

Knowledge, Attitude, and Practice of the Use of Irradiated Meat among Respondents to the FoodNet Population Survey in Connecticut and New York†

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ABSTRACT

Irradiation of fresh meat to control microbial pathogens received approval from the federal government in February 2000. Food irradiation is a useful, albeit underutilized, process that can help protect the public from foodborne illnesses. The objective of this study was to determine consumer knowledge, attitudes, and practices toward irradiated meat products. Data were obtained from a single-stage random-digit dialing telephone survey of residents of the Foodborne Diseases Active Surveillance Network (FoodNet) sites conducted in 2002 to 2003, which included supplemental questions about food safety and irradiated meat for residents of the Connecticut and New York sites. Thirty-seven percent of 3,104 respondents knew that irradiated fresh meat was available for purchase; however, only 2% found the product where they shopped. Knowledge of product availability was significantly influenced by whether a respondent lived in a county with one or more grocery stores operated by chain A, which had actively promoted the sale of irradiated fresh ground beef during the survey period. In a logistic regression model, after adjusting for other factors, respondents living in a county with chain A were more likely to know that irradiated products could be purchased than respondents living in other counties (odds ratio 2.0; 95% confidence interval 1.5 to 2.5). This finding suggests that public education efforts by an individual grocery store chain can have an important effect on knowledge of irradiated food.

Despite numerous efforts to curtail foodborne diseases, foodborne pathogens were estimated in 1999 to be responsible for approximately 76 million illnesses and 5,000 deaths annually in the United States (16). While national data from the Foodborne Disease Active Surveillance Network (FoodNet) have shown declines in the incidence of laboratory-confirmed infections due to *Campylobacter*, *Escherichia coli* O157, and *Salmonella* (4), additional measures are needed to ensure a sustained reduction that meets national health objectives set out in Healthy People 2010 (20).

Substituting irradiated raw meat and poultry for non-irradiated products would reduce an individual's risk of acquiring a foodborne illness. Several pathogenic bacteria, including Shiga toxin-producing *E. coli*, *Campylobacter* sp., *Listeria* sp., and *Salmonella* serovars, are sensitive to irradiation. Food irradiation, also known as cold pasteurization, is not a new technology. The ability of irradiation to kill trichinae in pork was tested by the U.S. Department of Agriculture (USDA) as early as 1921 (18). Irradiation for pathogen control in raw poultry was approved by the U.S. Food and Drug Administration (FDA) in 1990 and the USDA in

1992 (13, 18). The use of irradiation for commercial fresh meat received approval from the federal government in February 2000 (19). Irradiation is also used to sterilize other items, including medical supplies, cosmetics, wine corks, and packaging materials (13, 21).

The estimated human health benefit of irradiating half of all ground beef, poultry, pork, and processed meat would be the prevention of at least 900,000 cases of foodborne infection, 8,500 hospitalizations, and 350 deaths each year (18). Despite this and endorsement from numerous health organizations including the World Health Organization, Centers for Disease Control and Prevention (CDC), and the American Medical Association, irradiated products have been slow to appear on supermarket shelves (14, 17). While irradiated beef products can be found across the country, only an estimated 15 million pounds of ground beef are irradiated each year, a small fraction of the 9 billion pounds of ground beef produced annually (5). Many in the food industry are reluctant to launch irradiated products for fear of an adverse reaction from the public (11).

Consumers often associate the term "irradiation" with radioactivity and have expressed concern about the safety of irradiated foods (17). Taste is also cited as a deterrent to purchasing irradiated meat. For example, changes in the odor and flavor have been cited when comparing irradiated and nonirradiated chicken (15). A similar evaluation of ground beef found that consumers had no difference in

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preference between irradiated and nonirradiated cooked ground beef (9).

Nevertheless, recent studies indicate interest among consumers in purchasing irradiated meat. The 1998 to 1999 FoodNet Population Survey found that nearly 50% of respondents were willing to buy irradiated meat and poultry (8). Willingness to purchase has also increased in recent years. A 2003 survey of consumers found that 69% were willing to buy irradiated meat, compared to only 29% in 1993 (12). Retail trials have shown that when irradiated and nonirradiated chicken was sold at the same price, the irradiated product had 43% of the market share (6). Studies have found that educating consumers about the safety and benefits of irradiation increases preference for those products (6, 9, 10).

In the 2002 to 2003 FoodNet Population Survey, the Connecticut and New York State Emerging Infections Programs included a module designed to assess state residents' knowledge and behaviors regarding irradiated meats, to guide education and other initiatives important for the promotion of irradiated meat.

