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Achievements in Public Health, 1900-1999: Safer and Healthier Foods

During the early 20th century, contaminated food, milk, and water caused many foodborne infections, including typhoid fever, tuberculosis, botulism, and scarlet fever. In 1906, Upton Sinclair described in his novel The Jungle the unwholesome working environment in the Chicago meat-packing industry and the unsanitary conditions under which food was produced. Public awareness dramatically increased and led to the passage of the Pure Food and Drug Act (1). Once the sources and characteristics of foodborne diseases were identified--long before vaccines or antibiotics--they could be controlled by handwashing, sanitation, refrigeration, pasteurization, and pesticide application. Healthier animal care, feeding, and processing also improved food supply safety. In 1900, the incidence of typhoid fever was approximately 100 per 100,000 population; by 1920, it had decreased to 33.8, and by 1950, to 1.7 (Figure 1). During the 1940s, studies of autopsied muscle samples showed that 16% of persons in the United States had trichinellosis; 300-400 cases were diagnosed every year, and 10-20 deaths occurred (2). Since then, the rate of infection has declined markedly; from 1991 through 1996, three deaths and an average of 38 cases per year were reported (3).

Nutritional sciences also were in their infancy at the start of the century. Unknown was the concept that minerals and vitamins were necessary to prevent diseases caused by dietary deficiencies. Recurring nutritional deficiency diseases, including rickets, scurvy, beri-beri, and pellagra were thought to be infectious diseases. By 1900, biochemists and physiologists had identified protein, fat, and carbohydrates as the basic nutrients in food. By 1916, new data had led to the discovery that food contained vitamins, and the lack of "vital amines" could cause disease. These scientific discoveries and the resulting public health policies, such as food fortification programs, led to substantial reductions in nutritional deficiency diseases during the first half of the century. The focus of nutrition programs shifted in the second half of the century from disease prevention to control of chronic conditions, such as cardiovascular disease and obesity.

Food Safety

Perishable foods contain nutrients that pathogenic microorganisms require to reproduce. Bacteria such as *Salmonella* sp., *Clostridium* sp., and *Staphylococcus* sp. can multiply quickly to sufficient numbers to cause illness. Prompt refrigeration slows bacterial growth and keeps food fresh and edible.

At the turn of the 20th century, consumers kept food fresh by placing it on a block of ice or, in cold weather, burying it in the yard or storing it on a window sill outside. During the 1920s, refrigerators with freezer compartments became available for household use. Another process that reduced the incidence of disease was invented by Louis Pasteur--pasteurization. Although the process was applied first in wine preservation, when milk producers adopted the process, pasteurization eliminated a substantial vector of foodborne disease (see box, page 907). In 1924, the Public Health Service created a document to assist Alabama in developing a statewide milk sanitation program. This document evolved into the Grade A Pasteurized Milk Ordinance, a voluntary agreement that established uniform sanitation standards for the interstate shipment of

Grade A milk and now serves as the basis of milk safety laws in the 50 states and Puerto Rico (4).

Along with improved crop varieties, insecticides and herbicides have increased crop yields, decreased food costs, and enhanced the appearance of food. Without proper controls, however, the residues of some pesticides that remain on foods can create potential health risks (5). Before 1910, no legislation existed to ensure the safety of food and feed crops that were sprayed and dusted with pesticides. In 1910, the first pesticide legislation was designed to protect consumers from impure or improperly labeled products. During the 1950s and 1960s, pesticide regulation evolved to require maximum allowable residue levels of pesticides on foods and to deny registrations for unsafe or ineffective products. During the 1970s, acting under these strengthened laws, the newly formed Environmental Protection Agency (EPA) removed DDT and several other highly persistent pesticides from the marketplace. In 1996, the Food Quality Protection Act set a stricter safety standard and required the review of older allowable residue levels to determine whether they were safe. In 1999, federal and state laws required that pesticides meet specific safety standards; the EPA reviews and registers each product before it can be used and sets levels and restrictions on each product intended for food or feed crops.

