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Prevalence of High-Risk Egg-Preparation Practices in Restaurants That Prepare Breakfast Egg Entrées: An EHS-Net Study

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ABSTRACT

Salmonella enterica serotype Enteritidis (SE) is a common cause of foodborne illness in the United States. Foods prepared with raw shell eggs have often been associated with SE outbreaks. The federal government published the Egg Safety Action Plan in December 1999 that called for reduction of egg-preparation practices that may contribute to the survival and proliferation of SE. In seven states, an interview and brief site evaluation of 153 restaurants that prepare eggs during all hours of operation was conducted by the Environmental Health Specialists Network to determine the prevalence of such practices. Fifty-four percent (83 of 153) of restaurants pooled raw shell eggs not intended for immediate service. These pooled eggs were held a median of 4 h for scrambled eggs, 5.5 h for omelets, and 6 h for pancakes and French toast. Nearly 26% (39 of 152) of restaurants reported storing eggs at room temperature, and 5% (7 of 152) stored eggs on ice or in cold-water baths before cooking. Generally, eggs were cooked to 72 to 83°C, which is above the recommended final cook temperature of 63 to 68°C. Employees reported sanitizing utensils used to prepare eggs less than once every 4 h in 42% (57 of 136) of restaurants. Several areas were identified in which further emphasis might reduce egg-associated SE infections in accordance with Healthy People 2010 goals.

Infection with *Salmonella enterica* serotype Enteritidis (SE) remains an important public health problem in the United States. Although most foodborne illnesses go unreported, an estimated 1.4 million *Salmonella* infections occur each year in the United States *(16).* In 2001, 18% of isolates in the National *Salmonella* Surveillance system were SE *(4).* Numerous studies, including investigations of outbreaks, indicate many of these infections are acquired from eating SE-contaminated eggs *(11, 19).* In 2001, 23 states reported 46 confirmed SE-associated outbreaks to the Centers for Disease Control and Prevention (CDC), resulting in 1,681 reported illnesses and 102 hospitalizations. Of the 46 outbreaks reported in 2001, 61% (28 outbreaks) occurred in commercial food establishments. Implicated food items associated with transmission of the illness were confirmed in 52% (24) of the outbreaks, and eggs were identified 63% (15) of the time as an ingredient of the implicated food item *(5).*

In 1999, the President's Council on Food Safety and consumer and egg-industry advocates identified egg safety as an area of concern warranting immediate federal interagency action. This initiative led to the development of the Council's Egg Safety Action Plan to reduce the number of SE infections in the United States *(20).* Reducing the number of SE outbreaks is also one of the goals of the U.S. Department of Health and Human Services Healthy People 2010 initiative *(27).*

Because a substantial number of outbreaks have occurred in restaurants *(3, 5, 12, 19, 24),* studies are specifically needed to determine the prevalence of high-risk egg-preparation practices in restaurant kitchens. High-risk food-preparation practices associated with SE transmission include those that allow proliferation or survival of SE in or on eggs. Mixing of shelled raw eggs and then subsequently storing them at temperatures higher than the U.S. Food and Drug Administration (FDA) recommendation of 7°C *(9)* can permit one egg to contaminate a large batch of pooled eggs. The pooling of eggs has been documented as a food-preparation practice that results in outbreaks of SE infection *(26).* Other practices that support SE proliferation include improper hot or cold holding of eggs *(3, 15).* SE can survive when eggs are not cooked properly *(19).* Hedberg et al. *(11)* demonstrated that eating soft or slightly under-

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cooked scrambled eggs was associated with SE infection. Other high-risk food-preparation practices may facilitate contamination of equipment, food worker hands, or food items with SE. Contamination of properly cooked eggs by contact with contaminated items, such as improperly washed hands, has also been associated with SE transmission *(1, 12, 14).* The risk for SE transmission can be markedly reduced by use of pasteurized eggs, including pasteurized shell eggs, particularly in entrees containing undercooked eggs *(13, 25).*

The objective of this study was to identify the prevalence of high-risk egg-preparation practices and evaluate restaurant egg-preparation policies, including the use of pasteurized eggs, that may facilitate or hinder transmission of SE in restaurants that prepare a large volume of egg products.

MATERIALS AND METHODS

This study was conducted by staff of the Environmental Health Specialists Network (EHS-Net). The network, created by the CDC comprises environmental health specialists and epidemiologists at federal, state, and local levels who collaborate to evaluate food-preparation practices and policies and their relation to foodborne illness.