MATERIALS AND METHODS

FoodNet is a collaborative sentinel site surveillance program for foodborne infections conducted under the auspices of the CDC Emerging Infections Program (4). FoodNet conducts periodic population-based telephone surveys to determine the food handling and consumption practices of individuals who reside in Emerging Infection Program (EIP) sites. Individual EIP sites may add site-specific modules to the survey covering issues of local interest. In the 12-month FoodNet Population Survey conducted between March 2002 and February 2003, residents of New York State (NYS) and Connecticut were asked a series of supplemental questions to assess their knowledge, attitude, and practice regarding the use of irradiated meat.

The survey was administered by an independent contractor (MACRO International, Burlington, Vt.) using methods similar to the Behavioral Risk Factor Surveillance System employed by the CDC (2). Households from the entire state of Connecticut (8 counties) and from 18 counties in upstate New York were contacted using single-stage random-digit dialing, Genesys-ID sampling method, after screening to remove business and nonworking phone numbers. Within each household, one member was randomly selected for interview. Approximately 150 interviews were conducted each month at each site. All respondents were asked demographic information, including age, sex, race or ethnicity, education level, estimated household income, zip code, home location (e.g., urban, suburban, rural), and presence of children in the household. Interviews were conducted in English and Spanish. Only respondents ≥ 18 years of age were included in this analysis.

To measure knowledge of food safety, respondents were first asked to respond "agree, disagree, or not sure" to a series of statements about bacteria and irradiation. For the statements "bacteria on raw meat can get into other foods" and "irradiation kills bacteria," dichotomous measures were created by classifying respondents as correctly responding to the statement (answered agree) or incorrectly responding to the statement (answered disagree or not sure). For the statement "a person can get irradiation exposure from eating irradiated ground beef or chicken" those who responded "disagree" were coded as correctly responding to the statement. Respondents were then informed that "several years ago, the U.S. Food and Drug Administration (FDA) approved the

use of irradiation for meats like hamburger and chicken" and asked "did you know that it's now possible to buy them"? A dichotomous measure of knowledge of irradiated meat availability was created by classifying respondents into two groups: persons who answered "yes," and persons who answered "no" or "not sure." Respondents' practices were assessed by asking those who knew it was available if they had ever looked for irradiated meat. Respondents were also asked their preference between a restaurant that used irradiated meat and one that did not in order to ascertain attitudes towards such products. Respondents who refused to answer were excluded from any analysis of that variable with the exception of income where a third category, "not reported," was created for the analysis to retain the large number of respondents with missing income data ($n = 475$; 15%).

A large multistate outbreak, which greatly impacted NYS and implicated fresh ground beef, occurred during the time the survey was administered (3). Shortly after this outbreak, in May 2002, a chain of grocery stores in upstate New York (chain A) began selling and actively promoting irradiated fresh ground beef. The answers of respondents living in a county with chain A (six counties in NYS) were compared to those respondents that lived in a county where chain A did not operate (12 counties in NYS, 8 counties in Connecticut). An examination of knowledge before and after the launch of chain A's promotional campaign was also conducted. The precampaign time frame for the survey was March to May 2002 and the postcampaign time frame was June 2002 to February 2003.

Data were analyzed using weighted proportions to compensate for unequal probabilities of selection and to reflect the surveillance population by age and sex. Response rates were defined according to standard formulas of the Council of American Survey Research Organizations. A binomial logistic regression model was used to calculate adjusted odds ratios to determine the effect of demographic and knowledge characteristics on respondent's knowledge of the availability of irradiated meat. Analyses were performed using SAS 9.1 (SAS Institute, Cary, N.C.).

RESULTS

A total of 3,104 respondents ≥ 18 years of age were surveyed in NYS ($n = 1,560$) and Connecticut ($n = 1,544$). Most were white, non-Hispanic between 30 and 59 years of age (Table 1). Within the group of respondents, 40% had some level of college education, 35% reported an income less than \$40,000 in 2000, and 27% had children in the household.

Ninety-four percent of respondents understood that bacteria on raw meat could contaminate other foods. A majority (55%) also understood that irradiation kills bacteria. However, 62% were unsure about the safety of irradiation. A majority (63%) of respondents were unaware of the availability of irradiated meat; only 37% knew one could buy this product. Of the 1,167 respondents who recognized the availability of irradiated meat, only 8% had looked for it in grocery stores during the previous year; of these, 75% actually found the product. Only 22% of respondents were more likely to choose a restaurant that used irradiated meat and more than a quarter (28%) felt that they did not know enough about irradiated meat to make such a decision.

