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Raw and Undercooked Eggs: A Danger of Salmonellosis

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Microbial pathogens of the genus *Salmonella* are among the leading causes of foodborne illness in the United States. Between 696,000 and 3,840,000 cases of foodborne salmonellosis occur each year, causing mild to acute gastrointestinal symptoms, such as abdominal pain, frequent diarrhea, vomiting, fever, and chills. Infants, the elderly, and people with compromised immune systems are particularly vulnerable, and death from salmonellosis may occur in these high-risk population groups. These human illness cases and deaths cost society between \$600 million and \$3.5 billion each year in medical treatment, lost productivity, and loss of life.

Since the mid-1980's, *Salmonella enteritidis* has been one of the most frequently implicated species of the genus *Salmonella* in human illness cases reported to the National *Salmonella* Surveillance System, which is administered by the Centers for Disease Control and Prevention (CDC). According to the

CDC, the proportion of cases of salmonellosis due to *Salmonella enteritidis* increased from 5 percent in 1976 to 26 percent in 1994 when compared to all reported cases of salmonellosis reported to CDC. The CDC also reported that, between 1985 and 1995, there were 582 *Salmonella enteritidis* outbreaks (two or more people became ill from eating the same food), which accounted for 24,058 cases of illness, 2,290 hospitalizations, and 70 deaths. While many more people may have suffered the illness than what the outbreak data suggest, few seek medical help, so large numbers of cases probably are not reported to the CDC.

Raw or undercooked eggs and foods containing them have been implicated in about 80 percent of those *Salmonella enteritidis* outbreaks in which a food source was identified. And, 87 percent of the outbreaks between 1990 and 1994 were associated with eggs prepared in foodservice and in institutions, such as nursing homes and hospitals.

Eggs can become contaminated with the pathogen before laying and before the shell is formed. Pathogens carried in fecal material or dirt may also contaminate the shell exterior and then move through cracks or shell pores to the inner surface. The pathogen can be found in the yolk or egg white. Efforts are under-

way in the public and private sectors to prevent consumer exposure to contaminated eggs and to educate consumers about safe practices for egg preparation and consumption. However, our review of data from four recent surveys suggests some consumers are still consuming raw or undercooked eggs. Thorough cooking of eggs until both white and yolk are firm greatly reduces the chances of human infection. Proper refrigeration can prevent proliferation of the pathogen in contaminated eggs. Thus, further improvements in egg production, handling, and preparation practices can reduce the number of illnesses caused by *Salmonella enteritidis* due to the consumption of contaminated eggs and the costs these cases impose on society.

Outbreaks From Eggs Prepared Away From Home Declining

A major cause of the *Salmonella enteritidis* illness in foodservice and institutions is the pooling of shell eggs for quick preparation of foods, such as omelets and scrambled eggs. A single infected egg can contaminate a large pooled batch with *Salmonella enteritidis* and increase the chances of human infection. More-

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over, when pooled eggs are left sitting at room temperature for an extended period of time, the pathogen multiplies.

Due to the emergence of *Salmonella enteritidis* outbreaks with shell eggs prepared outside the home, the CDC has been strongly recommending since 1989 that foodservice and institutions use pasteurized eggs, particularly when high-risk population groups are served or when recipes call for pooling shell eggs. The pathogen can be killed by pasteurization—the heat treatment of shell eggs or egg products (liquid, frozen, or dried). In August 1990, the Food and Drug Administration (FDA) issued recommended guidelines for refrigerating, pooling, and cooking eggs, and advocated substituting pasteurized eggs for shell eggs by foodservice and institutions when possible. Currently, the USDA's Egg Products Inspection Act requires that all liquid, frozen, or dried egg products be pasteurized to destroy pathogens.

In response, many foodservice and institution operators have sub-

stituted pasteurized egg products for shell eggs because they are less likely to be contaminated with pathogens and are thus safer. For example, United Airlines and American Airlines have eliminated shell eggs from all of their flight kitchens and catering sources. Large hotel corporations such as Marriot and Hyatt have also substituted pasteurized egg products for shell eggs in recipes that call for raw or lightly cooked eggs. Fastfood chains such as Burger King and McDonald's have also switched from shell eggs to pasteurized liquid eggs in their breakfast menus when possible.

