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## **Food Recalls and Food Safety Perceptions: The September 2006 Spinach Recall Case**

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This study analyzes public perceptions of food safety using a national survey conducted in November 2006, soon after the September 2006 nationwide spinach recall. We explore relationships between peoples' perceived risks of food contamination (spinach in this case) and their trust in the institutions in charge of safeguarding/ensuring safety. Finally, we examine relationships between individual observance of basic good food handling practices and food safety. Trust in institutions through which food passes and regulatory agencies were shown to be critical in determining food safety perceptions. For example, confidence in the USDA as a regulatory agent was viewed positively, and hence contributed toward viewing the four types of spinach as safe for consumption. Conversely, skepticism with which the public views food corporations (processors, transporters, or retailers) impacted food safety perceptions negatively.

**Key Words:** food recalls, food safety, public perceptions, spinach

Food recalls play an important role in ensuring food safety. A food recall is intended to remove food products from commerce when there is reason to believe the products may be adulterated or misbranded. However, food recalls in the United States are voluntary. A manufacturer or distributor may voluntarily remove a product in question from the supply chain to protect the public from products that may cause health problems or possible death.

Given the substantial direct and indirect costs of a food recall, some manufacturers may be reluctant to comply with the full measures of the recall. Khan, Swerdlow, and Juranek (2001) report that the cost to a U.S. company of the 1998 recall of 30 million pounds of frankfurters and luncheon meats possibly contaminated by *Listeria* was between \$50 and \$70 million, and ultimately caused the processing facility to be closed. Yet, the costs of failing to prevent food contamination by fully complying with the recall measures can also mount as a consequence of damage to perceived reputation and quality (Worth, 2000). Other

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indirect costs include the costs of product liability litigation (Buzby, Frenzen, and Rasco, 2001; Lenain, Bonturi, and Koen, 2002), the loss of market value of company stock (Wang et al., 2002), and the loss of export markets (Buzby, 2001).

A recent report issued by the Centers for Disease Control and Prevention (CDC), in collaboration with the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA), shows that progress has been made in reducing foodborne infections (CDC, 2006). This report provided preliminary surveillance data highlighting important declines in foodborne infections due to common pathogens when compared against baseline data for the period 1996 through 1998. The data suggest that the incidence of infections caused by *Campylobacter*, *Listeria*, *Salmonella*, Shiga toxin-producing *E. coli* O157, *Shigella*, and *Yersinia* has declined. *Campylobacter* and *Listeria* incidences are approaching levels targeted by national health objectives.

However, the recent contamination of spinach from California may have prompted questions in the minds of many Americans about the adequacy of the existing food safety guidelines. The *E. coli* O157:H7 outbreak in spinach during the fall of 2006 caused over 200 reported cases of illness and three deaths. This and other outbreaks have potential not only to shake public trust in food safety regulatory agencies, but also to erode their confidence in the safety of the food supply chain, affect consumer perceptions, and lead to changes in food purchasing patterns (Buzby, 2001; Calvin, Avendano, and Schwentesius, 2004). The experience of the Mexican green onion hepatitis A in 2003, as well as recent *E. coli* and *Salmonella* outbreaks that led to recalls of varying magnitudes, are indicators that consumers may be skeptical of the safety of the food supply. Nevertheless, in spite of educational efforts about safe handling of food, particularly at the consumer level, the degree of long-standing consumer trust in our food supply may reduce self-protective behaviors such that some consumers may not take appropriate measures to help ensure food safety at the individual level. Specifically, their trust in the system decreases their personal participation in ensuring the food they consume is safe.

This study analyzes public perception of food safety using a national survey conducted in November of 2006, soon after the nationwide spinach recall. Fresh produce (specifically, spinach) was chosen for analysis because of the importance placed on the health attributes of fresh produce in human nutrition. Green leafy produce also provides the opportunity to explore relationships between peoples' perceived risks of food contamination and their trust in the institutions charged with safeguarding/ensuring safety. Finally, we explore relationships between individual observance of basic good food handling practices and food safety.

Although assurances from the government allude to solution strategies, the timely nature of this study is of particular importance as it puts into context peoples' perceptions about the safety of foods they eat. Any doubts the public expresses about food safety will ultimately impact interstate, intrastate, and across-the-border trade. In recent times, more than ever before, food safety has

emerged as an important global issue with international trade and public health implications. Accordingly, an examination of food safety perceptions will extend the debate and provide information that will contribute to policy making. Further, the results of this study will benefit the green leafy produce industry in the marketing and development and adoption of food safety strategies.

We apply the random utility discrete choice model to the survey data to test the hypothesis that the public perception of food safety is invariant to the type of food (fresh versus frozen versus canned produce in this study). The explanatory variables in the empirical model include food recall awareness, food contamination/contaminant knowledge and nature of resulting illness, trust in food-safety related institutions, and demographic variables (age, education, income).

Results indicate that food safety perception may be driven by public trust/confidence in institutions whose activities may be directly or indirectly related to food safety. Findings further reveal that food safety perceptions also may be related to the type of product; for example, the public perceives frozen spinach differently from bagged fresh spinach. Additionally, low levels of objective knowledge about food pathogens and the resulting illnesses are found to have implications with respect to overall food safety.

### Related Literature

Literature on foodborne outbreaks tends to be primarily investigative, i.e., with the objectives of tracing the source of the contaminant, assigning culpability where possible, and recommending remedial measures. Such investigations may provide information to better control and/or minimize future occurrences. We review literature on foodborne illnesses focusing specifically on food safety relating to green leafy produce.

Rangel et al. (2005) found that *E. coli* O157:H7 accounted for 73,000 illnesses in the United States annually. The study reviewed 350 outbreaks in 49 states representing 8,598 cases reported to the CDC between 1982 and 2002. The leading vector for transmission was ground beef (41%), while about one-fifth (21%) of outbreaks were attributable to produce. A large number of outbreaks attributable to produce comes as no surprise considering that, during the past two decades, the quantity of produce eaten per capita has been increasing steadily, creating a heightened potential for produce-related foodborne disease (Sewell and Farber, 2001).

