

## Research Paper

# Ground Beef Handling and Cooking Practices in Restaurants in Eight States†

APRIL K. BOGARD,<sup>1\*</sup> CANDACE C. FULLER,<sup>2</sup> VINCENT RADKE,<sup>3</sup> CAROL A. SELMAN,<sup>3</sup> AND KIRK E. SMITH<sup>2</sup>

<sup>1</sup>Environmental Health Division and <sup>2</sup>Acute Disease Investigation and Control Section, Minnesota Department of Health, P.O. Box 64975, St. Paul, Minnesota 55164-0975; and <sup>3</sup>Centers for Disease Control and Prevention, National Center for Environmental Health, 1600 Clifton Road, Atlanta, Georgia 30341, USA

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### ABSTRACT

Eating in table-service restaurants has been implicated as a risk factor for *Escherichia coli* O157:H7 infection. To explore this association and learn about the prevalence of risky ground beef preparation practices in restaurants, the Environmental Health Specialists Network (EHS-Net) assessed ground beef handling policies and practices in restaurants in California, Colorado, Connecticut, Georgia, Minnesota, New York, Oregon, and Tennessee. Eligible restaurants prepared and served hamburgers. EHS-Net specialists interviewed a restaurant employee with authority over the kitchen (defined as the manager) using a standard questionnaire about food safety policies, hamburger preparation policies, and use of irradiated ground beef. Interviews were followed by observations of ground beef preparation. Data from 385 restaurants were analyzed: 67% of the restaurants were independently owned and 33% were chain restaurants; 75% of the restaurants were sit down, 19% were quick service or fast food, and 6% were cafeteria or buffet restaurants. Eighty-one percent of restaurants reported determining doneness of hamburgers by one or more subjective measures, and 49% reported that they never measure the final cook temperatures of hamburgers. At least two risky ground beef handling practices were observed in 53% of restaurants. Only 1% of restaurants reported purchasing irradiated ground beef, and 29% were unfamiliar with irradiated ground beef. Differences in risky ground beef handling policies and practices were noted for type of restaurant ownership (independently owned versus chain) and type of food service style (sit down versus quick service or fast food). This study revealed the pervasiveness of risky ground beef handling policies and practices in restaurants and the need for educational campaigns targeting food workers and managers. These results highlight the importance of continued efforts to reduce the prevalence of *E. coli* O157:H7 in ground beef.

Foodborne *Escherichia coli* O157:H7 infections continue to be a significant public health problem in the United States, causing an estimated 61,153 illnesses and 20 deaths per year (15). Substantial monetary costs are also associated with foodborne *E. coli* O157:H7 infections (5). In numerous outbreak investigations and evaluations of sporadic *E. coli* O157:H7 infection cases, consumption of ground beef has been identified as a leading cause of infection (1, 4, 10, 14, 18).

Approximately half of the average American's food budget is spent on meals away from home (3, 19), and the National Restaurant Association (13) estimated that restaurant sales account for approximately 4% of the U.S. gross domestic product. More than 80% of Americans report eating out at least once per week (9, 17). In 2004, 8.2 billion hamburgers were served in commercial food establishments in the United States (12).

Eating in restaurants is also a risk factor for *E. coli* O157:H7 infection (9, 10, 17, 18). This association between infection and restaurants involves two factors: (i) consumption of pink hamburgers at the restaurants and (ii) simply eating at a sit-down restaurant (i.e., table service) regardless of what is eaten there (9, 10). This latter finding may indicate a problem with cross-contamination of ready-to-eat (RTE) foods from raw ground beef in table-service restaurants (8).

Our study was conducted to explore the association between *E. coli* O157:H7 infections and eating in restaurants. To learn about the prevalence of risky ground beef preparation practices in restaurants, we evaluated ground beef preparation and cooking policies and practices in restaurants that serve hamburgers, focusing on ground beef preparation practices that could lead to cross-contamination of RTE foods from raw ground beef and practices that could lead to undercooking of hamburgers made from ground beef. Both categories of practices (referred to as risky ground beef handling practices) could facilitate the transmission of *E. coli* O157:H7 to restaurant patrons. We also examined the association between several restaurant characteristics (presence of a certified food manager [CFM], restaurant ownership, and restaurant type) and ground beef preparation practices.

\* Author for correspondence. Tel: 651-201-5076; Fax: 651-201-4514; E-mail: april.bogard@state.mn.us.