Recent data from the CDC suggest that foodservice and institutional *Salmonella enteritidis* outbreaks are becoming less frequent (fig. 1). The decline may be related to this increased use of pasteurized eggs and egg products by this segment of the market. In 1992, foodservice and institutions used 16 pasteurized eggs per capita, compared with 10 in 1980. If this trend continues, the American Egg Board predicts that foodservice and institutional use of

pasteurized egg products will increase by another 12 eggs to 28 eggs per capita by the year 2000.

But Risk From Eggs Prepared at Home Increasing

Although the number of foodservice and institutional outbreaks appears to have declined in recent years, the CDC data suggest more outbreaks are occurring at home (fig. 1). And, the number of sporadic (single) cases has been rising since 1992.

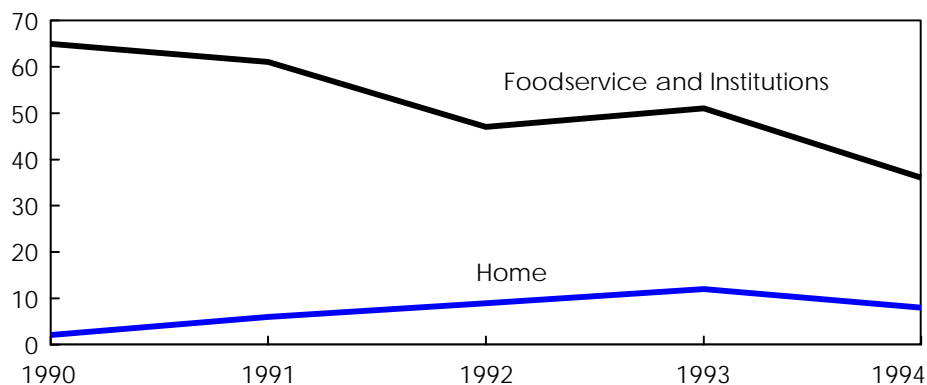
To assess the prevalence of unsafe egg preparation and consumption practices, particularly at home, we examined four recent national consumer surveys: the 1992-95 Menu Census survey, the 1996-97 Food Consumption and Preparation Diary (FCPD), the 1993 Food Safety Survey, and the 1994 Continuing Survey of Food Intakes by Individuals (CSFII) (see box for details about the surveys). Taken together, these surveys shed light on different aspects of how consumers prepare and use shell eggs and on the demographics of those who are exposed to home-prepared raw or undercooked eggs.

The surveys provide information on the consumption of two categories of potentially unsafe eggs: "raw or near raw" are raw eggs and uncooked or lightly heated foods containing eggs as ingredients, such as egg drinks, egg-based sauces, salad dressings, and desserts; "undercooked" are eggs prepared as a main dish (referred to here as egg dishes), which are not thoroughly cooked until both white and yolk are firm, such as a fried egg with a "runny" yolk.

Figure 1

Outbreaks of *Salmonella enteritidis* Illness From Eggs Prepared Away From Home May Be Declining, But Home-Related Outbreaks May Be Increasing

Number of outbreaks



Notes: "Foodservice and institutions" include restaurants, delicatessens, bakeries, nursing homes, chronic-care facilities, hospitals, homeless shelters, shelters for children, daycare centers, drug rehabilitation centers, camps, school cafeterias, other cafeterias, vending trucks, school classes, cruise ships, submarines, airplanes, and country clubs. "Home" also includes receptions, churches, and picnics.

Raw or Near-Raw Eggs Used as Ingredients

According to the Menu Census survey, 5 percent of the households surveyed in 1992-95 ate raw or near-raw eggs at least once a year. Most of the times that those foods were eaten (about 40 percent) occurred between July and September, while April-June was the least likely season of the year such foods were consumed.