While half of produce-associated outbreaks are linked to kitchen-level cross-contamination, the other half are due to produce already contaminated with *E. coli* O157 before purchase—including lettuce, sprouts, cabbage, apple cider, and apple juice (Rangel et al., 2005). Such produce items could have become tainted in the field from manure or contaminated irrigation water; during processing due to contaminated equipment, wash water or ice, or poor handling practices; during transport; or through contaminated storage equipment. Washing

produce with water or a chlorine-based solution reduces *E. coli* O157 only modestly. Therefore, once consumers obtain contaminated produce intended for raw consumption, little can be done to prevent illness.

The media has highlighted lingering doubts as to whether American consumers are being protected from foodborne illnesses. Fearing loss of public trust, media, consumers, and lawmakers have become concerned about the lack of resolution in the *E. coli* O157:H7 outbreak investigation, and some lawmakers have demanded the investigation be resolved with the aim of restoring public confidence in the regulatory institutions. Moreover, some lawmakers have argued that the food safety regulatory system needs reexamination.

For example, New York Senior Senator Charles Schumer (2006) contends there is a serious weakness in federal agencies, stemming from understaffing. Since the events of September 11, 2001, inspectors are overextended and instead of increasing staff, the number of staff has been decreasing or at least remained static. The Senator asserts that the monitoring of fruits and vegetables is years behind efforts to protect meat and poultry. He notes that federal efforts to monitor the food supply, track any contaminated food, and notify the public are significantly hampered because of jurisdictional tangles, a lack of staff, and a lack of funding at the FDA—the agency with oversight of nonmeat food products. As Schumer points out, under current laws, the USDA has the responsibility of protecting the nation's meat and poultry supply, while the FDA has oversight over fruits, vegetables, and other food products. In response to several major *E. coli* outbreaks in beef in the mid-1990s, Schumer acknowledges the USDA stepped up enforcement efforts, which are credited with reducing the frequency of *E. coli* outbreaks in meat and poultry.

The FDA's efforts to protect fruits and vegetables from contamination have been limited, and the number of produce inspections has been reduced dramatically. In 2005, the FDA conducted 4,573 on-site inspections of agricultural processing facilities. By contrast, the USDA conducts the same number of inspections in a matter of days (Schumer, 2006). Federal law requires a USDA inspector to be permanently placed at every meat processing plant in the country; however, there is no such requirement in the produce industry by the FDA (Schumer). The reasoning behind the absence of permanent inspectors in the produce industry is that most produce is consumed in fresh rather than processed form, unlike, for example, in the meat industry. Also, most of the contamination reported in the food supply is associated with meat, with only sporadic cases being linked to produce.

A common viewpoint in the public mind, given the recent *E. coli* and other successive outbreaks that followed within a short period, is that the regulatory agencies may want to become more involved in order to improve the nation's actual and perceived food safety problems. This is evidenced by a statement attributable to the acting FDA regional director for the Pacific region, who concurs that current agricultural practices in the leafy greens industry did not work to prevent *E. coli* illnesses. The regional director reiterated the need for

establishing mandatory good agricultural practices across the industry (Krauter, 2007). A brief to the U.S. Congress (Geoffrey, Becker, and Porter, 2007) indicates there is a substantial possibility of bringing food safety regulatory agencies under one umbrella. The regulatory system has been criticized for lacking the organization and resources to adequately combat foodborne illness. The 110th Congress may face calls for a review of federal food safety agencies and authorities, and proposals for reorganizing them. Among the issues likely to arise are whether reform can improve oversight, and the cost to industry, consumers, and taxpayers.

Outside California, however, the farm lobby argues in favor of self-regulation. The farm lobby asserts that a mandatory regulatory approach will be too expensive and will end up hurting many of the small-scale producers. Van Goethem (2007) argues that instead of waiting for the government to enact changes, companies should begin putting some measures in place to safeguard the consumer against foodborne illness. This is based on the assumption that the public trusts the safety of the U.S. food supply. Yet, as the green leafy produce industry pushes for a self-regulating approach, there is some evidence suggesting consumers may be favoring a mandatory approach (Brubaker, 2007). Whatever the case may be, the produce industry should learn from the experience of the meat and dairy industry that for strategic reasons of maintaining and ensuring repeated sales, food safety is paramount (Van Goethem).

### Conceptual Framework

We examine the impact of a food recall incident on public food safety perceptions. The Lancaster (1966a, b) model provides an appropriate setting to analyze food safety perceptions. In this model, individuals derive utility ( $U$ ) from the food safety attribute ( $z$ ), which is embodied (along with other attributes) in the product he/she consumes:

$$(1) \quad U = U(z_1, z_2, \dots, z_m).$$

Although Lancaster envisioned utility to depend on product attributes only, this framework can be viewed as one where utility depends on product attributes (particularly food safety and quality) as well as on consumers' personal attributes. In the context of this study, it is assumed the presence/absence of the safety attribute is relevant in influencing consumption decisions.

We analyze the individual's food safety perception by integrating the above model within the random utility discrete choice framework. Accordingly, the individual is assumed to have a well-behaved utility function (i.e., with preferences that are complete, reflexive, and transitive). Given the assumptions, the individual is able to compare and rank alternative attribute bundles (safety attribute). In this framework, individuals always choose what they believe to be

the best, in this case a safe food product. Individuals are therefore regarded as utility maximizers.

Following the random utility framework, it is assumed an individual faces a consumption choice driven by presence or absence of food safety. Utilities derived from perceived food safety are given by  $U_S$  and  $U_{NS}$ , where the subscripts denote safe and not safe, respectively. However, these utility levels are not directly observable. The observable variables are the product attributes ( $a = S, NS$ ) and a vector of individual characteristics ( $\mathbf{x}$ ). The random utility model assumes the utility derived by individual  $i$  from the perceived safety  $a$  ( $a = S, NS$ ) can be expressed as:

$$(2) \quad U_{ai} = V_{ai} + \varepsilon_{ai},$$

where  $U_{ai}$  is the latent utility level attained by the  $i$ th individual by evaluating food safety ( $a = S, NS$ ),  $V_{ai}$  is the explainable part of the latent utility that depends on the value attributes (e.g., awareness of the recall, trust in food safety-related institutions) and the personal characteristics, and  $\varepsilon_{ai}$  is the “unexplainable” random component in  $U_{ai}$ .

