FOODBORNE CONTAMINANTS

QUICK FACTS

Foodborne contaminants include chemicals and biologic pathogens or toxins which can be harmful to human health.[1]

Most foodborne disease outbreaks in which a single, contaminated food commodity is reported as the source are due to beef, dairy, fish or poultry.[2]

Health effects from ingesting foodborne contaminants can range from gastrointestinal symptoms to brain and nervous system damage.[1,2,3]

An estimated 1 in 6 Americans experience a foodborne illness each year.[1] Almost any type of food—domestic or imported, raw or processed—can be contaminated with a disease-causing agent. Some foods are riskier than others though, and foodborne disease is preventable when foods are produced, handled, and prepared properly.

WHAT ARE FOODBORNE CONTAMINANTS?

Most reported cases of foodborne illness are caused by ingestion of food contaminated with pathogens or toxins of biological origin. While raw or undercooked meat, poultry, shellfish, and eggs, and unpasteurized milk are the foods most likely to be contaminated with pathogens, fresh fruits and vegetables can also be contaminated.[2] Foodborne toxins usually show up in fish (fresh or cooked) and, to a lesser extent, mushrooms.[2] Occasionally, food contaminated with high concentrations of man-made, nonfood chemicals, such as cleaners or pesticides, has sickened people.

Adverse health outcomes associated with chronic exposures to contaminants in the food supply also contribute to the disease burden attributable to food contamination. In some cases, such as mercury in fish, the data are compelling enough to establish a link between chronic exposure to a foodborne contaminant and a specific health outcome. In other cases, scientists are still investigating possible connections. For example, long-term exposure to low levels of pesticides and other endocrine disruptors found in food may contribute to malformations and cancer, but the data are preliminary Endocrine disruptors

are chemicals that can disturb the body's endocrine system. These chemicals can produce negative developmental, reproductive, neurological, and immune effects in humans.[4] Monitoring food for the wide range of possible chemical contaminants poses a formidable challenge, especially as research suggests that even small doses of some chemicals may cause adverse health effects over the long term.

Numerous programs are in place to detect the better known chemical contaminants, such as pesticides, mercury, and dioxins. Foods may be removed from the food supply if they exceed certain health limits for those contaminants. Many other foodborne chemical contaminants, however, are not monitored. This chapter briefly reviews the status of foodborne contaminants in the United States with particular attention to what we know about the types of contaminants and foods involved.

WHAT ARE THE HEALTH EFFECTS OF FOODBORNE CONTAMINANTS?

The bacterial and viral infections responsible for most reported cases of foodborne illness produce symptoms of gastroenteritis (inflammation of the stomach and intestines), including vomiting, diarrhea, and sometimes fever. Cases range from mild and short-lived to deadly. The very young, the elderly, and people with compromised immune systems generally have the most severe symptoms. People with mild symptoms are often cared for at home; more serious cases usually need treatment by a physician. However, the specific source of illness (e.g. food, contact with infected persons or animals) is rarely determined in individual cases.

Illnesses caused by foodborne toxins rather than pathogens often manifest as gastroenteritis but can include additional symptoms. Most foodborne infections cause diarrheal illness, ranging from mild to severe. Persons in susceptible populations and some healthy persons can develop severe complications, such as hemorrhagic colitis, bloodstream infection, meningitis, joint infection, kidney failure, paralysis, miscarriage, and other problems. Skin flushing, palpitations, wheezing, itching, or dropping blood pressure can follow ingestion of fish-borne toxins. Several mushroom toxins cause life-threatening organ failure days to weeks after ingestion. Botulism is a rare but serious paralytic illness caused by a nerve toxin that is

produced by the bacterium *Clostridium botulinum* and sometimes by strains of *Clostridium butyricum* and *Clostridium baratii*. Foodborne botulism is caused by eating foods that contain the botulinum toxin. Infant botulism is caused by consuming the spores of the botulinum bacteria, which then grow in the intestines and release toxin. Adult intestinal toxemia (adult intestinal colonization) botulism is a very rare kind of botulism that occurs among adults by the same route as infant botulism. Lastly, iatrogenic botulism can occur from accidental overdose of botulinum toxin. All forms of botulism can be fatal and are considered medical emergencies. Foodborne botulism is a public health emergency because many people can be poisoned by eating a contaminated food.[5]