The Menu Census survey also indicates that frosting accounted for 53 percent of the times that raw or near-raw eggs were used as ingredients (table 1). Salad dressing was the next most popular use (18 percent). The data suggest the typical consumer of raw or near-raw eggs tended to be a 15- to 24-year-old white male who lived in the West. He came from a household earning an annual income of \$15,000-\$24,999 or \$50,000 and above. The head of the household had not attained a college education.

The prevalence of raw or near-raw egg consumption appears to be higher when based on the Food Safety Survey. In this survey, 53 percent of the respondents said they had ever eaten a food containing raw eggs, such as homemade cookie batter and homemade ice cream. Of those, 27 percent mentioned cookie batter as a specific raw egg food (table 1). Other reported foods containing raw eggs included ice cream, eggnog, and Caesar salad dressing. A typical consumer of foods containing raw eggs was white, 18-29 years old, and attained a post-graduate education.

The two surveys, however, are not comparable. The Menu Census data were based on reports by the homemaker of all foods every adult, child, and guest of participating households ate over a 14-day period. If consumption of raw or near-raw eggs occurred outside that

period, it would not have been recorded. In contrast, respondents in the Food Safety Survey, all of them adults, were asked to recall their

own consumption of specific foods over an unspecified period of time. A respondent who indicated eating such foods could have been refer-

Sources of Information

This article is based on four national consumer surveys because no individual survey provides all the information needed for this article.

1992-95 Menu Census. USDA's Economic Research Service (ERS) acquired from a commercial marketing research firm tabulations of data on consumption of raw and undercooked eggs among a nationally weighted sample of 16,500 people in 6,000 households. The data were derived from a 14-consecutive-day menu census survey administered continuously throughout a year by the firm between July 1992 and June 1995. The homemaker in the household recorded all foods and beverages consumed by every household member and guests, as well as how each food item was prepared and the ingredients used.

1996-97 Food Consumption and Preparation Diary (FCPD). To assess the prevalence of unsafe preparation practices of selected foods often associated with food-borne illness, ERS is also obtaining from the same firm information on how shell eggs are prepared from a base sample of about 2,000 nationally representative households. Homemakers in these households are asked to fill out a Food Consumption and Preparation Diary, which accompanies the 14-day Menu Census survey. Participants record how eggs are cooked (poached, scrambled, sunny side up, over easy, hard boiled, or soft boiled), the appearance when cooked (runny, runny yolk, runny white, or firm yolk and white), name of the food item, and who ate the food item. This article reports findings from the latest available

data from the year-long study—March-July 1996. During these 5 months, 830 households returned the survey with information on 2,282 people.

1993 Food Safety Survey. This national telephone survey, conducted by FDA and USDA's Food Safety and Inspection Service, provides information on consumption of specific foods containing raw eggs. The survey was administered to 1,620 English-speaking adults in late 1992 and early 1993.

Respondents in the survey were asked: "Do you ever eat foods that contain raw eggs, such as homemade cookie batter, homemade frosting with raw egg, Caesar salad, or homemade eggnog, homemade mayonnaise, homemade ice cream, shakes with raw egg, or homemade hollandaise sauce?" and what the foods were, if any of them were ever eaten.

1994 Continuing Survey of Food Intakes by Individuals (CSFII). USDA's Agricultural Research Service conducted this survey using personal interviews. The survey collected details of food and beverage consumption on 2 nonconsecutive days by a nationally representative sample of 5,589 people. The CSFII yielded less information than the other three surveys regarding consumption of specific raw or undercooked eggs or foods containing them. But, we combined cooking practice information from the FCPD and demographic information from the CSFII to obtain estimates of how frequently undercooked egg dishes were eaten and by whom. This was done because of insufficient information on the demographics of households participating in the FCPD survey.

ring to an experience that occurred a long time ago. Besides, consumption of raw cookie batter is more likely to be reported in the Food Safety Survey than in the Menu Census survey. The respondents in the Food Safety Survey were prompted with specific food items and, therefore, were more likely to recall such experiences than were the respondents in the Menu Census survey.