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## MATERIALS AND METHODS

**Sample selection.** This study was conducted by the Environmental Health Specialists Network (EHS-Net), a network of environmental health specialists and epidemiologists focused on the investigation of factors contributing to foodborne illness. EHS-Net is a collaborative project of the Centers for Disease Control and Prevention (CDC), the U.S. Food and Drug Administration (FDA), the U.S. Department of Agriculture (USDA), and state and local health departments (16). At the time this study was conducted, the EHS-Net sites were located in California, Colorado, Connecticut, Georgia, Minnesota, New York, Oregon, and Tennessee.

At each site, EHS-Net staff selected a convenience sample of regulatory jurisdictions (e.g., counties or cities) and obtained a list of all known restaurants within those jurisdictions. Each site was expected to enroll a minimum of 50 eligible restaurants randomly chosen from a list of restaurants in the selected jurisdictions. Eligible restaurants were defined as those that prepared and served hamburgers or cheeseburgers to customers and that met the EHS-Net definition of a restaurant (i.e., establishments that prepare and serve food or beverages to customers but are not institutions, food carts, mobile food units, temporary food stands, supermarkets, restaurants in supermarkets, or caterers). Only one restaurant from a particular local or national chain was included per site.

EHS-Net staff contacted the randomly chosen restaurants by telephone to ensure they met the eligibility requirements for inclusion in the study. When the restaurant was eligible, EHS-Net staff read restaurant personnel a short introduction describing the purpose of the study and how the collected data would be used. EHS-Net staff then arranged a convenient time to conduct an onsite interview and observe ground beef preparation. Only English-speaking managers were interviewed (i.e., when a manager was not English speaking, an English-speaking staff member responsible for management issues was interviewed instead).

Data were collected from April 2004 through September 2004. The study protocol was cleared by the CDC Institutional Review Board. Data collection was anonymous; i.e., no data were collected that could identify individual restaurants or managers.

**Data collection.** Once at the restaurant, EHS-Net staff obtained verbal consent from and conducted an interview with the owner, manager, chef, or other restaurant employee with authority over the kitchen (hereinafter referred to as the manager). The interview was designed to assess restaurant characteristics (e.g., ownership of the restaurant and approximately how many meals served daily) and general food safety practices with questions such as “Does the restaurant have at least one manager who is food safety certified?”; “Are employees required to report diarrhea and/or vomiting illnesses to the manager?”; and “Does the restaurant have a consumer advisory regarding the risk of eating undercooked hamburger or ground beef?” Other characteristics assessed included ground beef temperature control practices: whether final cook temperatures of hamburgers were measured with a thermometer, subjective measures were used to determine hamburger doneness (e.g., color of meat), temperatures of fresh ground beef were measured, hamburger patties were cooked to order or cooked and held for later service, and hamburger patties were cooked from a frozen or partially frozen state. Practices pertinent to potential cross-contamination were also assessed, e.g., whether hamburger was ground in the restaurant or hamburger patties were formed in the restaurant. Some practices assessed in the interview, such as failing to measure the final cook temperature of hamburgers, are considered risky foodborne illness practices. Some practices, such as grinding hamburger in the restaurant,

could increase foodborne illness risk if improperly implemented. Because irradiation of ground beef effectively destroys *E. coli* O157:H7 thereby substantially decreasing the risk of illness caused by cross-contamination or undercooking (20), the manager interview also assessed the restaurants’ use of irradiated ground beef. Likert scales were used for responses to some of the questions in the interview; managers were asked to answer using the terms “always,” “often,” “sometimes,” “rarely,” and “never.”

Interviews were followed by observations of the food preparation areas, which were recorded on a form developed by EHS-Net. EHS-Net staff assessed temperature control practices and practices that could lead to cross-contamination. They also assessed whether hamburgers cooked in the restaurant during their observation were cooked to the FDA’s recommended temperature of 155°F (68.3°C) by measuring the final cook temperature of one hamburger with a thermocouple (22, 24).

At the time temperatures were measured, EHS-Net staff also asked the cook or chef how the customer requested the hamburger be cooked. EHS-Net staff also assessed the occurrence of the following practices that could lead to cross-contamination: lack of hand washing between handling of raw ground beef and cooked ground beef or other RTE foods, use of the same utensils (without washing, rinsing, or sanitizing between uses) or gloved hands (with no glove change between uses) on raw ground beef and cooked ground beef or other RTE foods, and wiping hands on a wiping cloth or apron after handling raw ground beef (without hand washing between handling times).

EHS-Net staff also assessed through observation whether the restaurant was a quick-service or fast-food restaurant, where customers pay before they eat; a regular sit-down restaurant, where customers pay after they eat; or a cafeteria or buffet restaurant, where customers get their food themselves (regardless of whether they pay before or after they eat). Independently owned restaurants were defined as those with only one location; chain restaurants were defined as those with more than one location.