Among respondents living in a county with chain A ($n = 1,016$), the grocery store that began selling and actively promoting irradiated fresh ground beef following an outbreak, 50% knew that irradiated meat could be purchased

TABLE 1. *Characteristics of respondents surveyed*

Characteristics	No. (%) of respondents ^a
State	
Connecticut	1,544 (50)
New York	1,560 (50)
Gender	
Male	1,236 (40)
Female	1,868 (60)
Race	
White	2,748 (89)
Black	196 (6)
Other	111 (4)
Missing	49 (2)
Ethnicity	
Hispanic	129 (4)
Not Hispanic	2,958 (95)
Missing	17 (1)
Age group	
18–29	449 (14)
30–59	1,881 (61)
60+	774 (25)
Location of residence	
City	919 (30)
Suburb	1,017 (33)
Town	732 (24)
Rural or farm	417 (13)
Missing	19 (1)
Education	
High school	1,820 (59)
College+	1,243 (40)
Missing	41 (1)
Annual household income	
<\$40,000	1,099 (35)
\$40,000+	1,530 (49)
Not reported	475 (15)
Children in household	
Yes	841 (27)
No	2,263 (73)

^a Percentages may not add up to 100% due to rounding errors.

compared to only 31% of those living in a county without chain A ($n = 2,088$). A disproportionate percentage of the people who had looked for (67%) and found (83%) irradiated products lived in a county with chain A. There was no difference in knowledge of the availability of irradiated meat pre- and postcampaign among respondents living in a county with chain A ($P = 0.28$). Among respondents living in a county with chain A, 46% knew one could buy irradiated meat precampaign increasing to 51% postcampaign. There was a significant difference in knowledge pre- and postcampaign among respondents living in a county without chain A ($P = 0.0001$); however, 37% knew one could buy irradiated meat precampaign, decreasing to 28% postcampaign.

Adjusted odds ratios (OR) for knowledge of the availability of irradiated meat are shown in Table 2. After con-

trolling for all variables, respondents living in a county with chain A were more likely than respondents living in other counties to know that irradiated products were available for purchase (OR, 2.0; 95% confidence interval [CI], 1.5 to 2.5). Other factors associated with knowing one could buy irradiated meats included any college education (OR, 1.3; 95% CI, 1.1 to 1.6) and an annual income above \$40,000 (OR, 1.3; 95% CI, 1.1 to 1.6). Persons who knew that raw meat can cross-contaminate other foods (OR, 2.9; 95% CI, 1.8 to 4.6) and that irradiation kills bacteria (OR, 2.0; 95% CI, 1.6 to 2.3) were also more knowledgeable about irradiated meat availability. Factors associated with being less likely to know one could buy irradiated products included living in Connecticut (OR, 0.7; 95% CI, 0.6 to 0.9), being 18 to 29 years old (OR, 0.5; 95% CI, 0.4 to 0.7), and believing that a person can get irradiation exposure from eating irradiated meat (OR, 0.4; 95% CI, 0.3 to 0.5). There was no difference in knowledge of product availability by interview month, sex, race, ethnicity, location of residence, or having children in the household.

DISCUSSION

The results of this survey support previous findings that there is a general lack of awareness among consumers regarding the availability of irradiated meat and misunderstandings about the safety of irradiated meat (8, 9, 12). While this study and others have found persons with a higher income and a college education are more informed about such products being on the market (6, 8, 14), the proportion knowledgeable within these strata remains low. Most respondents understood that raw meat can contaminate other foods and that irradiation was capable of killing harmful bacteria. However, a higher percentage of respondents were unsure that irradiation is a safe process. This is similar to results of a 2003 survey of 50 consumers in which 74% failed to disagree with the statement that “irradiated foods contain natural radioactivity” (12). These issues appear to influence a respondents’ knowledge about the availability of irradiated meat. This gap in knowledge and safety misconception presents a major challenge for the food irradiation industry and those in public health whose goal is to reduce the occurrence of foodborne disease.

During the year that this survey was conducted, a large multistate outbreak was traced to a strain of multidrug resistant *Salmonella* Newport resistant to nine antimicrobials. In NYS, 34 persons had a culture-confirmed illness as a result of this outbreak and two cases were found in Connecticut (3). Ground beef was the implicated source of infection and on 19 April 2002, only 1 month after the population survey began, the USDA issued a Public Health Alert reminding consumers of food safety guidelines. After the outbreak and USDA alert, in May 2002, a chain of grocery stores in upstate New York (chain A) began selling and actively promoting irradiated fresh ground beef. Chain A is a family-owned grocery chain operating 68 stores in New York, Pennsylvania, New Jersey, and Virginia. The promotional campaign included press conferences at the time of introduction, in-store samples, newspaper advertisements, point-of-sale consumer information, and tempo-