The utility-maximizing individual will choose to consume a particular food variety if and only if  $V_S + \varepsilon_S > V_{NS} + \varepsilon_{NS}$ , or equivalently if  $\varepsilon_i = \varepsilon_{NS} - \varepsilon_S < V_S - V_{NS}$ . Since  $\varepsilon$  is unobservable and stochastic in nature, the individual's choice is not deterministic and cannot be predicted exactly. Instead, the probability of any particular outcome can be derived. The probability that individual  $i$  will choose to eat a particular food variety on the basis of perceived safety is given by:

$$(3) \quad p_i = \text{prob}(\varepsilon_{NS} - \varepsilon_S < V_S - V_{NS}) = \text{prob}(\varepsilon < V_S - V_{NS}).$$

Describing the density function of  $\varepsilon$  by  $f(\varepsilon)$ , the above probability is written as:

$$(4) \quad P_i = \int_{\varepsilon} Z_i(\varepsilon_i < V_S - V_{NS}) f(\varepsilon_i) d\varepsilon_i,$$

where  $Z_i$  is an indicator variable equal to 1 when the term inside the parentheses is true, and 0 otherwise. In other words, the indicator variable  $Z_i$  is a binary variable that equals 1 when the utility from food safety exceeds the utility from absence of food safety.

### The Empirical Model, Data, and Survey Method

In order to empirically implement the above conceptual framework, it is assumed that  $\varepsilon_{ai}$  is identically and independently distributed as a type I extreme value, in which case  $\varepsilon_i = \varepsilon_{NS} - \varepsilon_S$  follows the logistic distribution (Train, 2002). Under this distributional property of  $\varepsilon_i$ , the probability that an individual only consumes a particular food when it meets some acceptable food safety level is given by the

standard logit model of discrete choice (McFadden, 1974, 1984). The logistic model is estimated to explain and predict perceived food safety for selected produce. The maximum-likelihood (ML) estimation procedure is used to obtain the model parameters. The model summary statistics,  $\beta$ -coefficients (along with their  $t$ -ratios) and the marginal effects, were obtained by using the software package LIMDEP (Econometric Software, Inc., 2002).

The rationale behind the four separate models for spinach (bagged, loose, canned, and frozen) is that from a theoretical point of view, public food safety perceptions need not be homogeneous regarding the four types of spinach. People from different backgrounds (demographic, economic, etc.) may perceive various types of spinach as having different safety levels. Let  $Z_i$  denote individual  $i$ 's perceived food safety. People with different personal attributes such as income and education may rate the produce to be more or less safe than others. Accordingly,  $Z_i$  is modeled as a function of the  $i$ th consumer's economic, demographic, and value attributes as follows:

$$(5) \quad Z_i = \beta'X + v_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik} + v_i, \\ i = 1, 2, \dots, n,$$

where  $x_{ij}$  denotes the  $j$ th attribute of the  $i$ th respondent,  $\beta = (\beta_0, \beta_1, \dots, \beta_k)$  is the parameter vector to be estimated, and  $v$  is the error disturbance term (Greene, 2002). Under the logistic distributional assumption for the random term, the probability  $P_i$  (the  $i$ th individual's perception of food safety) can now be expressed as (Greene):

$$(6) \quad P_i = F(Z_i) = F\left(\beta_0 + \sum_{j=1}^k \beta_j x_{ij}\right) = F(\beta X_i) = \frac{1}{1 + \exp(-\beta X_i)}.$$

The estimated  $\beta$ -coefficients of the equation do not directly represent the marginal effects of the independent variables on the probability  $P_i$  that the food variety is safe. In the case of a continuous explanatory variable, the marginal effect of  $x_j$  on the probability  $P_i$  is given by:

$$(7) \quad \frac{\partial P_i}{\partial x_{ij}} = \frac{[\beta_j \exp(-\beta X_i)]}{[1 + \exp(-\beta X_i)]^2}.$$

However, if the explanatory variable is qualitative or discrete in nature,  $\partial P_i / \partial x_{ij}$  does not exist. In such a case, the marginal effect is obtained by evaluating  $P_i$  at alternative values of  $x_{ij}$ . For example, in the case of a binary explanatory variable  $x_{ij}$  that takes values of 1 and 0, the marginal effect is determined as:

$$(8) \quad \frac{\partial P_i}{\partial x_{ij}} = P(x_{ij} = 1) - P(x_{ij} = 0).$$



The following empirical model is specified to model an individual food safety perception:

$$\begin{aligned}
 (9) \quad FOODSAFE_i = & \beta_0 + \beta_1 FEMALE + \beta_2 YOUNG + \beta_3 MIDAGE \\
 & + \beta_4 B\_HISCHOOL + \beta_5 TWO\_YRCLG + \beta_6 WHITE \\
 & + \beta_7 INCLT\_35 + \beta_8 INC35-75 + \beta_9 TRUST\_FDA \\
 & + \beta_{10} TRUST\_USDA + \beta_{11} TRUST\_CDC \\
 & + \beta_{12} SKEP\_FCORPS + \beta_{13} SKEP\_GROCER \\
 & + \beta_{14} SKEP\_GVT + \beta_{15} TRUST\_ORGFARM \\
 & + \beta_{16} TRUST\_CONVFARM + \beta_{17} COR\_SYMPT \\
 & + \beta_{18} INCOR\_SYMPT + \beta_{19} ECOLI\_QUIZ + \varepsilon,
 \end{aligned}$$

where the variables are defined and listed in table 1 (an asterisk is assigned to a variable's reference category against which the influence of other categories on food safety perception is measured).