The EHS-Net selected a convenience sample of restaurants defined as facilities that prepare and serve breakfast-type egg entrées to customers throughout all hours of operation in 13 metropolitan areas in seven states: California, Connecticut, Colorado, Minnesota, New York, Oregon, and Tennessee. Each of these states participates in CDC's Emerging Infections program. Restaurants that serve breakfast-type egg entrées throughout the entire day were selected because they use large quantities of shell eggs and therefore have a large potential for handling SE-infected eggs. Lists of restaurants that met this definition were not available in all states; therefore, restaurants were selected by the most comprehensive list of food-service establishments available to the local regulatory authority. A database of restaurant ownership, number of meals served, or seating capacity was not available or easily obtainable in each state; thus, stratifying selection on these parameters was not possible. Only one restaurant from regional or national chains was included per area.

After obtaining permission from the restaurant, an EHS-Net specialist or a trained local environmental health specialist conducted an on-site interview with either the restaurant manager or another employee using a standardized questionnaire. The questionnaire included both checklists and open-ended questions about the restaurant demographics, food safety policies, and practices related to the preparation of omelets, soft-boiled eggs, hard-boiled eggs, fried eggs, scrambled eggs, poached eggs, French toast, and pancakes. Demographic information included restaurant ownership (independently owned versus a chain or franchise), where eggs were purchased, and the type of eggs used in the facility. Data collected on food safety policies and sanitation included information about manager food safety certification requirements, storage of shell eggs, the use of pasteurized and nonpasteurized shell eggs, type of egg entrées prepared, pooling of shelled eggs, and cooking practices. For this evaluation pooling of shelled eggs consists of breaking and combining more than one shell egg in preparation of multiple entrées not intended for immediate service. Two open-ended questions were used to identify the location of shell eggs before cooking and restaurant policy on washing and sanitizing whisks and bowls used to prepare egg entrées. Responses to the questions about where shell eggs are kept before cooking were classified into one of three categories: (i) eggs kept in a cooling unit before cooking, (ii) eggs stored at room temperature before cooking, and (iii) eggs kept on ice or in a cold-water bath before cooking. Responses to the question concerning restaurant policy on washing and sanitizing whisks and bowls used to prepare egg entrées were categorized into three groups: (i) whisks and bowls washed and sanitized at least once in 4 h, (ii) whisks and bowls washed and sanitized once in a 4- to 24-h period, and (iii) responses that did not fall into either of the aforementioned categories (e.g., utensils were washed and sanitized when needed, with no specific timeline noted). This study did not address the FDA Food Code recommendation 4-602.11, which stipulates that utensils and equipment may be cleaned less frequently than every 4 h if these items are kept in a refrigerated room or in an area maintained at specified temperatures and that these items be cleaned at a frequency specified based on the corresponding temperature *(9).*

Each interview was followed by a limited observational assessment that involved measuring the internal temperature of one uncooked shell egg in a cooling unit, taking final cook temperatures of three egg entrées, and assessing the location of handwashing facilities. From the batch of stored shell egg in a cooling unit, one egg was selected from the most central location to determine the internal temperature of an uncooked refrigerated shell egg. The temperature of the refrigerated shell egg was taken by inserting a thermocouple into the shell. Temperatures of an omelet, scrambled eggs, and French toast, prepared with no special requests, were measured using a thermocouple. Final cook temperatures were taken immediately after the entrée was cooked and immediately before it was served. All site visits were conducted at the restaurants 22 January through 26 February 2002.

Data were entered into Epi Info 6.04d *(7).* Microsoft Excel 2000 was used to categorize responses to open-ended questions *(2).* Data were analyzed using univariate and bivariate analyses performed with SAS 8.2 for Windows 2000 *(23).* Prevalence odds ratios (PORs) were used to investigate trends and differences in specific egg-preparation practices.

RESULTS

Demographics. A total of 153 restaurants were studied (Table 1). Of these, 63% (96 of 152) were independently owned restaurants, and 37% (56 of 152) were corporate chains or franchises. A median of 200 (25% quartile = 130; 75% quartile = 450) meals were served per day. All 153 restaurants used shell eggs. Eggs purchased were primarily grade AA shell eggs (109 of 141) from a wholesaler (124 of 153). Many restaurants used additional egg products such as pasteurized shell eggs (30 of 148), liquid egg products (88 of 153), and powdered egg product (9 of 150).