**Statistical analysis.** Data from each state were entered into a Web-based system developed by EHS-Net. EpiInfo 2000 (CDC, Atlanta, GA), Excel 2000 (Microsoft, Redmond, WA), and SAS version 9.2, (SAS Institute, Cary, NC) were used for data analysis. Descriptive statistics on the ground beef preparation practice variables were obtained. Bivariate analyses were conducted to examine associations between three restaurant characteristics of primary interest and ground beef preparation practices. The restaurant characteristics of interest included whether the restaurant reported having a CFM, type of ownership (independently owned versus corporate or franchise chain), and type of food service (sit down versus quick service or fast food).

For both the bivariate and multivariate analyses, questions with Likert scale responses were recoded as binary variables by combining “always” and “often” into one category and combining “sometimes,” “rarely,” and “never” into a second category.

## RESULTS

**Restaurant demographics.** Of the 2,645 restaurants that were contacted, 778 were eligible for the study, and of these, 390 (50%) agreed to participate. Because of substantial missing data, five restaurants were excluded from analyses. Sixty-seven percent (258) of the managers of the 385 restaurants included in the study said their restaurants were independently owned, and 33% (126) said their restaurants were chain restaurants. EHS-Net staff

classified 75% (290) of the study restaurants as sit down, 19% (72) as quick service or fast food, and 6% (23) as cafeteria or buffet. Ten percent (37) of study restaurants were independently owned, quick service or fast food; 57% (205) were independently owned, sit down; 10% (35) were chain, quick service or fast food; and 23% (84) were chain, sit down.

Managers reported the number of meals served per day at their restaurant, the number of restaurant employees, and the number of years they had been working in the food service industry. The median number of meals served per day in study restaurants was 178 (range, 3 to 7,143), with a median of 120 hamburgers (range, 2 to 10,000) served weekly. The median number of employees was 16 (range, 1 to 170), and 65% (252) of interviewed managers reported they had been working in the food service industry for >15 years.

**Manager interview data on general food safety practices.** Manager interview data are provided in Table 1. Seventy-nine percent of managers said at least one manager in their restaurant was a CFM; 17% said this was not the case. Seventy-one percent of managers said workers were required to tell a manager when they were experiencing gastrointestinal illness symptoms; 28% said this was not the case. Twenty percent of managers said their restaurants had posted a consumer advisory regarding the risk of eating undercooked hamburger or ground beef; 77% said this was not the case. Sixty-two percent of the posted consumer advisories were in states that required a consumer advisory. Three states required posting a consumer advisory; 20% (10 of 50) of the restaurants in New York complied, 24% (12 of 50) in Georgia complied, and 48% (25 of 52) in Connecticut complied. Five states had no requirement for posting a consumer advisory; 4% (2 of 46) of the restaurants in California, 4% (2 of 52) in Tennessee, 6% (2 of 32) in Oregon, 10% (5 of 51) in Colorado, and 23% (12 of 52) in Minnesota posted consumer advisories voluntarily.

**Manager interview data on temperature control and cross-contamination.** A majority (77%) of managers said that they did not always (i.e., sometimes, rarely, or never) measure the final cook temperature of hamburgers with a thermometer (Table 1). A high percentage of managers said that they measured the “doneness” of hamburgers by methods other than measuring the temperature of hamburger: 49% said that they always or often checked doneness by the color of the inside of the hamburger; 61% said that they always or often checked doneness by the external appearance of the hamburger (e.g., “the juices run clear”); and 37% said that they always or often checked doneness by the feel or texture of the hamburger. Sixty percent (228) of managers said they received fresh (i.e., not frozen) ground beef. Of these, 65% said they never measured the temperature of fresh ground beef upon delivery. Thirty percent of managers said that they often or always cooked hamburgers from a frozen or partially frozen state. Eight percent of managers said that they often or always cooked hamburgers and held them for

later service. Three percent of managers said that they often or always ground hamburger in the restaurant. Twenty-two percent said that they often or always formed hamburger patties in the restaurant.

**Manager interview data on the use of irradiated ground beef.** When asked how often their restaurant used irradiated ground beef, 29% (110 of 384) of managers reported not knowing what irradiated ground beef was. Of the remaining 274 managers, 2% (5) said that they had used irradiated ground beef (3 said that they always use it; 2 said that they sometimes use it), 81% (223 of 274) said that they have never used irradiated ground beef, and 17% (46 of 274) said that they did not know how often they used irradiated ground beef.