Newly recognized foodborne pathogens have emerged in the United States since the late 1970s; contributing factors include changes in agricultural practices and food processing operations, and the globalization of the food supply (Table 1). Seemingly healthy food animals can be reservoirs of human pathogens. During the 1980s, for example, an epidemic of egg-associated *Salmonella* serotype Enteritidis infection spread to an estimated 45% of the nation's egg-laying flocks, which resulted in a large increase in egg-associated foodborne illness within the United States (6,7). *Escherichia coli* O157:H7, which can cause severe infections and death in humans, produces no signs of illness in its nonhuman hosts (8). In 1993, a severe outbreak of *E. coli* O157:H7 infections attributed to consumption of undercooked ground beef (9) resulted in 501 cases of illness, 151 hospitalizations, and three deaths, and led to a restructuring of the meat inspection process. The most common foodborne infectious agent may be the calicivirus (a Norwalk-like virus), which can pass from the unwashed hands of an infected foodhandler to the meal of a consumer. Animal husbandry and meat production improvements that have contributed to reducing pathogens in the food supply include pathogen eradication campaigns, the Hazard Analysis and Critical Control Point (HACCP) programs (10), better animal feeding regulations (11), the use of uncontaminated water in food processing (12), more effective food preservatives (13), improved antimicrobial products for sanitizing food processing equipment and facilities, and adequate surveillance of foodhandling and preparation methods (14). HACCP programs also are mandatory for the seafood industry (15).

Improved surveillance, applied research, and outbreak investigations have elucidated the mechanisms of contamination that are leading to new control measures for foodborne pathogens. In meat-processing plants (16), the incidence of *Salmonella* and *Campylobacter* infections has decreased. However, in 1998, apparently unrelated cases of *Listeria* infections were linked when an epidemiologic investigation indicated that isolates from all cases shared the same genetic DNA fingerprint; approximately 100 cases and 22 deaths were traced to eating hot dogs and deli meats produced in a single manufacturing plant (17). In 1998, a multistate outbreak of shigellosis was traced to imported parsley (18). During 1997-1998 in the United States, outbreaks of cyclosporiasis were associated with mesclun mix lettuce, basil/basil-containing products, and Guatemalan raspberries (19). These instances highlight the need for measures that prevent food contamination closer to its point of production, particularly if the food is eaten raw or is difficult to wash (20).

Any 21st century improvement will be accelerated by new diagnostic techniques and the rapid exchange of information through use of electronic networks and the Internet. PulseNet, for example, is a network of laboratories in state health departments, CDC, and food regulatory agencies. In this network, the genetic DNA fingerprints of specific pathogens can be identified and shared electronically among laboratories, enhancing the ability to detect, investigate, and control geographically distant yet related outbreaks. Another example of technology is DPDx, a computer network that identifies parasitic pathogens. By combining

PulseNet and DPDx with field epidemiologic investigations, the public health system can rapidly identify and control outbreaks. CDC, the Food and Drug Administration, the U.S. Department of Agriculture (USDA), other federal agencies, and private organizations are enhancing food safety by collaborating in education, training, research, technology, and transfer of information and by considering food safety as a whole--from farm to table.

Nutrition

The discovery of essential nutrients and their roles in disease prevention has been instrumental in almost eliminating nutritional deficiency diseases such as goiter, rickets, and pellagra in the United States. During 1922-1927, with the implementation of a statewide prevention program, the goiter rate in Michigan fell from 38.6% to 9.0 % (21). In 1921, rickets was considered the most common nutritional disease of children, affecting approximately 75% of infants in New York City (22). In the 1940s, the fortification of milk with vitamin D was a critical step in rickets control.

Because of food restrictions and shortages during the first world war, scientific discoveries in nutrition were translated quickly into public health policy; in 1917, USDA issued the first dietary recommendations based on five food groups; in 1924, iodine was added to salt to prevent goiter. The 1921-1929 Maternal and Infancy Act enabled state health departments to employ nutritionists, and during the 1930s, the federal government developed food relief and food commodity distribution programs, including school feeding and nutrition education programs, and national food consumption surveys.

Pellagra is a good example of the translation of scientific understanding to public health action to prevent nutritional deficiency. Pellagra, a classic dietary deficiency disease caused by insufficient niacin, was noted in the South after the Civil War. Then considered infectious, it was known as the disease of the four Ds: diarrhea, dermatitis, dementia, and death. The first outbreak was reported in 1907. In 1909, more than 1000 cases were estimated based on reports from 13 states. One year later, approximately 3000 cases were suspected nationwide based on estimates from 30 states and the District of Columbia. By the end of 1911, pellagra had been reported in all but nine states, and prevalence estimates had increased nearly ninefold (23). During 1906-1940, approximately 3 million cases and approximately 100,000 deaths were attributed to pellagra (24). From 1914 until his death in 1929, Joseph Goldberger, a Public Health Service physician, conducted groundbreaking studies that demonstrated that pellagra was not infectious but was associated with poverty and poor diet. Despite compelling evidence, his hypothesis remained controversial and unconfirmed until 1937. The near elimination of pellagra by the end of the 1940s (Figure 2) has been attributed to improved diet and health associated with economic recovery during the 1940s and to the enrichment of flour with niacin. Today, most physicians in the United States have never seen pellagra although outbreaks continue to occur, particularly among refugees and during emergencies in developing countries (25).