Food safety policies. Seventy percent (99 of 141) of restaurants reported that at least one manager had received food safety certification. Fifty-five percent (75 of 136) of restaurants reported washing and sanitizing their whisks and bowls at least once in 4 h. Nearly 42% (57 of 136) reported washing and sanitizing at least once during a 4- to 24-h period, and 3% (4 of 136) of the responses fell into the other category (Table 2).

Egg-preparation practices. Twenty-six percent (39 of 152) of restaurants reported holding eggs at room temperature before cooking, and 5% (7 of 152) kept eggs on ice

TABLE 1. *Demographics for 153 restaurants*

Parameter	No. (%) of restaurants
Restaurant ownership	
Independent	96 (63)
Chain or franchise	56 (37)
Missing[a]	1
Egg source	
Wholesaler	124 (81)
Local producer	27 (18)
Other	2 (1)
Shell eggs used	
Yes	153 (100)
No	0
Grade of shell eggs	
Grade AA	109 (77)
Grade A	32 (23)
Missing[a]	12
Pasteurized shell eggs used	
Yes	30 (20)
No	118 (80)
Missing[a]	5
Liquid eggs used	
Yes	88 (58)
No	65 (42)
Powdered eggs used	
Yes	9 (6)
No	142 (94)
Missing[a]	2

[a] Information was not provided and therefore was not included in analyses.

TABLE 2. *Self-reported egg-handling policies and practices in 153 restaurants*

Policies and practices	No. (%) of restaurants
Manager(s) has food safety certification	
Yes	99 (70)
No	42 (30)
Missing[a]	12
Restaurants pool shelled eggs	
Yes	83 (54)
No	70 (46)
Whisks and bowls washed and sanitized	
At least once in 4 h	75 (55)
4–24 h	57 (42)
Other	4 (3)
Missing[a]	17
Shell eggs held before cooking	
In a cooling device	106 (70)
At room temperature	39 (26)
On ice or in cold-water bath	7 (4)
Missing[a]	1

[a] Information was not provided and therefore was not included in analyses.

or in a cold-water bath before cooking (Table 2). Twenty percent (30 of 148) of restaurants used pasteurized shell eggs; 2 of those 30 restaurants used pasteurized shell eggs to prepare each of the eight egg entrées surveyed. The percentages of egg entrées prepared with pasteurized shell eggs versus nonpasteurized shell eggs were similar for all egg entrées. Overall, restaurant chains and franchises used pasteurized shell eggs to prepare egg entrées significantly more often (POR = 5; 95% confidence interval = 2, 11) than did independently owned restaurants (36% [20 of 56] of restaurant chains, 10% [10 of 96] of independent restaurants). Because of small sample size, this POR was not adjusted for modifiers such as volume of eggs prepared or the number of breakfast entrees prepared with pasteurized shell eggs.

Ninety-five percent (146 of 153) of restaurants reported preparing fried eggs. Poached eggs were prepared by 86% (132 of 153) of restaurants. Among restaurants that made omelets and scrambled eggs, 84% (128 of 153) used shell eggs to make omelets, and 86% (131 of 153) used shell eggs to prepare scrambled eggs. A median of two shell eggs were used to cook one order of pancakes, one order of French toast, an omelet, or one order of scrambled eggs.

Shelled eggs were pooled in 54% (82 of 153) of restaurants: 69% (66 of 96) of independently owned restaurants and 29% (16 of 56) of chains and franchises. Pooling practices were determined for the preparation of omelets, scrambled eggs, and the combined preparation of pancakes and French toast. The median number of shelled eggs pooled was 18 (25% quartile = 12; 75% quartile = 30) for the preparation of pancakes or French toast, 48 (25% quartile = 24; 75% quartile = 90) for the preparation of omelets, and 36 (25% quartile = 18; 75% quartile = 90) for scrambled eggs. The median amount of time between the the pooling of shelled eggs and the cooking of the product was 4 h (25% quartile = 2 h; 75% quartile = 24 h) for scrambled eggs, 5.5 h (25% quartile = 3 h; 75% quartile = 24 h) for omelets, and 6 h (25% quartile = 3.25 h; 75% quartile = 24 h) for pancakes or French toast.

Many restaurants in this study used nonpasteurized shell eggs to prepare soft or runny egg entrées. Soft or runny fried eggs were prepared by 78% (94 of 121) of restaurants, runny omelets by 42% (44 of 104), and soft poached eggs by 74% (83 of 112) (Table 3). Whether soft or runny eggs were prepared by customer request or as part of the establishment's regular practice was not determined.