Some foodborne illnesses can have severe sequelae in addition to the common signs of gastroenteritis. Examples of these include cases of Guillain-Barre syndrome (paralysis) associated with *Campylobacter* infection, hemolytic uremic syndrome (acute kidney failure) associated with Shiga toxin-producing *E. coli* infection, and miscarriage and stillbirths associated with *Listeria monocytogenes* infection.
Brain and nervous system damage are linked with ingestion of foodborne mercury at high concentrations, but even low doses of mercury can interfere with fetal development (see the Mercury in Fish sidebar). Other foodborne exposures, especially chronic exposure to foodborne endocrine disruptors (pesticides, phthalates, etc.), are believed to be linked with adverse health effects, but more data are needed to demonstrate an association.

HOW ARE WE TRACKING FOODBORNE CONTAMINANTS?

At the federal level, monitoring the nation's food supply for pathogens and chemical contaminants is mainly the responsibility of the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA), although many other groups also play a role. The FDA oversees the safety of all food—domestic and imported—except meat, poultry, and processed egg products, which fall under the regulatory authority of the USDA.

The Food Safety and Inspection Service (FSIS) of the USDA inspects raw meat, poultry, and egg products[8] sold in interstate and foreign commerce, including imported goods. Some states have their own inspection programs for meats sold only within the state, but these programs must be at least as stringent as that of the FSIS. If meat, poultry, or egg products are contaminated, FSIS may issue a recall. Current and archived recall alerts are listed online.[9]
The FDA assists state and local agencies that assume primary responsibility for keeping the rest of the food supply safe. Foodborne contaminants detected by either a food facility's own monitoring or during inspections of the facility are generally handled at the facility or the local level unless "there is reasonable probability that an article of food will cause serious adverse health consequences."[10] In those special cases, the facility must report the problem to the FDA's Reportable Food Registry.

Most recalls and reported food problems involve pathogens, such as *E. coli* O157:H7 or Salmonella, but both the USDA and FDA also have programs to monitor the food supply for a range of chemical contaminants. The USDA has been operating the Pesticide Data Program (PDP) since 1991. Each year, about 20 commodities (fresh fruits and vegetables, meat, dairy, grain, etc.) and drinking water are sampled from more than 500 food distribution sites across eleven states, and the raw samples are analyzed for a host of pesticides. The results are published in annual reports, which the U.S. Environmental Protection Agency (EPA) uses to set limits for pesticide residues in food.[11]

