive place such as the brain. However, toxoplasmosis is very dangerous for immuno-suppressed individuals and fetuses of pregnant women. *T. gondii* parasites frequently infect cats and then are excreted in cat feces, so litter boxes are a common source of human infection. The infection also can be caused by eating undercooked meat from infected animals or by eating vegetables grown in soil contaminated with infectious feces, typically cat feces. Infection may be avoided by cooking meat thoroughly, washing vegetables well, and washing hands carefully after cleaning a cat's litter box. Pregnant women should be particularly careful to avoid all contact with cat feces and never clean litter boxes.

Giardia lamblia *and* ***Cryptosporidium parvum.*** These two protozoan parasites are becoming all too common in the U.S. *G. lamblia* is frequently spread via the fecal-oral route and is a fairly common problem in day care centers. Water contaminated with *C. parvum* cysts from the fecal matter of mammals and foods prepared with this water have caused several major outbreaks in the U.S. in recent years. When the presence of these and other protozoan parasites is detected in municipal water supplies, households are usually instructed to boil their tap water or use bottled water until the water supply is declared safe. It may take weeks to lower the numbers of these parasites to a level that isn't likely to cause disease because these parasites are so small they may slip past the water filters municipal water companies commonly used. Also, these parasites may be able to withstand chlorine treatments used to sanitize water supplies (Mason, 1993).

Infectious Protein-Containing Particles

Infectious protein-containing particles are associated with cattle suffering from Bovine Spongiform Encephalopathy (BSE, or 'mad cow' disease) and are suspected of causing a foodborne disease called new variant Creutzfeldt-Jakob Disease (nvCJD) in humans. Both BSE and nvCJD are chronic, degenerative neurological disorders for which there is no known cure (USDA, 2001a). The infectious agent is not yet well understood; scientists believe it is a type of protein called a prion, a virus with unusual characteristics, or a type of nucleic acid known as a virino (USDA, 2001a). Cattle contract BSE when given feed containing meat and bone meal from sheep affected by a disease like BSE called scrapie. More than 95 percent of all BSE cases have occurred in the U.K.; no confirmed cases have occurred in the U.S. (USDA, 2001a). Nearly all cases of nvCJD have occurred in the U.K.

Consumption of infected meat is the most likely transmission route to humans (WHO, 2000a; USDA, 2001a). Even when heated to high temperatures, the infectious agent causing nvCJD remains infective. Thus, governments around the world have taken steps to prevent meat and products from infected animals from entering the human food chain (Sharp & Reilly, 1994). For example, in Europe cattle suspected of having BSE have been destroyed and export of materials at risk of being contaminated has been curtailed (CDC, 2002). And, BSE-free countries, such as the U.S., have implemented preventative control measures. Currently, the U.S. prohibits the importation of live cattle and other ruminants, meat from ruminants, as well as dietary supplements and cosmetic ingredients containing compounds derived from cattle that originated in countries identified as having BSE or at risk for BSE (USDA, 2001b). In addition, it has prohibited the inclusion of most mammalian protein in ruminant feeds whether they are produced domestically or imported (USDA, 2001b). In the U.S., the CDC recommends that travels to Europe consider either totally avoiding beef and beef products or choosing beef or beef products that have a reduced risk for being contaminated with BSE, such as solid pieces of meat instead of brains or beef products such as burgers and sausages) (CDC, 2002).

Figure 3: The Fight Bac! Campaign (Partnership for Food Safety Education, 2000).

Keeping Food Safe to Eat

Although government agencies have an official responsibility to ensure the safety of the food supply, every person who handles food, including food producers, processors, shippers, foods store workers, and consumers, also assume some of this responsibility.