No differences in practices or policies were reported among restaurants that employed at least one manager with food safety certification compared with restaurants who reported that they did not have a food safety–certified manager.

Observations. The median internal temperature of a raw shell egg in a refrigerator was 5°C. In 9% (13 of 139) of restaurants, a shell egg selected from a refrigerator had an internal temperature above the FDA-recommended ambient holding temperature for eggs of 7°C *(9)*. One internal

TABLE 3. *Self-reported types of egg entrées prepared in 153 restaurants*

Entrée	No. (%) of restaurants		
	Shell eggs used	Pasteurized shell eggs used	Prepared runny or soft with nonpasteurized shell eggs
Fried eggs			
Yes	146 (95)	24 (16)	94 (78)
No	7 (5)	122 (84)	27 (22)
Missing[a]	0	0	1
Poached eggs			
Yes	132 (86)	19 (15)	83 (74)
No	21 (14)	112 (85)	29 (26)
Omelets			
Yes	128 (84)	23 (18)	44 (42)
No	25 (16)	105 (82)	60 (58)
Missing[a]	0	0	1
Scrambled eggs			
Yes	131 (86)	25 (19)	61 (58)
No	22 (14)	106 (81)	45 (42)

[a] Information was not provided and therefore was not included in analyses.

temperature reading of <0°C was labeled as incorrect and eliminated from the data set.

Most final cook temperatures for scrambled eggs (43 of 86), omelets (35 of 62), and French toast (28 of 56) were 72 to 83°C (Figs. 1 through 3). The minimum temperature recorded for scrambled eggs was slightly lower than that for French toast and omelets. In this study, most egg entrées prepared closer to or below the recommended 63°C were prepared with pasteurized shell eggs, thus reducing the potential for SE transmission among contaminated undercooked nonpasteurized shell eggs.

Four final cook temperatures recorded as ≥100°C were flagged as inaccurate temperature measurements and were omitted from the analyses. The practice of pooling shelled eggs for use in scrambled eggs or omelets compared with preparing individual shell eggs for immediate service resulted in no differences in final cook temperatures. Data were not available for stratification of pooling practices for French toast.

Interviewers in 136 kitchens indicated whether a hand-washing station was present. Hand-washing stations were visible in 90% (123 of 136) of these kitchens. Interviewers then noted the presence of soap, hot water, and paper towels for hand washing and drying. Only one of 122 restaurants did not have soap at the hand sink; 2% (2 of 121) did not have hot water, and 3% (4 of 122) did not have paper towels near the hand-washing station. Interviewers also checked employee restrooms in 146 restaurants for signage reminding employees to wash their hands before returning to food preparation; 56% (81 of 146) had such signage. Interviewers did not assess whether food workers used hand-washing stations in the kitchens or in the employee restrooms.

DISCUSSION

In this multistate survey of restaurants that prepare egg entrées during all hours of operations, high-risk egg-preparation practices such as improper cold storage of shell eggs before cooking, pooling of eggs, and improperly washing and sanitization of utensils were common. Approximately 26% of restaurants improperly stored cold shell eggs before cooking them, 54% of restaurants pooled shelled eggs, and 42% of restaurants reported washing and sanitizing utensils used to prepare eggs less than once in a 4-h period. These specific findings have been identified as food-preparation practices that can contribute to foodborne outbreaks of SE in restaurants *(3, 14, 15)*. For example, in various egg-related SE-associated outbreaks in California, undercooking or improper holding temperatures of nonpasteurized pooled egg mixtures have been identified as potential causes *(3, 17, 18)*. In the current study, restaurants that pooled shelled eggs reported holding the eggs at ambient temperature for a mean of 4 to 6 h before cooking, depending on the entrée, and in some cases reported serving cooked eggs soft or runny. Restaurants with these practices may have a higher risk for transmitting SE. Even though final cook temperatures observed in this study were within the FDA-recommended range for eggs not broken for immediate service,