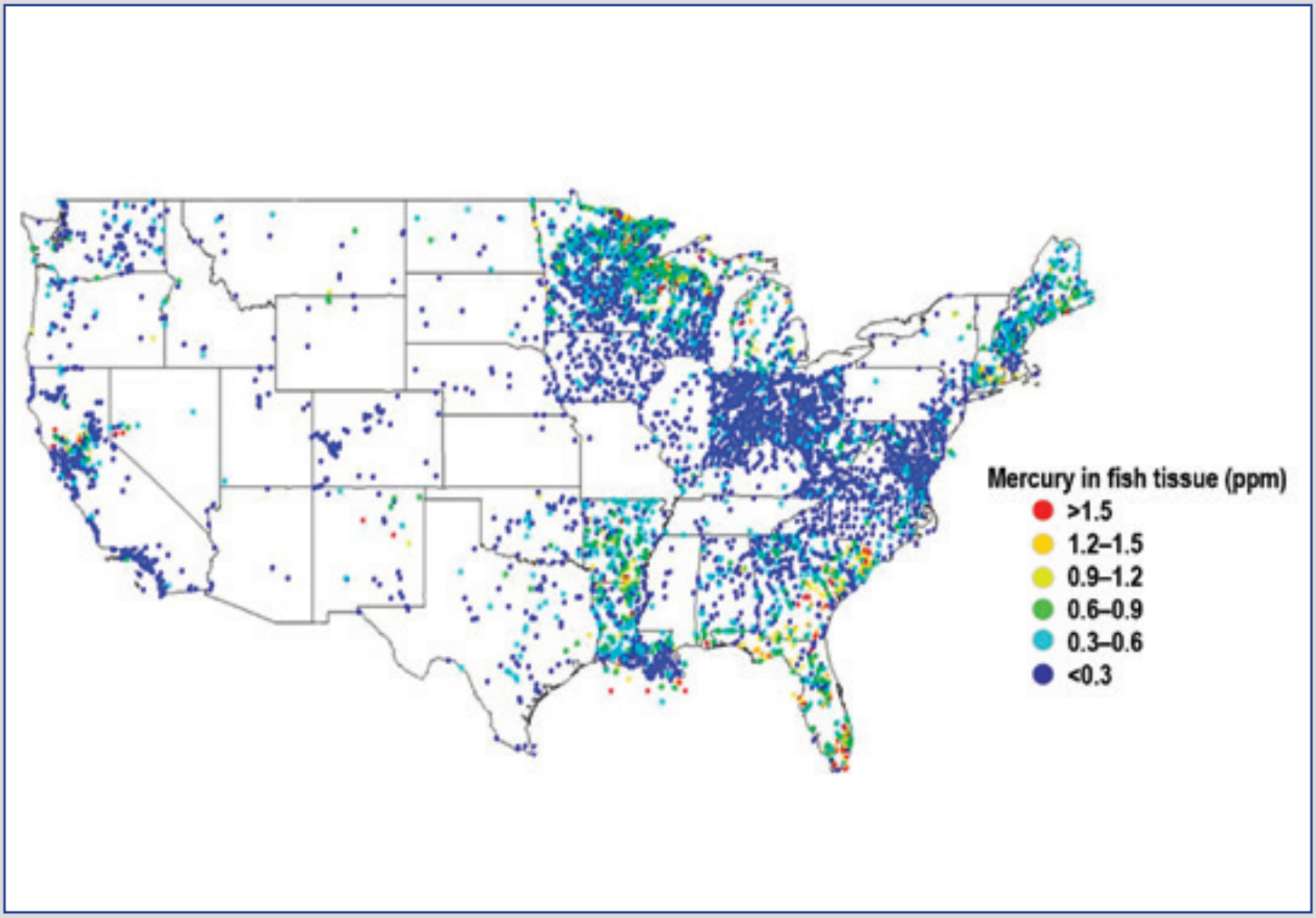
The FDA's pesticide residue monitoring program is a focused sampling program intended to detect pesticide residue levels (in food) that exceed EPA-established limits. Both domestic and imported foods, especially commodities that are not usually sampled during regulatory monitoring or that are suspected of having pesticide residues, are sampled and analyzed. The FDA has published annual reports since 1987 summarizing results of the pesticide residue monitoring program.[12]

An ongoing complement to FDA's pesticide residue monitoring program is the Total Diet Study. A "market basket" of about 280 different foods that represent the average U.S. consumer's diet is collected four times per year, once from each of four different regions of the United States. The foods are prepared for consumption (peeled, cooked, etc.) and are then analyzed for a variety of industrial chemicals and toxic elements, such as pesticides, PCBs, and heavy metals. The analytical results are reported online.[13]

Another program, directed jointly by representatives from the FDA, USDA, EPA, and numerous other agencies, has been monitoring dioxin levels in various foods, particularly meat, poultry, eggs, fish, and dairy products. This program is called the Interagency Working Group on Dioxin (Dioxin IWG). Some foods are tested for dioxins in the Total Diet Study, but the interagency group has collected and analyzed samples from other foods as well. The goal of the monitoring program is to find abnormally high levels of dioxin and to remove contaminated foods from the food supply.[14]

STATUS AND TRENDS

The CDC receives reports of foodborne disease outbreaks from local, state, and territorial health departments that are responsible for detecting and investigating outbreaks in their jurisdiction. Although many foodborne disease outbreaks reported to the CDC do not contain information about etiology or food vehicle, surveillance for foodborne disease outbreaks provides valuable information about the foods, contributing factors, and consumption settings



Mercury in Fish[6,7]