Respondents with at least some college education were more likely to be familiar with irradiated ground beef than were respondents with a high school diploma or less (odds ratio [OR], 2.57; 95% confidence interval [CI], 1.51 to 4.36;  $P < 0.001$ ). Managers who said they had never used irradiated ground beef were asked a follow-up question: “What prevents the restaurant from using irradiated ground beef?” Managers provided multiple reasons; the most common reason was “I didn’t know I could get it” ( $n = 75$ , 34%), followed by “product not available” ( $n = 46$ , 21%), “cost” ( $n = 35$ , 16%), “not acceptable to customers” ( $n = 30$ , 13%), “safety concerns” ( $n = 30$ , 13%), “purchasing is a corporate decision” ( $n = 28$ , 13%), and “taste/texture/quality” ( $n = 19$ , 8%).

**Observation data on temperature control practices.** Data on temperature control practices are provided in Table 2. Hamburgers were being cooked in 234 restaurants during the EHS-Net staff observations. The median temperature of these 234 hamburgers as measured by EHS-Net staff was 172°F (77.8°C) (range, 113 to 210°F [45 to 98.9°C]).

Twelve percent of the hamburgers were undercooked (cooked to <155°F [68.3°C]). The percentage of undercooked hamburgers differed by customer-requested level of doneness. For example, 40% of the hamburgers requested as medium rare by customers were undercooked, whereas only 8% of the hamburgers customers requested as well done were undercooked.

**Observation data on cross-contamination.** Data on cross-contamination are provided in Table 3. Ground beef burger preparation was occurring in 247 restaurants during the EHS-Net staff observations. No hand washing was observed between handling raw ground beef and RTE foods or cooked ground beef in 62% of restaurants in which bare hands were used to handle ground beef. In 37% of restaurants, the same utensils (without washing, rinsing, or sanitizing between uses) or gloved hands (without changing gloves between handling times) were used on raw ground beef and RTE foods. In 42% of restaurants, the same utensils (without washing, rinsing, or sanitizing between uses) or gloved hands (without a glove change between handling times) were used on raw ground beef and cooked

TABLE 1. Data from manager interviews about general food safety, ground beef temperature control, and practices that could lead to cross-contamination

Interview item	n (%) <sup>a</sup>
<b>General food safety</b>	
At least one manager was a CFM (certified in food safety)	
Yes	304 (79)
No	66 (17)
Respondent did not know	15 (4)
Employees required to report gastrointestinal illness to a manager	
Yes	272 (71)
No	108 (28)
Respondent did not know	5 (1)
Displayed consumer advisory regarding the risk of eating undercooked animal products	
Yes	76 (20)
No	295 (77)
Respondent did not know	12 (3)
<b>Temperature control</b>	
Measured with thermometer the final cook temperature of hamburgers	
Always	46 (12)
Often	40 (10)
Sometimes	58 (15)
Rarely	49 (13)
Never	190 (49)
Do not know	2 (1)
Determined doneness by color (internal appearance)	
Always	112 (29)
Often	78 (20)
Sometimes	55 (14)
Rarely	13 (3)
Never	125 (33)
Do not know	2 (1)
Determined doneness by the way it looks (external appearance, i.e., “the juices run clear”)	
Always	151 (39)
Often	84 (22)
Sometimes	49 (13)
Rarely	12 (3)
Never	88 (23)
Determined doneness by feel or texture	
Always	85 (22)
Often	56 (14)
Sometimes	66 (17)
Rarely	18 (5)
Never	157 (41)
Do not know	3 (1)
Measured with thermometer the temperature of fresh ground beef when delivered to restaurant <sup>b</sup>	
Always	44 (19)
Often	10 (4)
Sometimes	13 (6)

TABLE 1. Continued

Interview item	n (%) <sup>a</sup>
Rarely	14 (6)
Never	147 (65)
Cooked hamburgers from a frozen or partially frozen state	
Always	104 (27)
Often	11 (3)
Sometimes	44 (11)
Rarely	26 (7)
Never	199 (52)
Cooked hamburger and held for later service	
Always	23 (6)
Often	7 (2)
Sometimes	18 (5)
Rarely	12 (3)
Never	324 (84)
Served hamburgers rare or medium rare upon customer request	
Always	180 (47)
Often	11 (3)
Sometimes	13 (4)
Rarely	12 (3)
Never	165 (43)
<b>Practices that could lead to cross-contamination</b>	
Grind hamburger in restaurant	
Always	6 (2)
Often	2 (1)
Sometimes	9 (2)
Rarely	9 (2)
Never	358 (93)
Formed hamburger patties in restaurant	
Always	81 (21)
Often	7 (2)
Sometimes	9 (2)
Rarely	8 (2)
Never	279 (73)

<sup>a</sup> Study included 385 restaurants; however, those with missing responses were excluded from analysis, so percentages were not calculated based on N = 385 in all cases.