Undercooked Egg Dishes Also Popular

According to the FCPD survey, 27 percent of all egg dishes consumed were undercooked—described as either “runny yolk,” “runny,” or “runny white.” Each person on average consumed undercooked eggs 20 times a year.

Eggs fried “over easy” and “sunny side up” accounted for almost half (49 percent) of the undercooked eggs eaten (fig. 2). This reflects both the relative popularity of fried eggs and the relatively high probability that they will be undercooked. Eggs fried “over easy” and “sunny side up” accounted for over one-quarter (27 percent) of all eggs

Table 1
Raw or Undercooked Eggs in a Variety of Homemade Foods

Frosting was the most common use of raw or near-raw eggs as ingredients by households participating in the Menu Census survey¹

Ingredient:	Percent of raw egg eating occasions
Frosting	52
Salad dressing	18
Flavored milk beverages	16
Ice cream	6
Sauces	5
Other	3

Cookie batter topped the list of foods containing raw eggs eaten by FSS respondents²

Food:	Percent of all foods mentioned
Cookie batter	27
Ice cream	19
Eggnog	16
Caesar salad dressing	12
Frosting	11
Other	15

Notes: ¹Based on the 1992-95 Menu Census data. ²Based on the 1993 Food Safety Survey.

Figure 2
Fried Eggs Accounted for Nearly Half of Undercooked Eggs...

...In Part, Because They Were Eaten Frequently

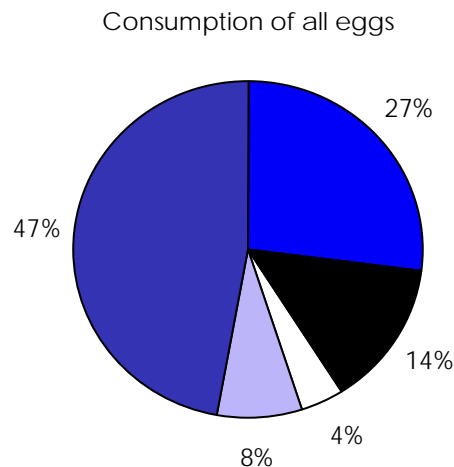
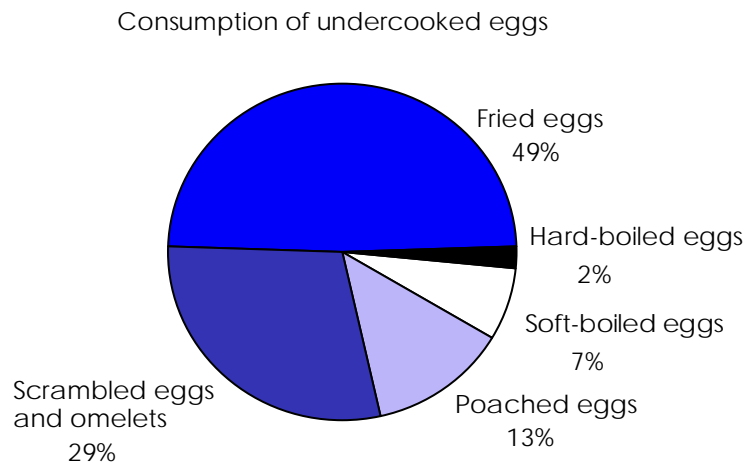
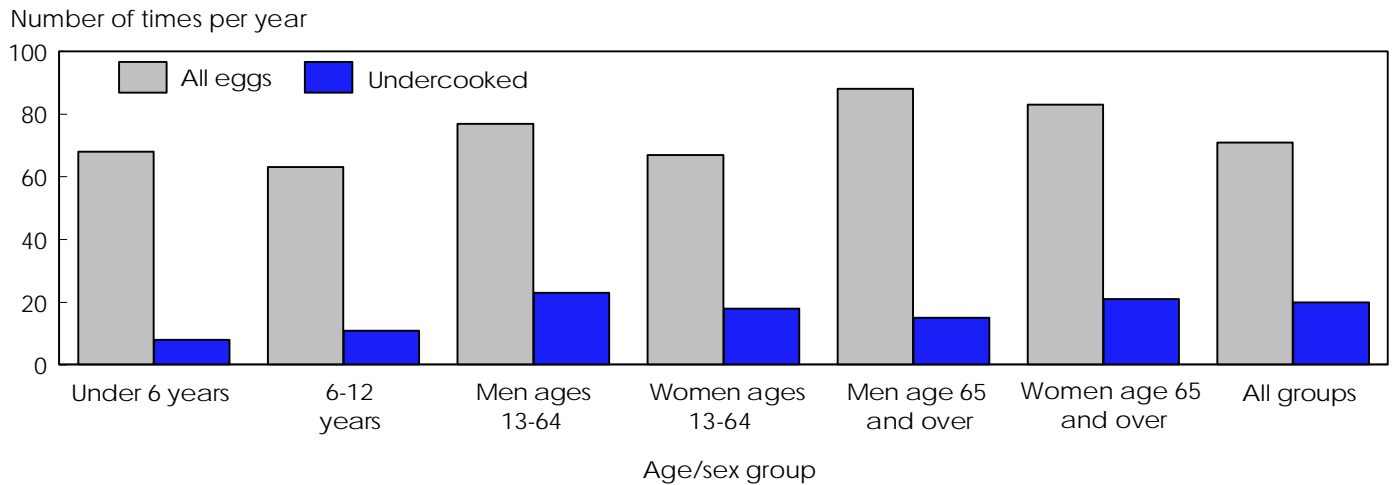