Consumption of contaminated fish is the major source of human exposure to methylmercury in the United States. Although fish and shellfish are an important part of a healthy diet, some fish and shellfish have mercury levels high enough to harm an unborn baby's or young child's developing brain and nervous system. Children exposed to mercury in utero have exhibited problems with cognitive thinking, memory, attention, language, and fine motor and visual spatial skills. The Environmental Mercury Mapping, Modeling & Analysis (EMM-MA) project of the United States Geological Survey (USGS) has a database of approximately 35,000 fish tissue mercury records from various sources. Using these data, maps have been constructed showing methylmercury concentrations in fish tissues throughout the United States. Generally, the eastern and Gulf of Mexico coastal areas and the upper Great Lakes area have the highest fish mercury concentrations. These are also the areas with the most fish consumption advisories attributable to mercury.

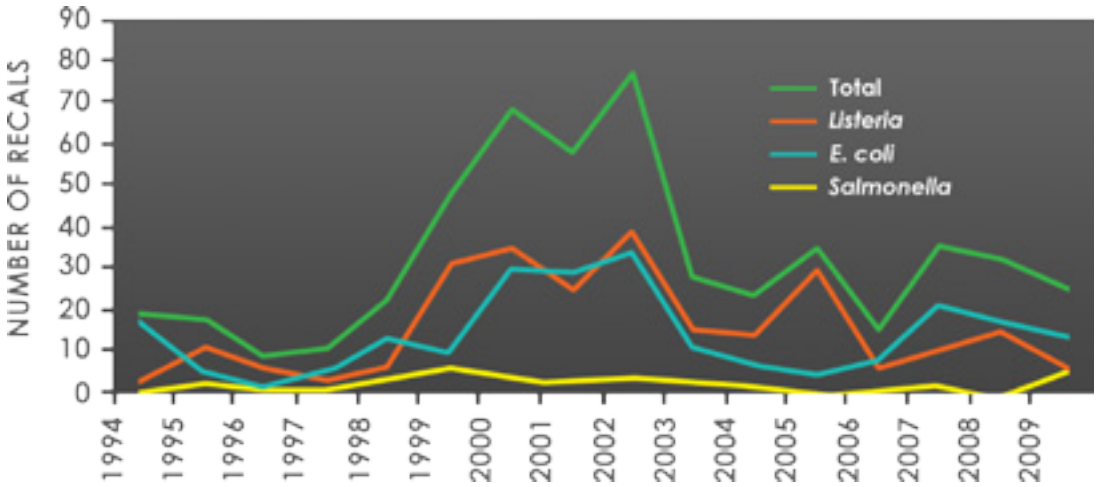


Figure 1. USDA food recalls attributable to foodborne pathogens. Total includes other pathogens in addition to *Salmonella*, *E. coli*, and *Listeria*.[16]

associated with foodborne illness. From these reports, we know that most reported outbreaks in which a single food commodity was implicated are related to contaminated poultry, beef, or finfish. Contaminated leafy vegetables, fruits, and nuts are also major contributors to foodborne illness outbreaks.[2]