A nationally representative sample in terms of gender, age, and ethnicity of 1,200 adult Americans from all 50 states was interviewed by telephone during November 8–29, 2006. Using Computer-Assisted Telephone Interview (CATI) software, interviews were conducted with non-institutionalized adults aged 18 or over. Proportional random-digit dialing was used to select survey participant households and the CATI system was programmed to provide prompts to select the appropriate proportions of male and female participants.

To maximize generalizability, working nonbusiness numbers were contacted using a 12-callback design to contact elusive individuals. The calls were made at different times and days throughout the week. Interviewers left a voice mail message on the second, fifth, and ninth attempts, explaining the study and the purpose for calling. The CATI software maintained callback appointments and prompted the interviewers to leave an answering-machine message when necessary. The cooperation rate was 48% (i.e., 1,200 individuals were reached out of the sample of 2,500 individuals), with a resulting sampling error of  $\pm 2.8\%$ . Data were weighted by gender, age, race, ethnicity, and education to approximate U.S. Census figures.

The term “spinach recall” was used in the survey instrument in referring to the period of time and the events associated with the contamination of fresh spinach with *E. coli* O157:H7 and the subsequent foodborne illness outbreak. This is consistent with the terminology used in much of the media coverage that occurred during the period of interest. Some questions were tailored to respondents depending on whether they had heard about the spinach recall. For example, respondents who had heard about the spinach recall were asked, “Did you eat spinach before the recall?” while consumers who were unaware of the recall were simply asked, “Do you eat spinach?” All interviews were conducted in English.

**Table 1. Definitions of Variables and Their Descriptive Statistics**

Variable	Description of Variable	Mean	Std. Dev.
<i>FEMALE</i>	=1 if respondent is female; = 0 if male	0.57	0.50
<i>YOUNG</i>	=1 if age is less than 35 years; 0 otherwise	0.22	0.41
<i>MIDAGE</i>	=1 if age is between 35 and 54 years; 0 otherwise	0.48	0.50
<i>MATURE<sup>a</sup></i>	=1 if age is 55 years or higher; 0 otherwise	0.31	0.46
<i>B_HISCHOOL</i>	=1 if below high school education level; 0 otherwise	0.32	0.47
<i>TWO_YRCLG</i>	=1 if some 2-year college education; 0 otherwise	0.27	0.44
<i>FYRCLG_AB<sup>a</sup></i>	=1 if 4-year college education or higher; 0 otherwise	0.41	0.49
<i>INCLT_35</i>	=1 if annual income is below \$35,000; 0 otherwise	0.26	0.44
<i>INC35-75</i>	=1 if annual income is between \$35,000 and \$75,000; 0 otherwise	0.41	0.49
<i>INC_AB75<sup>a</sup></i>	=1 if annual income is greater than \$75,000; 0 otherwise	0.33	0.47
<i>WHITE</i>	=1 if respondent is white (Caucasian); 0 otherwise	0.82	0.39
<i>TRUST_FDA</i>	=1 if respondent trusts the FDA to ensure safety of the U.S. food supply; 0 otherwise	0.61	0.49
<i>TRUST_USDA</i>	=1 if respondent trusts the USDA to ensure safety of the U.S. food supply; 0 otherwise	0.64	0.48
<i>TRUST_CDC</i>	=1 if respondent trusts the CDC to ensure safety of the U.S. food supply; 0 otherwise	0.69	0.46
<i>SKEP_FCORPS</i>	=1 if respondent is skeptical about the food companies to ensure safety of the U.S. food supply; 0 otherwise	0.47	0.50
<i>SKEP_GROCER</i>	=1 if respondent is skeptical about the grocery stores to ensure safety of the U.S. food supply; 0 otherwise	0.38	0.48
<i>SKEP_GVT</i>	=1 if respondent is skeptical about the state government to ensure safety of the U.S. food supply; 0 otherwise	0.50	0.50
<i>TRUST_ORGFARM</i>	=1 if respondent trusts organic farmers to ensure safety of the U.S. food supply; 0 otherwise	0.61	0.49
<i>TRUST_CONVFARM</i>	=1 if respondent trusts conventional farmers to ensure safety of the U.S. food supply; 0 otherwise	0.56	0.50
<i>QECOLI</i>	=1 if respondent identified the spinach contaminant correctly; 0 otherwise	0.86	0.35
<i>COR_SYMPT</i>	Respondent correctly identified the symptoms for <i>E. coli</i> illness (average score)	1.64	0.57
<i>INCOR_SYMPT</i>	Respondent incorrectly identified the symptoms for <i>E. coli</i> illness (average score)	2.85	0.81
<i>ECOLI_QUIZ</i>	Respondent correctly answered knowledge questions related to the spinach <i>E. coli</i> contamination	3.37	1.52
<i>HEARD_RECALL</i>	Respondent heard about food recalls in general	3.00	1.04

<sup>a</sup>This variable was dropped during estimation to avoid the dummy variable trap.

**Table 2. Collapsed Categories, Percent Respondents, Means, and Percentiles: Safety Perceptions of Various Spinach Types (N = 782 respondents)**

Description	Spinach Type			
	Bagged Fresh Spinach	Loose Fresh Spinach	Canned Spinach	Frozen Spinach
Mean	7.05	7.19	8.02	7.95
<b>Percentiles:</b>				
25	5.0	5.0	7.0	7.0
50	8.0	8.0	9.0	9.0
75	9.0	10.0	10.0	10.0
<b>Collapsed Categories:<sup>a</sup></b>	<b>0–5</b>	<b>6–8</b>	<b>8–10</b>	
Bagged Fresh Spinach	15.7	25.8	58.5	
Loose Fresh Spinach	14.3	25.8	60.0	
Canned Spinach	11.1	15.2	73.7	
Frozen Spinach	11.5	16.0	72.5	

<sup>a</sup> Collapsed categories are defined as follows: 0–5 = “not safe at all” rating, 6–8 = “somewhat safe” rating, and 8–10 = “completely safe” rating.