Figure 3

Teenage Boys, Adult Men, and Elderly Women Ate Undercooked Egg Dishes Most Frequently



Notes: The frequency of egg consumption by demographic classification was estimated from the 1994 CSFII. These data were used because the demographic data are incomplete for the preliminary data from the 1996-97 FCPD. The overall estimated frequency of egg consumption from the FCPD was similar to that from the CSFII.

consumed by households participating in the FCPD survey, and nearly half of these dishes were described as “runny,” “runny yolk,” or “runny white.” Scrambled eggs and omelets accounted for only 29 percent of undercooked eggs. While these eggs were the most popular style of eggs consumed, they were not as likely as fried eggs to be undercooked.

Based on the combined data of the CSFII and the FCPD survey, teenage boys and adult men (13-64 years old) and elderly women (over 65 years) had the highest frequencies of consuming undercooked egg dishes, at 23 and 21 times per year, respectively (fig. 3). Of these two groups, elderly women present the more serious concern for foodborne illness, because they are more likely to have weakened immune systems. Women over 65 consumed 25 percent of their egg dishes undercooked, slightly less than the average of all age/sex groups (27 percent). However, they ate eggs more frequently than did most other groups, except elderly men. Elderly men consumed eggs more frequently than did elderly women (88 versus 83 times per year), but the

elderly men had among the lowest probabilities of consuming their eggs undercooked (17 percent). By comparison, teenage boys and adult men consumed the highest proportion of their eggs undercooked (30 percent), but they ate those foods less frequently. Children under 6 years of age, who are also more susceptible to foodborne illness, had the lowest frequencies for consuming undercooked eggs (8 times per year).

FCPD respondents with annual household incomes below \$15,000 ate undercooked eggs more frequently than any other income group, at 24 times per year. Although the percentage of eggs eaten undercooked does not differ dramatically across income groups (between 25 and 29 percent), low-income respondents ate eggs more often than the average for all income groups (92 times versus 71 times per year). This is a potential public-health concern for foodborne illness because the poor tend to have less access to medical care.

Consumers in the West ate undercooked eggs more frequently than in any other region, at 21 times per

year. While consumers in the Midwest ate a higher percentage of their eggs undercooked (31 percent), western consumers ate eggs of all styles more often.