<sup>b</sup> Percentages were based on N = 228 because only those restaurants that received fresh ground beef answered this question.

ground beef. Hands were wiped on wiping cloths or aprons after handling raw ground beef (without hand washing between handling times) in 40% of restaurants. Two or more of these four practices were seen in 53% (132 of 247) of the restaurants where practices that could lead to cross-contamination were observed.

**Restaurant characteristics associated with food safety and ground beef preparation practices.** In bivariate analysis, the presence of a CFM was significantly associated with several food safety and ground beef preparation practices. Managers in restaurants with a CFM said that workers were required to tell a manager when they were experiencing gastrointestinal illness symptoms more

TABLE 2. Data from cook or chef interview about customer ordering preferences and observational data on temperatures of cooked hamburgers in 234 restaurants

Level of doneness <sup>a</sup>	No. (%) of customer requests	Median (range) temp, °F [°C], of cooked hamburger <sup>b</sup>	No. (%) of undercooked hamburgers <sup>c</sup>
Medium rare	15 (6)	158 (113–184) [70 (45–84.4)]	6 (40)
Medium	36 (15)	166 (128–186) [74.4 (53.3–85.6)]	10 (28)
Medium well	68 (29)	174 (145–205) [78.9 (62.8–96.1)]	4 (6)
Well	50 (22)	179 (135–210) [81.7 (57.2–98.9)]	4 (8)
Preference not considered <sup>d</sup>	65 (28)	177 (137–210) [80.6 (58.3–98.9)]	5 (7)
Total	234 (100)	172 (113–210) [77.8 (45–98.9)]	29 (12)

<sup>a</sup> Question asked of the chef: “How did the customer request this hamburger be cooked?”

<sup>b</sup> Final cook temperature as measured by EHS-Net staff.

<sup>c</sup> “Undercooked” was defined as cooked to <155°F (68.3°C) because the Food Code states that ground beef patty should be cooked to 155°F for 15 s.

<sup>d</sup> Restaurant cooked hamburger to one level of doneness only and disregarded customer-requested level of doneness.

often than did managers in restaurants without a CFM (222 of 303 [73%] versus 37 of 63 [59%]; OR, 1.93; 95% CI, 1.10 to 3.38;  $P = 0.021$ ). Managers in restaurants with a CFM reported measuring the final cook temperature of hamburgers more often than did managers in restaurants without a CFM (79 of 303 [26%] versus 5 of 65 [8%] OR, 0.24; 95% CI, 0.09 to 0.61;  $P = 0.001$ ) and reported serving rare or medium-rare hamburgers upon customer

request less often (141 of 301 [47%] versus 42 of 65 [65%]; OR, 0.48; 95% CI, 0.28 to 0.84;  $P = 0.009$ ).

Table 4 provides information regarding the association between restaurant ownership type and food safety and ground beef preparation practices. Managers in independently owned restaurants said they had at least one CFM and required workers to tell a manager when they were experiencing gastrointestinal illness symptoms less often than did managers in chain restaurants. Independent restaurant managers said they measured the final cook temperature of hamburgers less often than did chain restaurant managers. Independent restaurant managers said they checked doneness of hamburgers by internal color, external appearance, and feel or texture more often than did chain restaurant managers. Independent restaurant managers said they measured the temperature of fresh ground beef delivered to the restaurant and cooked hamburgers from a frozen or partially frozen state more often than did chain restaurant managers. Independent restaurant managers said they formed hamburger patties in the restaurant and served rare or medium-rare hamburgers upon customer request more often than did chain restaurant managers.

Workers at independent restaurants were observed using the same utensils on raw ground beef and cooked ground beef products without the utensils being washed, rinsed, or sanitized between uses and wiping their hands on cloths or aprons after handling raw ground beef without hand washing between handling times more often than did workers at chain restaurants. A similar association with using the same utensils on raw ground beef and RTE foods approached statistical significance.