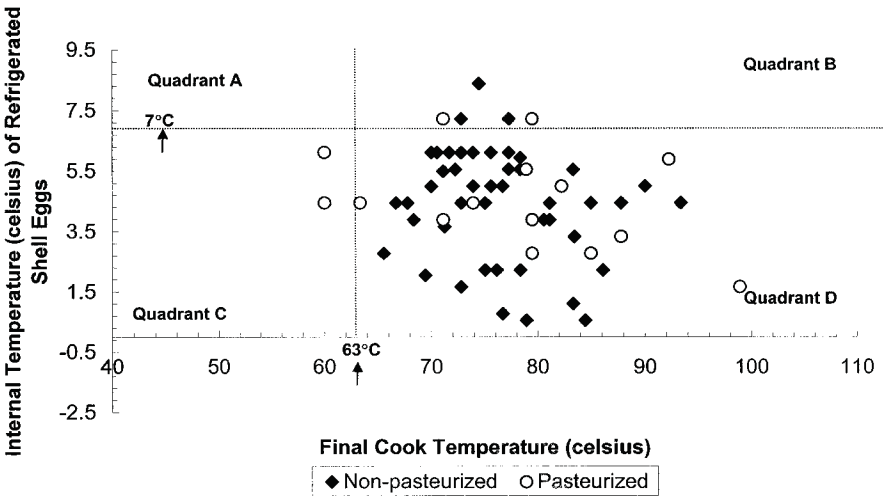

FIGURE 1. *Refrigeration and final cook temperatures for scrambled eggs. Arrows at 7 and 63°C represent the FDA-recommended refrigeration temperature and the final cook temperature of eggs, respectively. Quadrants represent eggs that are improperly refrigerated and undercooked (A), improperly refrigerated and correctly cooked (B), properly refrigerated and undercooked (C), and properly refrigerated and properly cooked (D).*

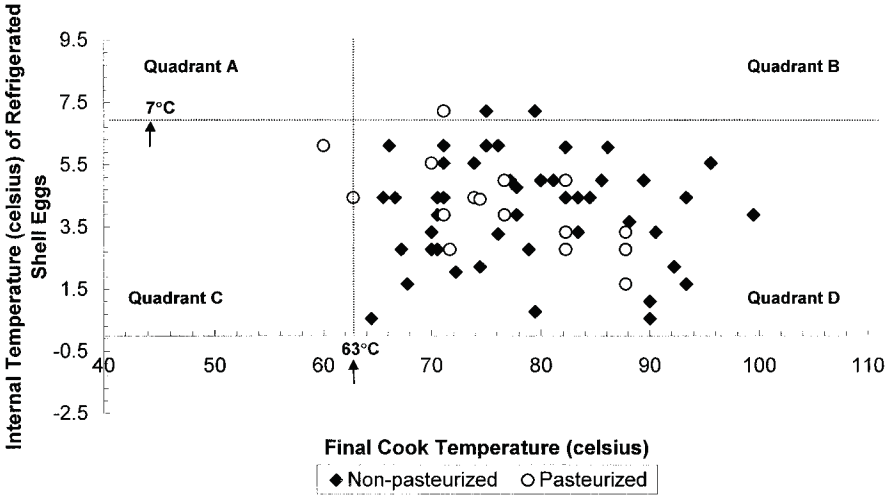

FIGURE 2. *Refrigeration and final cook temperatures for omelets. Arrows at 7 and 63°C represent the FDA-recommended refrigeration temperature and the final cook temperature of eggs, respectively. Quadrants represent eggs that are improperly refrigerated and undercooked (A), improperly refrigerated and correctly cooked (B), properly refrigerated and undercooked (C), and properly refrigerated and properly cooked (D).*

the practice of pooling shelled eggs provides an opportunity for multiplication and dissemination of SE in the restaurant. If cooked properly, an egg entrée produced from raw pooled eggs may not cause illness. However, pooling allows one infected egg to contaminate a much larger batch of pooled eggs; the batch of contaminated pooled eggs can then serve as a reservoir for SE in the restaurant. For example, when a whisk or other utensil is used in the pooled egg mixture and then not properly washed and sanitized that utensil can contaminate other food-contact surfaces, potentially resulting in the spread of SE in the kitchen. Hand contact with the contaminated pooled egg mixture and then with other surfaces is another possible route of exposure; hand washing can prevent this exposure.

The high prevalence of high-risk egg-preparation practices found in this study and the continuing occurrence of outbreaks of SE infections associated with eating eggs at restaurants emphasize the need for increased efforts to reduce the transmission of SE. Restaurants can reduce the likelihood of SE transmission by using pasteurized eggs and pasteurized egg products; use of pasteurized eggs may be particularly warranted for restaurants that serve large quantities of eggs. In the present study, only 20% of the restaurants that prepare eggs during all hours of operations used pasteurized shell eggs, and restaurant chains were more likely than independently owned restaurants to use pasteurized shell eggs, similar to the findings of Mohle-Boetani et al. *(18).* However, we did not determine whether restaurants that use pasteurized eggs prepare these eggs separately from nonpasteurized eggs or whether pasteurized eggs are used by customer request only.