During the telephone interview, survey participants were asked to reveal their views on fresh produce food safety. In addition, they were asked to disclose their views on food safety of beef and chicken prepared at home. The exact statement used to elicit food safety responses was, “On a scale of 0 through 10, where 0 is ‘not safe at all’ and 10 is ‘completely safe’ ... How safe would you say it is right now to eat ... [insert appropriate food (bagged fresh spinach, loose fresh spinach, canned spinach, frozen spinach, bagged fresh lettuce, loose fresh lettuce, fresh beef cooked at home, and fresh chicken cooked at home)].

In this study the focus is on spinach, which was the subject of the 2006 recall. Thus, responses to some of the questions in the survey were not applicable to this investigation, thereby excluding some respondents from the sample during empirical analysis. As a result of omitting these respondents, a total of 782 out of 1,200 completed surveys were used for our empirical analysis.

To provide justification for dichotomizing the safety perception, preliminary analysis on raw data was carried out. Table 2 shows that the mean rating for the bagged and loose spinach was about 7, while the mean rating for the canned and frozen spinach was approximately 8. Similarly, when the raw data are considered in percentile terms, a consistent pattern emerges, with the ratings for canned and frozen spinach being relatively higher than those for bagged or loose types. The lower percentile (i.e., 25% of the respondents) rated bagged spinach at about 5, while canned and loose spinach were rated at 7. When ratings across the types of spinach were combined, approximately 60% of the respondents rated bagged and loose spinach as completely safe, and about 73% rated canned and frozen spinach as safe.

Given the above findings, the initial variable structure was based on raw frequencies for a natural “breaking point,” and the Mann-Whitney nonparametric test was conducted to determine whether the aggregation of categories resulted in a loss of information. The test revealed no loss of information when collapsing the categories in the dependent variable relating to “*somewhat*” and “*not safe at all*.” In fact, the consumer concern was ultimately whether the food is perceived to be “*safe*” or “*not safe*”; hence, the intermediate category of “*somewhat safe*” does not translate into “*somewhat*” consumption. The Mann-Whitney test is based on the Z-test. The calculated symmetric Z-value is 0.6817, with a *p*-value of 0.05. This value suggests that the “*not safe at all*” and “*somewhat safe*” categories of food safety are not statistically different from each other. We therefore conclude that no information is lost by collapsing these two response choices into one category.

Using consumers’ responses to the above statement, a binary dependent variable, *FOODSAFE* (food safety perception), was defined by assigning a value of 1 if the respondent’s safety rating ranged between 8 and 10 (i.e., “*completely safe*”) and a value of 0 was assigned if the response was either “*somewhat safe*” (a rating ranging between 6 and 8) and “*not safe at all*” (a rating ranging between 0 and 5).

The rationale for including the explanatory variables in the empirical model is based on the assumption that they have a potential to influence an individual’s perception of food safety. The explanatory variables in the empirical model include food recall awareness, food contamination/contaminant knowledge, knowledge about symptoms of *E. coli*-caused illnesses, trust in food safety-related institutions, and the demographic variables. The awareness variable is included in the model based on the assumption that the incident involving the spinach contamination was widespread in scope, and possibly a retentive memory of this event would affect the public’s view on food safety in general, and particularly the safety of fresh produce.

Trust in regulatory institutions/agencies<sup>1</sup> is assumed to be pivotal in influencing food safety perceptions. The higher the public trust in the agencies, the higher the likelihood that food in general is going to be perceived as safe. For example, in the spinach contamination incident, if the public was assumed to have total trust in the food safety-related agencies and their capability to ensure food supply safety, then there would be a greater likelihood of rapid restoration of consumer trust in the safety of the food supply chain. We measure trust through a trust indicator in the ability of related institutions to ensure food supply safety against contamination.

We also hypothesize that objective knowledge on food safety associated with *E. coli* contamination may indicate how the differences in level of knowledge

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<sup>1</sup> An agent here is used to refer to a point in the food chain (farm, processing, transport, wholesale and retailing) and those regulatory agencies (USDA, FDA, CDC, state and local governments) charged with safeguarding the food supply.

**Table 3. *E. coli* Objective Questions Quiz**

Question	True	Likely True	Likely False	False
<i>Most people infected with E. coli O157:H7 die as a result of the infection. Would you say this is ...</i>				
<i>All people are equally susceptible to E. coli infection. Would you say this is ...</i>				
<i>Contamination with E. coli can come from animal waste. Would you say this is ...</i>				
<i>All food that is cooked to 120° Fahrenheit is safe to eat. Would you say this is ...</i>				
<i>Bagged spinach marked as “triple washed” is certain not to have any E. coli. Would you say this is ...</i>				
<i>You can catch E. coli from an infected person through their coughing or sneezing. Would you say this is ...</i>				

about food supply chain issues may play into the perception of public food safety. It is assumed that the higher the individual knowledge level, the better equipped a person is to interpret information which effectively may lead to better judgment of food safety. (The objective quiz on *E. coli* knowledge is presented in table 3.)

Gender is used to distinguish whether males or females have differing views on food safety. For example, since women perform most of the food shopping and cooking, they are assumed to view food safety differently. The age variables represent possible differences in perception toward food safety due to life experiences. We use education as the knowledge metric. Individuals with more education may be more aware and knowledgeable on issues of food safety across the food supply chain. Finally, income is used as a metric of wealth. Income can reflect many attributes, including education, but may also indicate a broader knowledge base and awareness of current events, etc., leading to differences in food safety perceptions.

### Empirical Results

The maximum-likelihood (ML) estimates of the model coefficients, the marginal effects on the dependent variable, and the associated *p*-values are reported in tables 4–7. Also reported in these tables are the log-likelihood functions of the unrestricted and the restricted (i.e., all slope coefficients are zero) models and the model prediction success. The reported values of the McFadden's  $R^2$  are measures of goodness of model fit.

Among the 782 respondents included in this study, 479 (61%) perceived bagged fresh spinach as safe (table 4). In the case of loose fresh spinach, 491 (63%) of respondents perceived it as safe (table 5). In the cases of canned and frozen spinach, these numbers jumped to 609 (78%) and 597 (76%), respectively (tables 6 and 7).