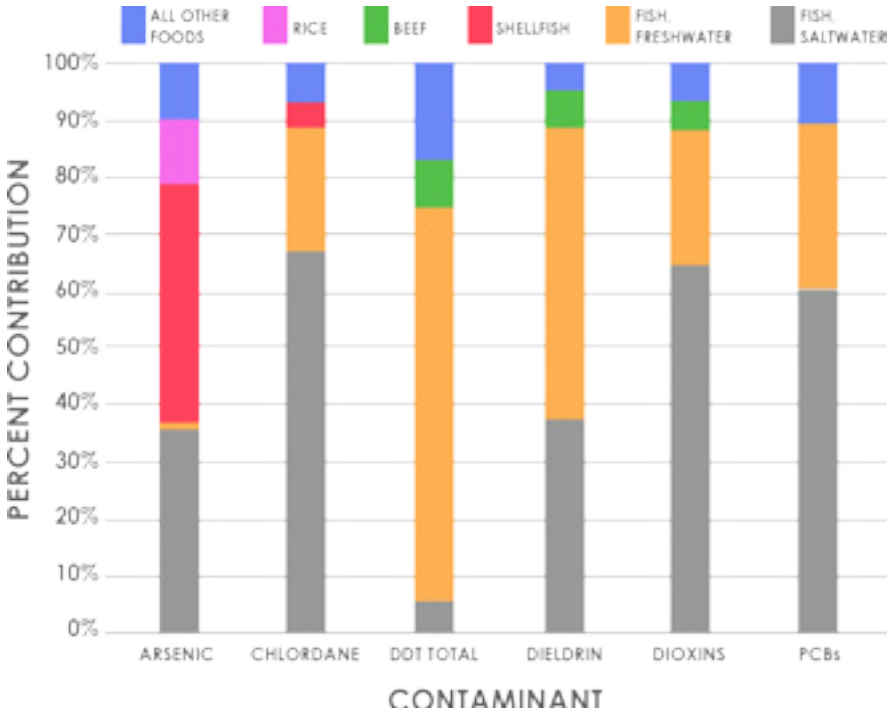
RISKIEST FOODS

Beef, poultry, and finfish are the foods associated with the largest number of foodborne outbreaks. Foods included in the vine-stalk vegetables and the fruits-nuts groups have also been associated with large numbers of outbreak-associated illnesses.[2]

FOOD RECALLS

The USDA recalls provide information on foodborne contaminants in meat, poultry, and processed egg products. Most recalls are prompted by suspected or confirmed contamination with pathogens, although some recalls are matters of mislabeling, undeclared allergens, or inclusion of extraneous material (e.g., bone, plastic).[15] The number of USDA food recalls initiated because of the presence, or suspected presence, of foodborne pathogens has fluctuated over the past 15 years, peaking during the period 1999–2003 (Figure 1).

Figure 2. Contribution of individual foods to total average national exposures[18]



CHEMICAL CONTAMINANTS

The USDA has also conducted several surveys on dioxins and related chemicals in various foods,[17] including foods from the domestic meat and poultry supply. Samples of beef, pork, chicken, and turkey were gathered from across the United States and analyzed for dioxins, furans, and dioxin-like PCBs. Comparing results of surveys from 1994–1996, 2002–2003, and 2007–2008, the toxic burden of these chemicals in the food supply appears to be declining.[18]

Data on foodborne chemical contaminant levels from the Total Diet Study, Pesticide Data Program, and other resources coupled with information on food consumption patterns from the USDA's Continuing Survey of Food Intakes by Individuals have allowed researchers to estimate the relative contribution of various foods to the average American's exposure to foodborne chemical contaminants. Considering 34 food types and 37 chemical contaminants ranging from pesticides to industrial pollutants, scientists found that the average American's exposure to six contaminants—arsenic, chlordane, DDT, dieldrin, dioxins, and PCBs—exceeded benchmark concentrations (daily concentrations below which there is a high probability of no adverse health effect). Foods that contributed most significantly to exposure to these six contaminants were saltwater and freshwater fish, shellfish, beef, and rice (Figure 2). For children 1 to 5 years of age, milk also was a significant contributor to DDT exposure. Fruits and vegetables contributed only negligible amounts of these six chemicals, perhaps because only three pesticides were included in the final list of six contaminants.

In 2011, 51% of samples analyzed in USDA's Pesticide Data Program (PDP) had detectable pesticide residues, with more residues found in fresh fruit and vegetables than in processed foods, milk, eggs, municipal drinking water and drinking water from private residential wells.[11] On average, two-thirds of raw but washed fruits and vegetables had detectable pesticide residues compared with about half of the grain samples and one-third of processed

Table 1. Pesticide residue detection rates for selected commodities. Blank entries (shown with a dash) indicate that the food was not tested that year.[18]