The growth of publicly funded nutrition programs was accelerated during the early 1940s because of reports that 25% of draftees showed evidence of past or present malnutrition; a frequent cause of rejection from military service was tooth decay or loss. In 1941, President Franklin D. Roosevelt convened the National Nutrition Conference for Defense, which led to the first recommended dietary allowances of nutrients, and resulted in issuance of War Order Number One, a program to enrich wheat flour with vitamins and iron. In 1998, the most recent food fortification program was initiated; folic acid, a water-soluble vitamin, was added to cereal and grain products to prevent neural tube defects.

While the first half of the century was devoted to preventing and controlling nutritional deficiency disease, the focus of the second half has been on preventing chronic disease with initiation of the Framingham Heart Study in 1949. This landmark study identified the contribution of diet and sedentary lifestyles to the development of cardiovascular disease, and the effect of elevated serum cholesterol on the risk for coronary heart disease. With increased awareness, public health nutrition programs have sought strategies to improve diets. By the 1970s, food and nutrition labeling and other consumer information programs stimulated the

development of products low in fat, saturated fat, and cholesterol. Since then, persons in the United States have significantly decreased their dietary intakes of total fat from approximately 40% of total calorie intake in 1977-1978 to 33% in 1994-1996, approaching the recommended 30% (26); saturated fat intake and serum cholesterol levels also have decreased (27). Prevention efforts, including changes in diet (28) and lifestyle and early detection and improved treatment, have contributed to impressive declines in mortality from heart disease and stroke (29).

Populations with diets rich in fruits and vegetables have a substantially lower risk for many types of cancer. In 1991, the National Cancer Institute and the Produce for Better Health Foundation launched a program to encourage eating at least five servings of fruits and vegetables daily. Although public awareness of the "5 A Day" message has increased, only approximately 36% of persons in the United States aged greater than or equal to 2 years achieved the daily goal of five or more servings of fruits and vegetables (28). A diet rich in fruits and vegetables that provide vitamins, antioxidants (including carotenoids), other phytochemicals, and fiber is associated with additional health benefits, including decreased risk for cardiovascular disease.

The most urgent challenge to nutritional health during the 21st century will be obesity. In the United States, with an abundant, inexpensive food supply and a largely sedentary population, overnutrition has become an important contributor to morbidity and mortality in adults. As early as 1902, USDA's W.O. Atwater linked dietary intake to health, noting that "the evils of overeating may not be felt at once, but sooner or later they are sure to appear--perhaps in an excessive amount of fatty tissue, perhaps in general debility, perhaps in actual disease" (30). In U.S. adults, overweight (body mass index [BMI] of greater than or equal to 25 kg/m2) and obesity (BMI greater than or equal to 30 kg/m2) have increased markedly, especially since the 1970s. In the third National Health and Nutrition Examination Survey (NHANES III, 1988-1994), the crude prevalence of overweight for adults aged greater than or equal to 20 years was 54.9%. From 1976-1980 (NHANES II) to 1988-1994 (NHANES III), the prevalence of obesity increased from 14.5% to 22.5% (31).

Overweight and obesity increase risk for and complications of hypertension, hyperlipidemia, diabetes, coronary heart disease, osteoarthritis, and other chronic disorders; total costs attributable to obesity are an estimated $100 billion annually (32). Obesity also is a growing problem in developing countries where it is associated with substantial morbidity and where malnutrition, particularly deficiencies of iron, iodine, and vitamin A, affects approximately 2 billion people. Increasing physical activity in the U.S. population is an important step (33), but effective prevention and control of overweight and obesity will require concerted public health action.

As the U.S. population ages, attention to both nutrition and food safety will become increasingly important. Challenges will include maintaining and improving nutritional status, because nutrient needs change with aging, and assuring food quality and safety, which is important to an older, more vulnerable population. Continuing challenges for public health action include reducing iron deficiency, especially in infants, young children, and women of childbearing age; improving initiation and duration of breastfeeding; improving folate status for women of childbearing age; and applying emerging knowledge about nutrition on dietary patterns and behavior that promote health and reduce risk for chronic disease. Behavioral research indicates that successful nutrition promotion activities focus on specific behaviors, have a strong consumer orientation, segment and target consumers, use multiple reinforcing channels, and continually refine the messages (34). These techniques form a paradigm to achieve public health goals and to communicate and motivate consumers to change their behavior.

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Table 1

Note: To print large tables and graphs users may have to change their printer settings to landscape and use a small font size.