Among the demographic variables, it can be seen from tables 4–7 that the coefficients for the middle-aged (*MIDAGE*) and young (*YOUNG*) respondents are negative and statistically significant at the 10% level or lower in three models—the bagged and loose fresh spinach types and the frozen spinach type. The estimated coefficients suggest that relative to older consumers (55 years or older), the middle-aged and young respondents (age 54 or less) are more likely to perceive fresh bagged, loose, and frozen spinach as unsafe. With only the exception of the loose fresh spinach model, the coefficient representing individuals having below a high school level of education (*B\_HISCHOOL*) is negative and significant at the 10% level or lower. In addition, the coefficient for respondents having two years of college education (*TWO\_YRCLG*) is not significant in any of the four models. These results suggest that only respondents with no college education at all compared with those having four or more years of college education are more likely to perceive bagged fresh spinach, and canned and frozen types of spinach as not safe. Compared to their male counterparts, female respondents are more likely to perceive canned spinach as safe for consumption. Similarly, Caucasians (*WHITE*) are more likely to perceive spinach—irrespective of the type (i.e., bagged fresh, loose fresh, canned, or frozen)—as safe for consumption compared to other racial groups.

The relationship between income and consumers' safety perception is strong and significant across all four models. The coefficients associated with respondents earning less than \$35,000 annually (*INCLT\_35*) is negative and significant at 5% or lower across the four models. As the sign of the estimated coefficients suggests, relative to those with annual household incomes of \$75,000 or more, respondents with incomes of \$35,000 or less are more likely to perceive the four types of spinach as unsafe for consumption.

Results reported in tables 4–7 reveal that trust in private and public institutions associated with food safety has a significant influence on individuals' food safety perceptions. This is demonstrated by the public trust in regulatory agencies dealing with food safety. Coefficients for public trust in the USDA (*TRUST\_USDA*) and CDC (*TRUST\_CDC*) are positive and significant; however, the coefficient for public trust in the FDA (*TRUST\_FDA*) is negative and insignificant. Trust in the U.S. Department of Agriculture is positive and significant at the 10% level or lower in three models (fresh bagged, loose, and frozen spinach). Trust in the Centers for Disease Control and Prevention is positive and significant at the 5% level with respect to canned spinach. Yet, the results suggest food safety perception is not related to respondents' trust in the FDA. Thus, respondents who trust in the USDA and CDC to safeguard the food supply in an event of contamination, compared to those respondents who do not, will perceive bagged, canned, and frozen spinach types as safer for consumption.

**Table 4. Maximum-Likelihood Estimates of Model Coefficients and Marginal Effects: Bagged Fresh Spinach**

Variable	Safety Perception of Bagged Fresh Spinach		
	Model Coefficient	<i>p</i> -Value	Marginal Effect
Constant	−0.0300	0.96	—
<i>FEMALE</i>	−0.0338	0.84	−0.01
<i>YOUNG</i>	−0.5382	<b>0.02</b>	<b>−0.13</b>
<i>MIDAGE</i>	−0.3356	<b>0.09</b>	<b>−0.08</b>
<i>B_HISCHOOL</i>	−0.5411	<b>0.01</b>	<b>−0.13</b>
<i>TWO_YRCLG</i>	−0.2043	0.34	−0.05
<i>WHITE</i>	0.7608	<b>0.00</b>	<b>0.18</b>
<i>INCLT_35</i>	−0.6587	<b>0.01</b>	<b>−0.16</b>
<i>INC35-75</i>	−0.2899	0.14	−0.07
<i>TRUST_FDA</i>	−0.2196	0.36	−0.05
<i>TRUST_USDA</i>	0.5807	<b>0.02</b>	<b>0.14</b>
<i>TRUST_CDC</i>	0.2048	0.37	0.05
<i>SKEP_FCORPS</i>	−0.6401	<b>0.00</b>	<b>−0.15</b>
<i>SKEP_GROCER</i>	0.0251	0.91	0.01
<i>SKEP_GVT</i>	−0.1678	0.47	−0.04
<i>TRUST_ORGFARM</i>	0.1377	0.51	0.03
<i>TRUST_CONVFARM</i>	0.5282	<b>0.02</b>	<b>0.12</b>
<i>COR_SYMPT</i>	−0.0489	0.75	−0.01
<i>INCOR_SYMPT</i>	0.0046	0.97	0.00
<i>ECOLI_QUIZ</i>	0.1429	<b>0.01</b>	<b>0.03</b>
Log Likelihood	−446.18		
Restricted Log Likelihood	−522.06		
$\chi^2$	151.78		
Degrees of Freedom	19		
McFadden's $R^2$	0.15		
% Correct Predictions	69%		
ACTUAL	PREDICTED		TOTAL
	0	1	
0	144	159	303
1	85	394	479
TOTAL	229	553	782

Note: Values in boldfaced italics denote statistical significance at the 10% level or lower.

**Table 5. Maximum-Likelihood Estimates of Model Coefficients and Marginal Effects: Loose Fresh Spinach**

Variable	Safety Perception of Loose Fresh Spinach		
	Model Coefficient	<i>p</i> -Value	Marginal Effect
Constant	−0.4542	0.45	—
<i>FEMALE</i>	0.0690	0.68	0.02
<i>YOUNG</i>	−0.4177	<b>0.08</b>	<b>−0.10</b>
<i>MIDAGE</i>	−0.1655	<b>0.10</b>	<b>−0.04</b>
<i>B_HISCHOOL</i>	−0.2965	0.17	−0.07
<i>TWO_YRCLG</i>	−0.1900	0.37	−0.04
<i>WHITE</i>	0.8865	<b>0.00</b>	<b>0.21</b>
<i>INCLT_35</i>	−0.7260	<b>0.00</b>	<b>−0.17</b>
<i>INC35-75</i>	−0.1631	0.41	−0.04
<i>TRUST_FDA</i>	−0.1321	0.58	−0.03
<i>TRUST_USDA</i>	0.4147	<b>0.09</b>	<b>0.10</b>
<i>TRUST_CDC</i>	0.1829	0.43	0.04
<i>SKEP_FCORPS</i>	−0.6610	<b>0.00</b>	<b>−0.15</b>
<i>SKEP_GROCER</i>	0.0554	0.80	0.01
<i>SKEP_GVT</i>	−0.1562	0.50	−0.04
<i>TRUST_ORGFARM</i>	0.0202	0.92	0.00
<i>TRUST_CONVFARM</i>	0.5440	<b>0.02</b>	<b>0.12</b>
<i>COR_SYMPT</i>	−0.0735	0.62	−0.02
<i>INCOR_SYMPT</i>	0.0747	0.48	0.02
<i>ECOLI_QUIZ</i>	0.1624	<b>0.00</b>	<b>0.04</b>
Log Likelihood	−446.48		
Restricted Log Likelihood	−516.18		
$\chi^2$	139.41		
Degrees of Freedom	19		
McFadden's $R^2$	0.14		
% Correct Predictions	69%		
ACTUAL	PREDICTED		TOTAL
	0	1	
<b>0</b>	125	166	291
<b>1</b>	79	412	491
<b>TOTAL</b>	204	578	782