COMMODITIES	PERCENT DETECTIONS										
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	All years
Apples	97	95	95	98	-	-	90	79	91	91	93
Bananas	61	55	62	-	-	-	-	-	45	39	51
Carrots	65	69	71	78	-	-	-	80	81	85	75
Grapes	75	75	80	80	-	-	-	69	73	-	75
Green beans	66	61	57	-	-	-	-	69	62	-	63
Lettuce	51	53	-	-	-	-	38	37	49	-	47
Oranges	80	86	84	84	-	-	-	80	83	-	83
Peaches	91	93	92	96	-	-	-	94	99	98	95
Pears	-	-	-	-	95	85	74	-	-	-	85
Potatoes	79	78	83	-	-	-	-	70	82	90	80
Spinach	-	-	83	88	79	-	-	-	-	74	82
Strawberries	-	-	-	-	-	91	92	91	-	-	91
Tomatoes	-	-	-	64	63	62	67	-	-	-	63
Winter squash	-	-	-	-	40	42	41	-	-	-	41

foods. Six commodities that consistently had detectable pesticide residues in a high percentage of the samples (at least 90%) were apples, celery, cherries, nectarines, peaches, and strawberries. In any given year, however, fewer than 1% of all samples analyzed in the PDP had residues above established EPA tolerances (Table 1).[11,20]

Additional contaminants are known to be present in the food supply. Mercury is commonly found in fish, and phthalates, bisphenol A, and polybrominated diphenyl ethers have been detected in food and beverages, including breast milk.[21,22,23,24,25] Very low concentrations of some contaminants may not cause acute symptoms but could compromise health in people chronically exposed to them. For the most part, these foodborne contaminants are not tracked sufficiently to see trends, and removing the contaminant from the food supply is not straightforward.

WHAT YOU CAN DO

Many common and nutritious foods can be carriers Many common and nutritious foods can be contaminated, so it is likely that foodborne contaminants will be present at some time in your personal food supply. A few simple precautions can reduce the risk of foodborne diseases.

- **Clean**. Wash produce. Rinse fresh fruits and vegetables in running tap water to remove visible dirt and grime. Remove and discard the outermost leaves of a head of lettuce or cabbage. Because bacteria can grow well on the cut surface of fruit or vegetable, be careful not to contaminate these foods while slicing them up on the cutting board, and avoid leaving cut produce at room temperature for many hours. Don't be a source of foodborne illness yourself. Wash your hands with soap and water before preparing food. Avoid preparing food for others if you yourself have a diarrheal illness. Changing a baby's diaper while preparing food is a bad idea that can easily spread illness.
- **Separate**. Don't cross-contaminate one food with another. Avoid cross-contaminating foods by washing hands, utensils, and cutting boards after they have been in contact with raw meat or poultry and before they touch another food. Put cooked meat on a clean platter rather than back on one that held the raw meat.
- **Cook** meat, poultry, and eggs thoroughly. Using a thermometer to measure the internal temperature of meat is a good way to be sure that it is cooked sufficiently to kill bacteria: 145°F for whole meats (allowing the meat to rest for 3 minutes before carving or consuming), 160°F for ground meats, and 165°F for all poultry. Eggs should be cooked until the yolk is firm.
- **Chill**. Refrigerate leftovers promptly. Bacteria can grow quickly at room temperature, so refrigerate leftover foods if they are not going to be eaten within 4 hours. Large volumes of food will cool more quickly if they are divided into several shallow containers for refrigeration.
- **Report** suspected foodborne illnesses to your local health department. The local public health department is an important part of the food safety system. Often calls from concerned citizens are how outbreaks are first detected. If a public health official contacts you to find out more about an illness you had, your cooperation is important. In public health investigations, it can be as important to talk to healthy people as to ill people. Your cooperation may be needed even if you are not ill.
- More product-specific information on decreasing exposure to foodborne contaminants is available at www.fda.gov/Food/FoodSafety/Product-SpecificInformation/default.htm and www.fsis.usda.gov/Fact_Sheets/index.asp

ADDITIONAL RESOURCES

The CDC, USDA, and FDA have food safety Web sites that offer timely information on safe handling of food, a food safety chat room, regulations and policies, food recalls, foodborne disease outbreaks, and a page to report problems with food, among other topics.

- CDC's Food Safety Web site at http://www.cdc.gov/foodsafety
- USDA Food Safety and Inspection Service Web site at http://www.fsis.usda.gov
- FDA's Food Safety Web site at http://www.fda.gov/Food/ResourcesForYou/Consumers/ucm188807.htm
- U.S. Health and Human Services Food Safety Web site at http://www.foodsafety.gov
- FDA food safety tips for moms-to-be at http://www.fda.gov/Food/ResourcesForYou/HealthEducators/ucm081785.htm

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