TABLE 2. Logistic regression model of knowing you could buy irradiated meats^a

	Respondents who knew you could buy irradiated meat (%)	Odds ratio	95% confidence interval	P
FoodNet site				
Connecticut	29	0.71	0.56–0.90	0.004
New York	46	Reference		
Lived in county with chain A				
Yes	50	1.96	1.54–2.49	0.000
No	31	Reference		
Interview month				
March–May 2002	42	Reference		
June 2002–February 2003	36	0.86	0.71–1.04	0.123
Sex				
Male	42	1.07	0.90–1.27	0.430
Female	35	Reference		
Race				
White	39	1.37	1.00–1.89	0.051
Other	23	Reference		
Ethnicity				
Hispanic	21	0.84	0.50–1.42	0.517
Not Hispanic	38	Reference		
Age				
18–29	27	0.54	0.41–0.72	0.000
30–59	39	0.79	0.64–0.97	0.478
60+	41	Reference		
Location of residence				
City, town, or suburb	37	0.79	0.62–1.00	0.052
Rural or farm	43	Reference		
Education				
College+	45	1.33	1.12–1.59	0.002
High school	33	Reference		
Annual household income				
<\$40,000	33	Reference		
\$40,000+	43	1.28	1.05–1.56	0.003
Not reported	32	0.93	0.71–1.21	0.113
Children in household				
Yes	35	0.89	0.73–1.08	0.236
No	38	Reference		
Knowledge of cross-contamination				
Yes	39	2.92	1.83–4.65	0.000
No	14	Reference		
Know irradiation kills bacteria				
Yes	49	1.93	1.61–2.31	0.000
No	24	Reference		
Know irradiation is safe				
Yes	26	Reference		
No	57	0.39	0.33–0.47	0.000

^a $n = 2,986$ respondents with complete information on all variables in model.

rary price reductions (1). This event produced a natural experiment that allowed us to compare an area where commercial information about the availability, price, and benefits of irradiated beef was widely disseminated to areas where exposure to irradiated meat had likely remained un-

changed since the product was approved by the FDA. The impact of this real-life situation is seen clearly in the results. Those who lived in a county with chain A were more likely to know that you could buy irradiated meat and three times more likely to have actively looked for the product.

The fact that there was no significant difference in knowledge of the availability of irradiated meat among respondents who lived in a county with chain A after the launch of the promotional campaign may be explained, in part, by the timing of the outbreak of *Salmonella* Newport. This outbreak was recognized in February 2002 (3), before the start of the survey. The outbreak received media coverage and affected the same counties analyzed because chain A had carried the implicated ground beef in their stores. Also, most (76%) of the respondents were interviewed after the launch of chain A's promotional campaign. Availability knowledge among those living in a county without chain A actually decreased (compared to a slight increase among those living in a county with chain A), negating any overall difference between the two time frames.

The retail market for irradiated meat changed in January 2004 when one of the major providers of irradiated meat in the United States declared bankruptcy, effectively removing the product from the shelves of chain A. The bankruptcy was due to accounting irregularities and rapid expansion, not because of a lack of interest in the company's irradiation technology (7). As of June 2005, there were three facilities in the United States that irradiated ground beef (5). Still, this event illustrates the impact that the market and product exposure can have on knowledge, attitudes, and behaviors towards a particular food safety intervention. Differences in knowledge between those living in a county with or without chain A clearly demonstrate that it is possible to impact consumer knowledge and behavior. Improved knowledge makes it possible for individuals to make informed choices and ultimately practice behaviors that protect one from foodborne pathogens.

Several design limitations are found in this study. The survey did not collect information on the primary household shopper, or where the respondent did their grocery shopping. The supermarket variable created for the analyses was based on counties where chain A was known to have conducted an aggressive promotional campaign about irradiated meat. It is not possible to determine if the household members surveyed were directly exposed to this market campaign. Therefore, the results are only suggestive evidence of the impact this event had on knowledge. Information on purchasing practice may also be biased by other conditions, such as price or eating habits.

Additionally, the 2002 to 2003 FoodNet Population Survey used a split design where a set of core questions is administered to all respondents and different sections and modules are randomly assigned. Approximately one half of the respondents were asked additional questions about irradiation from the main survey before answering the NYS and Connecticut addendum questions. While the questions in the main section did not inform respondents that irradiated beef was available for purchase, there may have been a temporary increase in awareness about irradiation for some respondents. However, a comparison of respondents who were and were not asked the main survey irradiation questions found no difference in purchase availability knowledge ($P = 0.27$). Finally, other limitations include

the exclusion of households from the survey sample without telephones and individuals who did not speak English or Spanish, limiting generalizability.

In conclusion, the data from this analysis strongly suggest that there is a general lack of consumer knowledge concerning the availability and safety of irradiated meat. Knowledge about bacteria and the effect of irradiation on bacteria may affect practices and attitudes toward these products. Clearly, education can impact and improve people's awareness and can address these concerns. Finally, this study has shown the impact that a food retailer can have in raising the demand and awareness of safer food products like irradiated ground beef.

The issues of food safety and associated illness are ongoing and need to be addressed at the level of the consumer. Public health should continue to actively demonstrate the benefits of irradiation, address concerns and fears, and help promote irradiated meat so that consumers are fully informed of the choices they can make to further protect themselves from foodborne illnesses.

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