Note: Values in boldfaced italics denote statistical significance at the 10% level or lower.



**Table 6. Maximum-Likelihood Estimates of Model Coefficients and Marginal Effects: Canned Spinach**

Variable	Safety Perception of Canned Spinach		
	Model Coefficient	<i>p</i> -Value	Marginal Effect
Constant	1.0416	0.14	—
<i>FEMALE</i>	0.4651	<b>0.02</b>	<b>0.07</b>
<i>YOUNG</i>	−0.3785	0.17	−0.06
<i>MIDAGE</i>	−0.0841	0.72	−0.01
<i>B_HISCHOOL</i>	−0.4461	<b>0.08</b>	<b>−0.07</b>
<i>TWO_YRCLG</i>	−0.3281	0.21	−0.05
<i>WHITE</i>	0.9945	<b>0.00</b>	<b>0.17</b>
<i>INCLT_35</i>	−0.7677	<b>0.01</b>	<b>−0.12</b>
<i>INC35-75</i>	−0.1381	0.58	−0.02
<i>TRUST_FDA</i>	−0.0916	0.74	−0.01
<i>TRUST_USDA</i>	0.0514	0.86	0.01
<i>TRUST_CDC</i>	0.5026	<b>0.05</b>	<b>0.08</b>
<i>SKEP_FCORPS</i>	−0.8881	<b>0.00</b>	<b>−0.12</b>
<i>SKEP_GROCER</i>	0.1701	0.52	0.02
<i>SKEP_GVT</i>	−0.8915	<b>0.00</b>	<b>−0.13</b>
<i>TRUST_ORGFARM</i>	−0.2936	0.24	−0.04
<i>TRUST_CONVFARM</i>	0.1609	0.55	0.02
<i>COR_SYMPT</i>	0.3414	<b>0.05</b>	<b>0.05</b>
<i>INCOR_SYMPT</i>	−0.1856	0.14	−0.03
<i>ECOLI_QUIZ</i>	0.1846	<b>0.01</b>	<b>0.03</b>
Log Likelihood	−337.92		
Restricted Log Likelihood	−413.25		
$\chi^2$	150.66		
Degrees of Freedom	19		
McFadden's $R^2$	0.18		
% Correct Predictions	80%		
ACTUAL	PREDICTED		TOTAL
	0	1	
0	47	126	173
1	33	576	609
TOTAL	80	702	782

Note: Values in boldfaced italics denote statistical significance at the 10% level or lower.

**Table 7. Maximum-Likelihood Estimates of Model Coefficients and Marginal Effects: Frozen Spinach**

Variable	Safety Perception of Frozen Spinach		
	Model Coefficient	<i>p</i> -Value	Marginal Effect
Constant	1.1199	0.11	—
<i>FEMALE</i>	0.2515	0.19	0.04
<i>YOUNG</i>	−0.5770	<b>0.04</b>	<b>−0.10</b>
<i>MIDAGE</i>	−0.4287	<b>0.07</b>	<b>−0.07</b>
<i>B_HISCHOOL</i>	−0.4885	<b>0.05</b>	<b>−0.08</b>
<i>TWO_YRCLG</i>	−0.0852	0.74	−0.01
<i>WHITE</i>	1.0795	<b>0.00</b>	<b>0.20</b>
<i>INCLT_35</i>	−0.6758	<b>0.01</b>	<b>−0.12</b>
<i>INC35-75</i>	−0.0966	0.69	−0.02
<i>TRUST_FDA</i>	−0.3300	0.23	−0.05
<i>TRUST_USDA</i>	0.5851	<b>0.04</b>	<b>0.10</b>
<i>TRUST_CDC</i>	0.3859	0.13	0.06
<i>SKEP_FCORPS</i>	−0.5623	<b>0.02</b>	<b>−0.09</b>
<i>SKEP_GROCER</i>	0.0304	0.91	0.00
<i>SKEP_GVT</i>	−0.4439	<b>0.10</b>	<b>−0.07</b>
<i>TRUST_ORGFARM</i>	0.1698	0.48	0.03
<i>TRUST_CONVFARM</i>	0.0706	0.79	0.01
<i>COR_SYMPT</i>	0.3706	<b>0.03</b>	<b>0.06</b>
<i>INCOR_SYMPT</i>	−0.3371	<b>0.01</b>	<b>−0.05</b>
<i>ECOLI_QUIZ</i>	0.0839	<b>0.10</b>	<b>0.01</b>
Log Likelihood	−356.10		
Restricted Log Likelihood	−427.83		
$\chi^2$	143.47		
Degrees of Freedom	19		
McFadden's $R^2$	0.17		
% Correct Predictions	79%		
ACTUAL	PREDICTED		TOTAL
	0	1	
<b>0</b>	50	135	185
<b>1</b>	30	567	597
<b>TOTAL</b>	80	702	782

Note: Values in boldfaced italics denote statistical significance at the 10% level or lower.