Moreover, the government has no authority in one place where many foodborne illnesses start--the home kitchen. Most home kitchens would flunk a sanitation inspection! In one study, 99 percent of the households failed a kitchen inspection test based on guidelines adapted from the National Restaurant Association (Daniels, 1998). Even worse is that participants in this study knew someone would be visiting their home to observe and evaluate their kitchen practices---even with advance preparation, less than one percent met the minimum criteria for acceptable performance. The Centers for Disease Control and Prevention estimate that 85 percent of all foodborne illness could be avoided if people took precautionary steps in their own homes.

To help educators focus their efforts on the most critical food handling behaviors, the WHO developed Golden Rules for Safe Food Preparation (see Figure 2). In the U.S., government and private sector agencies formed the Partnership for Food Safety Education which launched the Fight BAC! campaign in 1997 to teach consumers about safe food handling (see Figure 3). In addition, numerous educational materials are available (see Figure 4). The basic steps consumers can take to protect themselves against pathogens, especially bacterial pathogens, and to otherwise ensure the food they eat at home is safe and contains as few pathogens as possible, are described below.

Practice Good Personal Hygiene. Pathogenic microorganisms found on skin, hair, and clothes can get into food and cause foodborne illness. Here's what consumers can do to avoid contaminating food during preparation.

- Wash their hands with hot, soapy water before handling foods and during food preparation right after coughing, sneezing, going to the bathroom, eating, drinking, touching bare parts of their bodies, or handling raw animal flesh, unwashed produce, or dirty dishes or food preparation equipment.
- Wear clean clothes and tie back long hair.
- Avoid preparing food when sick.
- Cover wounds, burns, sores, and infected areas while preparing food.

Keep the Kitchen Clean. Pathogenic microorganisms thrive in damp, dirty areas of the kitchen like cracks and dark corners. Pests, such as insects and mice, like dirty kitchens, too. They move in when crumbs, food spills, and garbage are left in the kitchen and spread microorganisms as they climb over counters, dishes, and food. Here's how to keep harmful microorganisms and pests under control.

- Wash all work surfaces (e.g., countertops, cutting boards) with soap and water and rinse well before using them and after they come in contact with raw animal flesh, eggs, or unwashed produce to avoid cross-contamination.
- Wash dish towels and sponges often because they teem with bacteria which easily spread to and from the hands and around the kitchen as towels or sponges are used.
- Sweep the floor regularly, wipe up spills as soon as they happen, and keep the garbage can covered. Pests like crumbs, spills, and garbage. And, bacteria grow quickly in spills.

Figure 4: Food Safety Education Information Sources

Numerous sources provide food safety reports and educational materials. Key resources are listed below.

- U.S. Department of Agriculture (USDA) Meat & Poultry Hotline at 800-535-4555.
- The FDA Outreach and Information Center at 888-SAFEFOOD.
- Subscribe to a free quarterly newsletter, The Food Safety Educator, by emailing your name, organization name, and mailing address to fsis.outreach@usda.gov. Or, visit www.fsis.usda.gov/oa/educator/educator.htm
- Subscribe to a free monthly electronic newsletter by sending this email message Subscribe EDNET-L to Listserv@foodsafety.gov .
- Join an online electronic food safety discussion group: www.nal.usda.gov/finc/foodborne.
- Learn about the USDA's Food Safety and Inspection Service (FSIS), which protects consumers by ensuring that meat, poultry, and egg products are safe, wholesome, and accurately labeled: www.fsis.usda.gov.
- Discover how to use thermometers to cook foods safely by visiting: www.fsis.usda.gov/thermy
- Learn about the Fight Bac! Campaign by visiting: www.fightbac.org.
- Link to U.S. and Other Countries' Food Safety websites by visiting: Gateway to Government Food Safety Information: www.foodsafety.gov.
- Learn about the activities of the FDA;s Center for Food Safety and Applied Nutrition: www.cfsan.fda.gov.
- Visit the USDA/FDA Foodborne Illness Education Information Center: www.nal.usda.gov/fnic/foodborne.
- Discover the role of the Centers for Disease Control and Prevention in preventing foodborne illness: www.cdc.gov/foodsafety.