More effort is needed to improve egg-preparation practices by food workers. Such efforts will require both educational and motivational approaches. Research has consistently shown that even when food workers know about safe food-preparation practices, they do not always use these practices *(6, 21).* Thus, to successfully reduce high-risk food-preparation practices in restaurants, researchers and restaurant managers must focus on a variety of factors in addition to education that influence behavior, such as facilitators of and barriers to food safety implementation, workplace norms, and the influence of these factors on behavioral change *(6, 8, 10, 22).*

Several limitations are evident in this study of predominately self-reported egg-preparation practices from a convenience sample of restaurants selected from registries of food-service establishments. A convenience sample is more subject to bias than is a random sample, and bias could

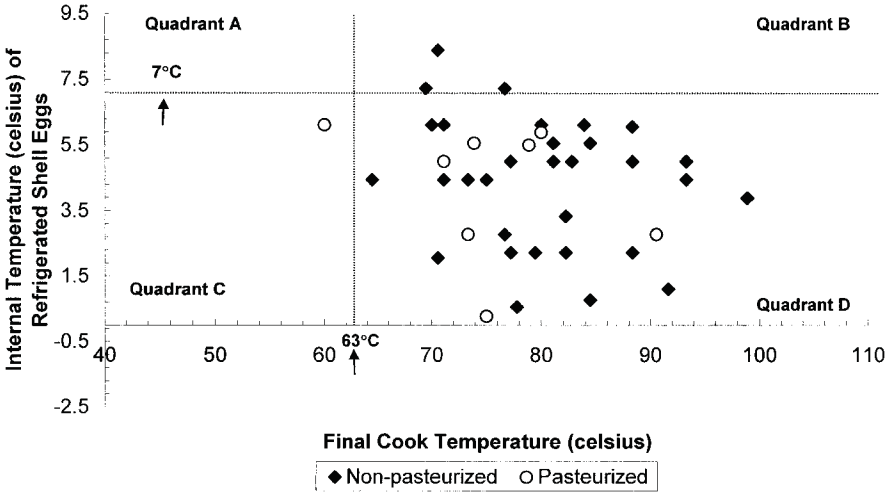

FIGURE 3. *Refrigeration and final cook temperatures for French toast. Arrows at 7 and 63°C represent the FDA-recommended refrigeration temperature and the final cook temperature of eggs, respectively. Quadrants represent eggs that are improperly refrigerated and undercooked (A), improperly refrigerated and correctly cooked (B), properly refrigerated and undercooked (C), and properly refrigerated and properly cooked (D).*

have affected our results, specifically the comparison of practices used in independently owned restaurants with those used in chains and franchises. However, a random sample of facilities that prepare and serve breakfast-type egg entrées to customers throughout all hours of operation could not be obtained in all seven states enrolled in this study. Although some observational data were collected, none of the information collected through self-report was validated by observation. Selection of a restaurant chain was limited to include only one type of chain per area because regional and national chains tend to adhere to the same company policies and food-preparation practices; once the data were aggregated, there was no way to distinguish whether a type of restaurant chain was represented in more than one state. Restaurants may have prepared more shell egg entrées than the eight that we evaluated. The length of time an egg had been cooled before being selecting by the interviewer for determination of the internal temperature was not recorded in this study. A few final cook temperatures appeared to be abnormally high. The high temperature readings could have resulted from steaming of egg entrées before service; these temperatures were interpreted as inaccurate and omitted from our analyses. Despite assurances from the interviewers that information collected would not incur regulatory action, food workers knew they were being monitored and may have altered their routine practices.

This multistate study of restaurants that serve egg entrées during all hours of operation revealed limited use of pasteurized eggs and a high prevalence of food-preparation practices that could facilitate the spread of SE. Restaurants, particularly those that prepare large quantities of eggs, should be informed of the egg-preparation practices that can lead to SE transmission. These restaurants also should be encouraged to use pasteurized shell eggs. To develop appropriate practices for prevention of SE infection, additional research is needed to identify the barriers and facilitators of safe egg-preparation practices in restaurants and to encourage the use of pasteurized eggs.

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