The coefficients for skepticism variables show how mistrust of institutions along the food supply chain might affect safety perceptions in a contamination event. Overwhelmingly and not surprisingly, the coefficient on respondents skeptical about the food companies (*SKEP\_FCORPS*) to ensure food safety of the U.S. food supply is negative and significant at less than the 5% level in all four models. Respondents who are skeptical about state governments' (*SKEP\_GVT*) capability to safeguard the food supply are more likely to perceive canned and frozen types of spinach as unsafe compared to those respondents who are not skeptical. Interestingly, the results reveal that trust in organic farmers (*TRUST\_ORGFARM*) is not related to food safety perception. Trust of conventional farmers (*TRUST\_CONVFARM*) to safeguard the food supply is only significant with respect to fresh spinach types.

Correct identification of the *E. coli* symptoms (*COR\_SYMPT*) by many of the respondents is positive and significant at the 5% level for both canned and frozen spinach. Respondents who correctly identified the symptoms of *E. coli* sickness are more likely to perceive canned and frozen spinach as safe for consumption than those who did not. On the other hand, incorrect identification of the symptoms (*INCOR\_SYMPT*) is negative and significant only with respect to frozen spinach. Hence, it is more likely for those respondents identifying wrong *E. coli* symptoms to perceive frozen spinach as unsafe. In terms of objective questions about *E. coli* contamination (*ECOLI\_QUIZ*), the sign of the coefficient is positive and significant, suggesting those with greater and more accurate knowledge about the *E. coli* contamination are more likely to perceive the four types of spinach as safe for consumption.

The estimated marginal effects of the independent variables (also presented in tables 4–7) show that respondents' objective *E. coli* knowledge, identification of the correct disease symptoms, public trust in institutions dealing with food safety, age, education, income, and gender influence food safety perceptions. Respondents who are skeptical about the ability of food corporations to safeguard the food supply were between 9% and 15% less likely than those who are not skeptical to perceive the four types of spinach as unsafe. On the other hand, individuals trusting of the USDA to safeguard the food supply were between 10% and 14% more likely to perceive the spinach types, with the exception of canned spinach, as safe for consumption, relative to those who do not trust the USDA; those with strong objective *E. coli* knowledge were between 3% and 4% more likely to do the same. White consumers were between 17% and 21% more likely to perceive the four types of spinach as safe compared to other races.

Individuals with annual incomes below \$35,000 were 12–17% less likely to perceive the four types of spinach as safe. Similarly, respondents with high school or lower levels of education were 7–13% less likely to perceive bagged, canned, and frozen spinach as safe. Young respondents (< 35 years) were 10–13% less likely to perceive bagged, loose, and frozen spinach as safe. Females were 7% more likely than their male counterparts to perceive canned spinach as safe.

The model summary statistics presented in the lower panels of tables 4–7 indicate that all four models have significant explanatory power. McFadden's  $R^2$  estimates are between 0.14 and 0.18, which are quite reasonable for cross-section data. The estimated models successfully predicted between 69% and 80% of responses.

### Conclusions

This paper has examined public perceptions of food safety, particularly focusing on spinach, which was the subject of a countrywide recall in 2006. Our findings suggest food safety perceptions may be related to the type of the product; in this context, the results indicate the public perceives frozen and canned spinach differently from bagged fresh spinach. The results also show that low levels of objective knowledge about food pathogens and the associated illnesses they cause may lead to consumers perceiving all food as unsafe for consumption.

Accurate knowledge of the contaminant and symptoms of the resulting illness may contribute to forming a balanced judgment on the safety of the particular food products. This study found that females, more frequently than males, judged the four types of spinach as safe for consumption. Likewise, Caucasians, more frequently than other races, also judged the four types of spinach as safe for consumption. These results contrast with views held by young people who, unlike middle-aged and mature individuals, more frequently viewed the four types of spinach as unsafe. Compared to those with a higher level of education, people with a below high school education level more frequently perceived the four types of spinach as unsafe. Similarly, those belonging to the lower income groups viewed the four types of spinach as unsafe more often than those in higher income groups.

Trust in institutions through which food passes and regulatory agencies was shown to be critical in determining food safety perceptions. For example, skepticism with which the public views food corporations (processors, transporters, or retailers) impacted food safety perceptions negatively. In contrast, confidence in the USDA as a regulatory agent was viewed positively, and hence contributed toward assessing the four types of spinach as safe for consumption.

Based on our findings, this study calls for efforts toward public education and outreach efforts on overall food safety targeting youth, low income groups, and those with education below the high school level. In addition, there is a need for regulatory agencies to change their image, given current low levels of public trust in their role of safeguarding the food supply. Moreover, our results indicate that bringing food safety regulatory agencies under one umbrella has the potential to boost the public's trust in regulatory agencies and improve consumers' perception about the effectiveness of regulation. The involvement of too many agencies in the food safety arena appears to create confusion among consumers as to the specific role of each of the agencies in the process. For instance, based on our

results, the FDA (unlike the CDC and USDA) is not perceived as trustworthy, possibly because of the public's lack of understanding of what the agency's role is with regard to food safety.

The mistrust of private companies involved in the food supply chain suggests the public believes that companies have an incentive to misrepresent or understate the extent of actual contamination in order to protect the profitability of their business operations. This mistrust is in contrast to confidence placed by consumers in regulatory agencies such as the CDC and USDA—confidence which possibly may be translated into consumers' desire to have in place strict and enforceable food safety regulations. Accordingly, it seems evident that the industry has a clear motivation to increase the level of public trust as well as a strong incentive to self-regulate and increase food safety standards in production given potential huge losses it faces in cases of outbreaks similar to the one examined here.

This study contributes to the emerging literature on food safety, particularly in modeling public views on the safety of the food they eat. We note, however, that our investigation is based on data collected after a widely publicized food recall; this may have biased the responses. In general, the findings generated should inform policy makers, farmers, and marketers of the need to prevent or minimize contamination occurrences, as they have a direct impact on overall food demand. Yet, given the scope of the survey data, not all foods are examined, and the consumer may perceive other foods outside this set differently. We therefore suggest that future studies expand this work by incorporating public opinions regarding a larger spectrum of foods.

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