Handle Foods Safely. Careless food handling sets the stage for bacterial growth and cross contamination. Here's how to handle foods safely.

- Wash raw fruits and vegetables thoroughly to remove soil particles and microorganisms. Some

people may want to peel them and throw away outer leaves of cabbage and lettuce.
- Keep raw foods, especially animal flesh and its juices, separated from cooked foods or foods that won't be cooked.
- Keep dirty utensils and dishes separated from clean dishes and food.
- Use a clean spoon each time food is tasted during preparation.
- Handle foods as little as possible; even clean hands carry small amounts of harmful pathogens.
- Take groceries home right after shopping and put frozen and refrigerated foods away immediately. Avoid storing canned and dry foods under a sink or near a range because bacteria and molds thrive in moist, warm places.
- Follow the storage and preparation directions on food packages.
- Use food as soon after purchasing it as possible. Clean out the refrigerator, freezer, and pantry often, discarding spoiled foods or those in torn or damaged containers; microorganisms and pests may have gotten into them.

Keep foods out of the danger zone. Bacteria grow fastest at danger zone temperatures (i.e., 40 to 140ºF or 5 to 60º C). Here's how to curtail bacterial proliferation and foodborne illness.
- Keep refrigerator temperatures between 32 and 40ºF (0-4ºC) and freezer temperatures at 0ºF or (-18ºC) or below. Leave cold foods in the refrigerator or freezer until they are needed. It is not safe to bring animal flesh, eggs, milk, and other protein-rich foods to room temperature before cooking them.
- Thaw frozen foods of animal origin in a microwave oven, in a refrigerator, or under cold running water. Thawing food on the countertop gives bacteria a chance to multiply. Once thawed, refrigerate or cook immediately.
- Thoroughly cook animal flesh. Between 25 and 75 percent of the meat sold is retail outlets may be contaminated with at least one pathogen (Zhao, Ge, DeVillena, et al, 2000), but most microorganisms are killed when meat and fish reach 160ºF (71ºC) and poultry reaches 180ºF the (82ºC). Common visual cues that consumers use to determine doneness may not ensure safety. Thus, a thermometer should be used to be sure they are cooked to safe temperatures. In the U.S., the Food Safety Inspection Service has launched an educational campaign called "Thermy" to encourage consumer to use thermometers (FSIS, 2001a) (see Figure 5).
- Keep cooked foods at 140ºF (60ºC) or higher until they are served. Do not allow them to remain at danger zone temperatures for more than 2 hours. Store leftovers right away. Keep leftovers no more than 3 days and reheat them to at least 165ºF (74ºC) to destroy microorganisms that contaminated the food after it was cooked.
- Pack lunches and picnics in an insulated cooler. Put the cooler in a cool location, out of direct sunlight.
- Avoid recipes in which eggs remain raw or only partly cooked (e.g., eggnog, mousse) or use only pasteurized eggs in these recipes. Eggs are safe to eat when the yolk and white are firm; *Salmonella* bacteria may still survive in eggs cooked 'sunny side up' or soft-scrambled (Brackett & Buchat, 1992).

Avoid foods from unsafe sources. Some foods pose greater food safety hazards than others. For example, fresh sprouts often are contaminated with harmful bacteria and because they are fragile and eaten raw, it is difficult to reduce the amount of bacteria they contain.
- Avoid eating raw sprouts.
- Only drink pasteurized milk and juices.
- Avoid eating raw or undercooked meat, fish, shellfish, poultry, and eggs.
- If at increased risk for foodborne illness, avoid soft cheeses, cold deli salads, and cold smoked fish and heat hot dogs and deli meats to 165ºF (75º C) before consumption.
- When shopping, reject cans that are damaged, jars that aren't tightly closed, and frozen foods that are soft, soggy, or have stained packages. These signs indicate that the food inside the package may be unsafe to eat. Check the dates on foods and never buy outdated foods.