Safe Practices and Pasteurized Shell Eggs Minimize Risk

Some consumers may not be aware of the risk of *Salmonella enteritidis* illness and its association with raw or undercooked eggs. In the Food Safety Survey, only 17 percent of the respondents had heard of *Salmonella* as “a problem in food” and could identify eggs and their products as related to the pathogen. To inform consumers about the risk of *Salmonella enteritidis* illness from eating raw or undercooked eggs and foods containing them, USDA, FDA, CDC, and the egg industry are providing information to consumers on safe practices for egg storage, preparation, and cooking.

In the near future, consumers may also be able to select pasteurized shell eggs. In April 1996, Minneapolis-based Michael Foods began

test-marketing pasteurized shell eggs—marked with a stylized “P” for easy identification by shoppers, packaged in a clear plastic carton, and sealed with shrink-wrap allowing visual inspection. These eggs are priced at \$1.39-\$1.59 per dozen, compared with about \$1.00 per dozen for nonpasteurized shell eggs in the test-market area.

The New Hampshire-based Pasteurized Eggs, L.P., recently received preliminary FDA clearance for its pasteurization process. According to the firm, the process is expected to cost 12 cents per dozen of shell eggs, and the firm has just begun to make their equipment available to egg producers.

Pathogen Control Also Reduces Risk

In 1990, USDA instituted two new programs aimed at controlling *Salmonella enteritidis* in egg laying operations. First, mandatory testing of breeder flocks for the pathogen was begun to eliminate transmission of the pathogen to laying hens and their environments. Second, a traceback program to identify flocks implicated in human foodborne outbreaks of salmonellosis was initiated. Under this traceback program, if the pathogen was detected at the farm of origin of the implicated eggs, then eggs from that source could not be sold as shell eggs. These eggs could, however, be pasteurized and subsequently sold as either hard-cooked eggs or pasteurized egg products. Furthermore, producers whose hens tested positive for *Salmonella enteritidis* could resume the sale of shell eggs only after compliance with USDA requirements which included eliminating flocks infected with *Salmonella enteritidis* and cleaning and disinfecting the premises prior to restocking with uninfected birds. In October 1995, as private and State-level *Salmonella enteritidis* control programs emerged, Congress deferred

Federal funding to USDA for *Salmonella* control, and USDA discontinued its involvement in the traceback program. FDA currently has responsibility for the Federal program.

The first of the programs initiated by industry, the Pennsylvania Egg Quality Assurance Program, began in April 1992. This is a cooperative effort between the Pennsylvania poultry industry, USDA, Pennsylvania Department of Agriculture, and two universities to reduce the number of eggs contaminated with *Salmonella enteritidis*. Producer participation in the program is voluntary.

Since then, other egg quality-assurance programs have emerged, such as the Maine/New England Risk Reduction Program, the California Egg Quality Assurance Program, and the United Egg Producers' Five-Star Program. *Salmonella enteritidis* control measures used in each of these quality-assurance programs vary widely and may include testing for the pathogen, cleaning and disinfecting houses and equipment, rodent and pest control, and refrigerating eggs immediately after collection.

USDA and FDA recently announced plans to initiate rulemaking to establish science-based standards for proper refrigeration of shell eggs from farm to retail. This joint effort is aimed at replacing a 1991 amendment to the Egg Products Inspection Act that USDA viewed as ineffective in minimizing bacterial

growth and inadequate for protecting consumers. The 1991 amendment requires an ambient temperature of 45 °F for storing shell eggs. However, in practice, an ambient temperature of 45 °F does not necessarily reflect the temperature inside an egg, which may often be higher than the ambient temperature. Scientific research has shown that internal egg temperatures of 45 °F or lower are necessary to reduce the risk of *Salmonella enteritidis* multiplication.

As with most food-safety problems, the public-health risk from *Salmonella enteritidis* in eggs needs to be addressed at every stage from the farm to the table. Producers and consumers working together can reduce the risk of *Salmonella enteritidis* illness from egg consumption. Producers are working to develop effective quality-assurance programs. Consumers can take protective actions, such as not eating raw or undercooked eggs, and thoroughly cooking all foods containing eggs.

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Michael Foods' logo provides easy identification of their pasteurized shell eggs.