Table 5 provides information regarding the association between restaurant food service type and food safety ground beef preparation practices. Managers of sit-down restaurants said they served rare or medium-rare hamburgers upon customer request and checked doneness of hamburgers by feel or texture more often than did managers of quick-service restaurants. Managers of sit-down restaurants said that hamburger patties were cooked from a frozen or partially frozen state and that hamburger patties were

TABLE 3. Data on observed practices that could lead to cross-contamination from ground beef

Practice	<i>n</i> (%) <sup>a</sup>
Washed hands between handling raw ground beef and cooked ground beef or RTE foods ( $N = 192$ ) <sup>b</sup>	
Yes	73 (38)
No	119 (62)
Used same utensils (without washing, rinsing, sanitizing) or gloves (without changing) on raw ground beef and RTE foods	
Yes	88 (37)
No	152 (63)
Used same utensils (without washing, rinsing, sanitizing) or gloves (without changing) on raw ground beef and cooked ground beef	
Yes	104 (42)
No	143 (58)
Wiped hands on either wiping cloths or aprons after handling raw ground beef (without hand washing between handling times)	
Yes	93 (40)
No	141 (60)

<sup>a</sup> Ground beef preparation was observed in only 247 of the 385 study restaurants. Those with missing responses were excluded from analysis, so percentages were not calculated based on  $N = 247$  in all cases.

<sup>b</sup> Percentages were based on  $N = 192$  because in 51 restaurants no hand contact was observed during ground beef preparation, and thus there was no need for hand washing.

TABLE 4. Bivariate analysis of food safety and ground beef preparation practices by restaurant ownership type<sup>a</sup>

Interview item	No. (%) of independent restaurants	No. (%) of chain restaurants	Odds ratio (95% CI)	P
<b>General food safety practices</b>				
A minimum of one manager was a certified food manager	190/247 (77)	114/122 (93)	0.23 (0.11–0.51)	<0.001
Employees required to report gastrointestinal illness to a manager	171/253 (68)	101/126 (80)	0.52 (0.31–0.86)	0.011
<b>Temperature practices</b>				
Measured with thermometer the final cook temperature of hamburgers	43/255 (17)	43/127 (34)	0.40 (0.24–0.65)	<0.001
Determined doneness by color (internal appearance)	135/255 (53)	55/127 (43)	1.47 (0.96–2.26)	0.076
Determined doneness by way it looks (external appearance)	164/256 (64)	71/127 (56)	1.41 (0.91–2.17)	0.123
Determined doneness by feel or texture	107/254 (42)	34/127 (27)	1.99 (1.25–3.17)	0.003
Determined doneness by color, look, or texture (aggregate variable)	217/257 (84)	94/127 (74)	1.90 (1.13–3.21)	0.015
Measured with thermometer the temperature of fresh ground beef when delivered to restaurant	36/170 (21)	18/57 (32)	0.58 (0.30–1.14)	0.11
Cooked hamburger patties from frozen or partially frozen state	66/256 (26)	49/127 (39)	0.55 (0.35–0.87)	0.010
Cooked hamburger patties and held for later service	9/256 (4)	21/127 (17)	0.18 (0.08–0.41)	<0.001
Served rare or medium-rare hamburgers upon customer request	141/254 (56)	50/126 (40)	1.90 (1.23–2.93)	0.004
<b>Practices that could lead to cross-contamination</b>				
Ground hamburger in restaurant	6/256 (2)	2/127 (2)	1.50 (0.30–7.53)	1.000
Formed hamburger patties in restaurant	77/256 (30)	11/127 (9)	4.54 (2.31–8.90)	<0.001
Washed hands between handling raw ground beef and cooked ground beef or RTE foods	78/127 (61)	41/65 (63)	0.93 (0.50–1.73)	0.823
Used same utensils (without washing, rinsing, sanitizing) or gloves (without changing) on raw ground beef and RTE foods	59/143 (41)	29/97 (30)	1.65 (0.95–2.85)	0.074
Used same utensils (without washing, rinsing, sanitizing) or gloves (without changing) on raw ground beef and cooked ground beef	72/150 (48)	32/97 (33)	1.88 (1.10–3.19)	0.020
Wiped hands on either wiping cloths or aprons after handling raw ground beef (without hand washing between)	68/138 (49)	25/96 (26)	2.76 (1.57–4.85)	<0.001

<sup>a</sup> Because of missing data from nonresponse, denominators differ among practices.

cooked and held for later service less often than did managers of quick-service restaurants.