Conclusion

Knowing that the food on the dinner table could make someone sick is a disturbing thought. But, even worse is knowing that the incidence of foodborne illness could be greatly reduced by taking a few simple precautions. Yet, few health education classes address this topic. As we enter the 21st century, it is vital to recognized that all health professionals play critical roles in decreasing the burden of foodborne illness (Tauxe, et al, 2000).

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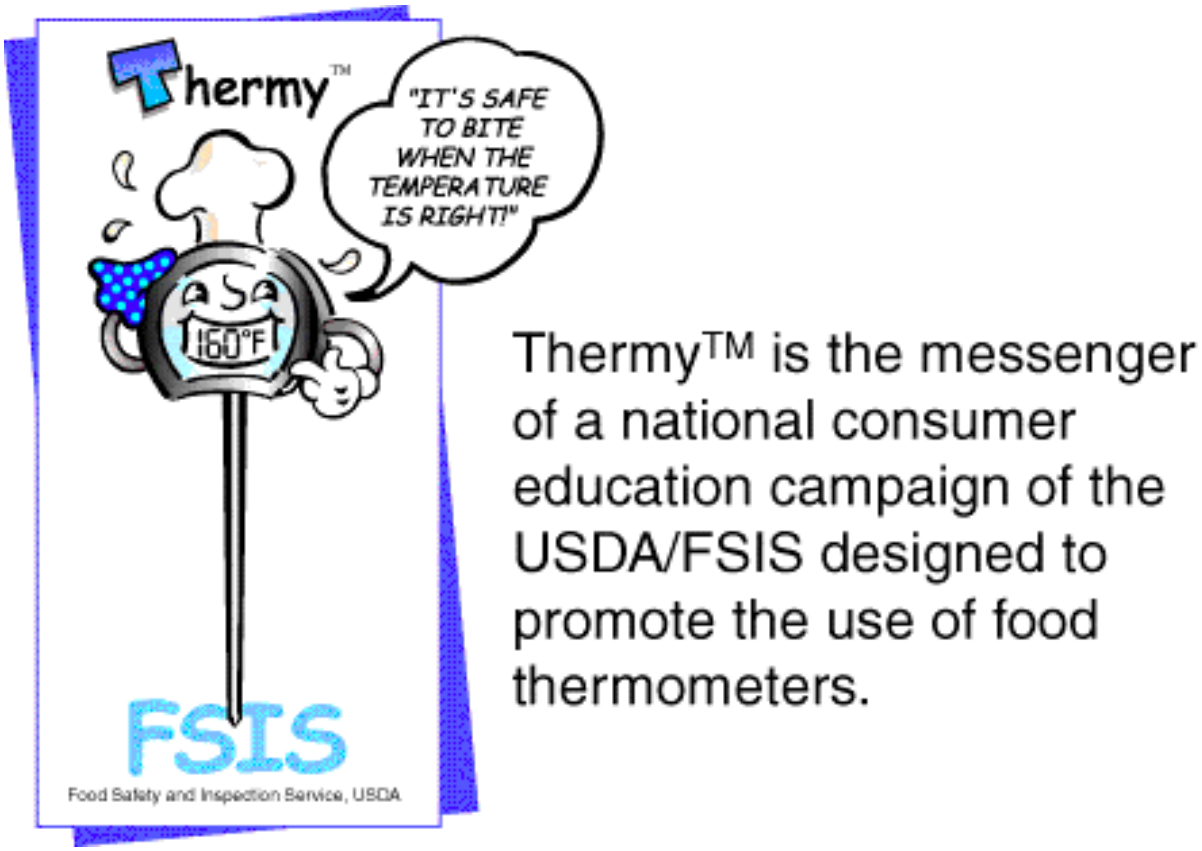
Figure 5: The Thermy consumer education campaign (FSIS, 2001c).



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