TABLE 1. Newly recognized pathogens identified as predominantly foodborne

Campylobacter coli
Campylobacter jejuni
Campylobacter fetus ssp. *fetus*
Cryptosporidium parvum
Cyclospora cayetanensis
Escherichia coli O157:H7 and related *E. coli* (e.g., O111:NM and O104:H21)
Listeria monocytogenes
Norwalk-like viruses
Nitschia pungens (cause of amnesic shellfish poisoning)
Salmonella serotype Enteritidis
Salmonella serotype Typhimurium DT 104
Vibrio cholerae Non-O1
Vibrio vulnificus
Vibrio parahaemolyticus
Yersinia enterocolitica

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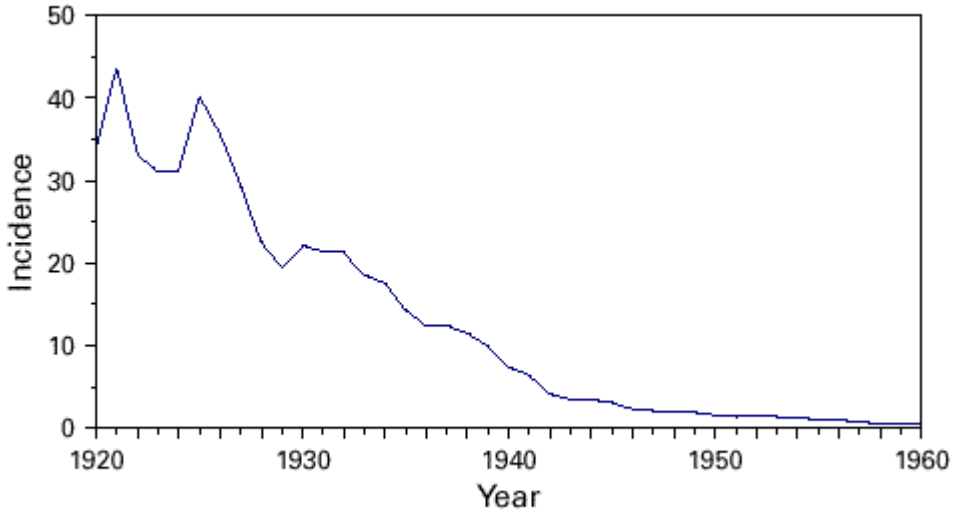
Figure 1

FIGURE 1. Incidence* of typhoid fever, by year — United States, 1920–1960



*Per 100,000 population.

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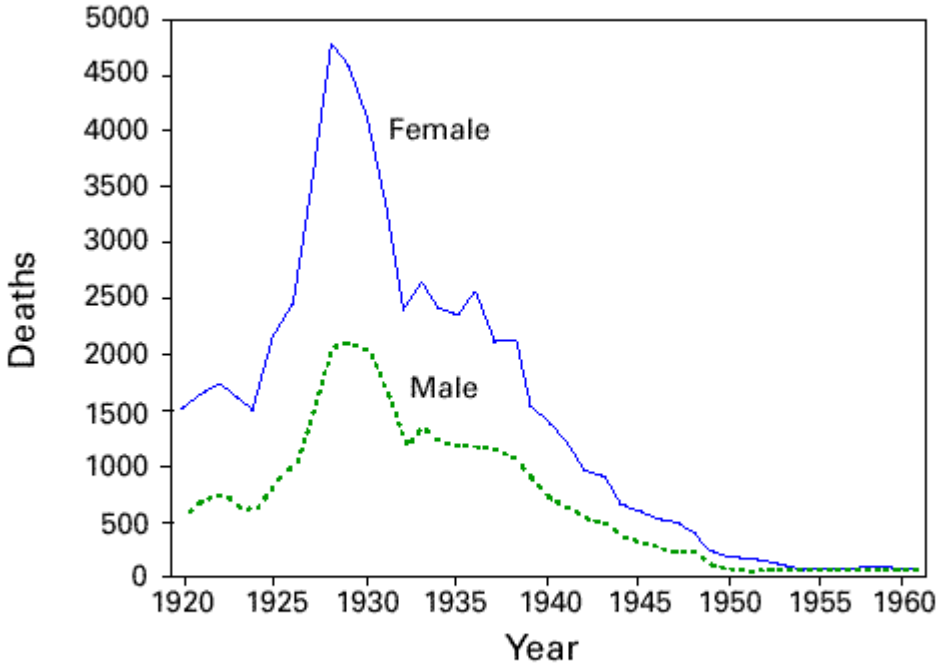
Figure 2

FIGURE 2. Number of reported pellagra deaths, by sex of decedent and year — United States, 1920–1960



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