## DISCUSSION

This multistate study of restaurants that serve hamburgers revealed the pervasiveness of risky ground beef preparation practices in restaurants. These findings provide a possible explanation for the association between sporadic cases of *E. coli* O157:H7 infection and eating at table-service restaurants, as observed in a FoodNet case-control study (10). Specifically, the high potential for cross-contamination documented in this study reveals a mechanism by which restaurant patrons can acquire *E. coli* O157:H7 regardless of what they eat at the restaurant. The potential for undercooking hamburgers as documented in a substantial proportion of restaurants reinforces the epidemiologic link between sporadic cases of *E. coli* O157:H7 infection and eating pink hamburgers in restaurants.

In this study, differences in risky ground beef handling practices were seen by type of restaurant ownership (independently owned versus chain) and type of food service (sit down versus quick service or fast food). Many of the risky policies and practices documented in this study were observed in a significantly higher proportion of

independently owned restaurants than in chain restaurants. Sit-down restaurants served rare or medium-rare hamburgers upon customer request and their cooks checked the doneness of hamburgers by feel or texture more often than these practices occurred at quick-service restaurants.

In a nationwide study conducted between 1990 and 1992, Slutsker et al. (18) found that eating at a fast food restaurant was a risk factor *E. coli* O157:H7 infection. After the large outbreak of *E. coli* O157:H7 infection in the Pacific Northwest in 1992 and 1993 (1), the fast-food industry and government regulators implemented significant changes to food handling policies and practices in response to issues identified during the outbreak investigation. These changes included adopting the hazard analysis critical control point system, self-inspections, and increased food safety training and certification. In case-control studies conducted since the Slutsker et al. study (18), no association between sporadic cases of *E. coli* O157:H7 infection and quick-service or fast-food restaurants has been found, and these types of restaurants have not been an important venue for *E. coli* O157:H7 outbreaks in recent years. In our study, a higher number of risky ground beef practices were observed and reported in independent restaurants than in chain restaurants. The lower level of risky practices in chain

TABLE 5. Bivariate analysis of food safety ground beef preparation practices by restaurant service type<sup>a</sup>

Interview item	No. (%) of sit-down restaurants	No. (%) quick-service restaurants	Odds ratio (95% CI)	P
General food safety practices				
A minimum of one manager was a certified food manager	232/278 (83)	53/71 (75)	1.71 (0.92–3.19)	0.09
Employees required to report gastrointestinal illness to a manager	203/287 (71)	52/71 (73)	0.88 (0.49–1.58)	0.68
Temperature practices				
Measured with thermometer the final cook temperature of hamburgers	61/288 (21)	21/72 (29)	0.65 (0.36–1.17)	0.15
Determined doneness by color (internal appearance)	141/288 (49)	38/72 (53)	0.86 (0.51–1.44)	0.56
Determined doneness by way it looks (external appearance)	177/289 (61)	43/72 (60)	1.07 (0.63–1.81)	0.81
Determined doneness by feel or texture	117/287 (41)	16/72 (22)	2.41 (1.32–4.40)	0.004
Determined doneness by color, look, or texture (aggregate variable)	237/290 (82)	57/72 (79)	1.18 (0.62–2.24)	0.62
Measured with thermometer the temperature of fresh ground beef when delivered to restaurant	42/184 (23)	9/30 (30)	0.69 (0.29–1.62)	0.39
Cooked hamburger patties from frozen or partially frozen state	58/289 (20)	44/72 (61)	0.16 (0.09–0.28)	<0.001
Cooked hamburger patties and held for later service	4/289 (1)	20/72 (28)	0.04 (0.01–0.11)	<0.001
Served rare or medium-rare hamburgers upon customer request	172/286 (60)	15/72 (21)	5.73 (3.10–10.61)	<0.001
Practices that could lead to cross-contamination				
Ground hamburger in restaurant	4/289 (1)	20/72 (28)	0.04 (0.01–0.11)	<0.001
Formed hamburger patties in restaurant	66/289 (23)	17/72 (24)	0.96 (0.52–1.76)	0.89
Washed hands between handling raw ground beef and cooked ground beef or RTE foods	87/146 (60)	24/35 (69)	0.68 (0.31–1.48)	0.328
Used same utensils (without washing, rinsing, sanitizing) or gloves (without changing) on raw ground beef and RTE foods	68/175 (39)	14/50 (28)	1.63 (0.82–3.25)	0.160
Used same utensils (without washing, rinsing, sanitizing) or gloves (without changing) on raw ground beef and cooked ground beef	80/180 (44)	16/52 (31)	1.80 (0.93–3.48)	0.078
Wiped hands on either wiping cloths or aprons after handling raw ground beef (without hand washing between)	74/172 (43)	15/49 (31)	1.71 (0.87–3.37)	0.118

<sup>a</sup> Because of missing data from nonresponse, denominators differ among practices.

restaurants may be the results of better access to resources for developing and implementing (or requiring) standardized staff food safety training policies. In turn, this access to resources and intervention implementation may contribute to the reduction of *E. coli* O157:H7 transmission in chain restaurants.

In this study, a high proportion of restaurant managers reported that they always or often used subjective measures to determine the doneness of hamburgers and did not measure the final temperature of cooked hamburgers. Many food workers believe that these subjective measures are both an indicator of doneness and a dependable means of ensuring food safety. However, in several studies subjective measures have been neither a reliable indicator of doneness nor a dependable means of ensuring food safety (2, 11, 21).

Our study documented the extremely limited use of and knowledge about irradiated ground beef generally. The federal government approved using radiation to reduce foodborne pathogens in raw meat and meat products in 2000 (23) because it effectively destroys *E. coli* O157:H7 (20). Given the findings of our study and previous studies associating *E. coli* O157:H7 infection with eating in table-service restaurants in the United States, wider use of irradiated ground beef in restaurants might result in a substantial reduction in the number of *E. coli* O157:H7 infections. The use of irradiated ground beef might be a

more effective means of preventing *E. coli* O157:H7 infections in restaurants than would better staff training, especially in those restaurants that lack the resources or structure to develop and implement standardized policies and training programs (6). However, the limited availability of irradiated ground beef and its higher cost may be barriers to its increased use.

Risky ground beef temperature practices and practices pertinent to potential cross-contamination were reported and observed in our study, and restaurant managers reported that good general food safety practices often were not followed. For example, the presence of a CFM was beneficial in a previous study of restaurants that had and had not experienced foodborne illness outbreaks (7), and our data also revealed fewer risky food safety practices in restaurants with a CFM. However, 18% of the restaurants in our study had no CFM, and 28% of restaurants did not require food workers to report gastrointestinal illness to a manager. Even in states with required consumer advisories regarding the risk of undercooked animal products, compliance with the required advisory was poor. This finding of poor compliance with important and even mandated food safety policies indicates the need for interventions to improve the levels of compliance.

This study has limitations. First, it was conducted 9 years ago in 2004; however, no new data on the

association between *E. coli* O157:H7 infections and eating in restaurants have been published since then. *E. coli* O157:H7 infections remain a problem, and restaurants continue to be a common source of foodborne illness outbreaks. Regulations pertaining to restaurant practices in the United States have not changed greatly since 2004, and it is unlikely that restaurant practices have changed; therefore, our results probably are still relevant. Second, only one restaurant of any given chain was included per state because we assumed that most outlets in a particular chain followed the same or similar corporate policies and practices. This sampling design resulted in undersampling of chain restaurants. The design and low number of restaurants in certain categories (i.e., quick-service chain restaurants) prevented meaningful evaluation of both ownership type and food service style in multivariate models. Third, the response rate for this study was only 50%. Participation in the study was voluntary, and restaurants that declined participation may have conducted ground beef handling activities differently than restaurants that chose to participate. Fourth, we did not collect data on whether a restaurant had established ground beef standard operating procedures (SOPs). Use of thermometers to determine the final cook temperature of ground beef is a crucial food safety step. The finding that some managers used methods other than thermometers (e.g., color of ground beef) to determine the final cook temperature of ground beef is concerning. However, measuring the temperature of all cooked ground beef is not always necessary. In cases in which a restaurant has established SOPs that are tested and verified to ensure that these SOPs consistently address food safety hazards, the restaurant can rely on those SOPs. Thus, restaurants that have developed an SOP that has been tested and verified to result in consistent cooking of ground beef to the required temperature do not have to measure the temperature of all cooked ground beef when using the verified procedure. Fifth, food workers may have altered their practices because they knew they were being watched during the study; therefore, risky food handling practices may be more prevalent than what was observed in this study.

In conclusion, this study underscores the need for educational campaigns targeting food workers and managers. Training efforts should focus on the importance of avoiding cross-contamination, improving hand hygiene, and verifying the final cook temperatures of ground beef. Independently owned establishments should be a particular focus for this education. When food workers and managers cannot be adequately trained to follow safe ground beef handling practices, the increased use (or mandated use) of irradiated ground beef might help mitigate the problem of risky food handling practices such as those observed in our study. Additional efforts should be made to educate restaurant owners that irradiated ground beef, if available, is a viable option. Our study also demonstrates the importance of continued efforts by the beef processing industry and the USDA to continue to reduce the prevalence of *E. coli* O157:H7 in ground beef.

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