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FOOD RECALLS AND FOOD SAFETY PERCEPTIONS:

THE SEPTEMBER 2006 SPINACH RECALL CASE

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Abstract:

This study analyzes public perceptions on food safety using a national survey conducted soon after the nationwide spinach recall (November 2006). 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 explore 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, skepticism with which the public views food corporations (processors, transporters or retailers) impacted food safety perceptions negatively. On the other, 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.

Key words**: food recalls; food safety; public perceptions; spinach**

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Introduction

Food recalls may 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 direct and indirect costs of a food recall, some manufactures may be reluctant to be compliant 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. On the other hand, the costs of failing to prevent food contamination by fully complying with the recall measures can also mount as the result of damage to perceived reputation and quality (Worth, 2000). Other 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 and the loss of export markets (Wang, Salin, Hooker, and Leatham, 2002).

A recent report issued by Centers for Disease Control and Prevention (CDC, 2006) in collaboration with the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA), shows that progress has been made in reducing foodborne infections. This report provided preliminary surveillance data that highlight important declines in foodborne infections due to common pathogens in 2005 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* incidence are approaching levels targeted by national health objectives.

However, the recent contamination of spinach from California may have brought questions about the adequacy of the existing food safety guidelines to the minds of many Americans. The *E. coli* O157:H7 outbreak in spinach caused over 200 reported cases of illness and three deaths. This and other outbreaks have not only shaken public trust in food safety regulatory agencies, but also have eroded their confidence in the safety of the food supply chain. On the other hand, 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 result in a

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reduction of self-protective behaviors such that some consumers may not take appropriate measures to help ensure food safety at the individual level. That is, their trust in the system reduces their participation in ensuring the food they consume is safe.

In this paper we examine the impact of a food recall incident on public food safety perceptions. This study analyzes public perceptions on food safety using a national survey conducted soon after the nationwide spinach recall (November 2006). Fresh produce 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 in charge of safeguarding/ensuring safety. Finally, we explore relationships between individual observance of basic good food handling practices and food safety.

We apply the random utility discrete choice model on the survey data to test the hypothesis that the public perception of food safety is invariant to the type of food. 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. The results further suggest that food safety perceptions may be related to the type of the product; for example, the public perceives frozen spinach differently from bagged fresh spinach. Additionally, the results show that low levels of objective knowledge about food pathogens and the resulting illnesses have implications on overall food safety.

Literature

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

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 due 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 (Ranagek et al., 2005**)**. Such produce items could have become contaminated 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.

In 2005 Ranagek *et al.* found that *E. coli* O157:H7 accounted for 73,000 illnesses in the United States annually. The study found that between 1982 and 2002 there were 350 outbreaks in 49 states representing 8,598 cases. The leading vector for transmission was ground beef (41%), while about one-fifth (21%) of outbreaks were attributable to produce. Moreover, their results showed that most of the outbreaks were occurring at restaurants due to cross contamination during food preparation.

Although most *E. coli* O157:H7 related illnesses have been associated with eating undercooked, contaminated ground beef, some studies have shown that people have also become ill from eating contaminated bean sprouts or fresh leafy vegetables such as lettuce and spinach. Other means of transmission include person-to-person contact in families and child care centers. In addition, infection can occur after drinking raw milk and after swimming in or drinking sewage-contaminated water (Doane, et al, 2007). It may be interesting also to note that the occurrence of E. coli O157:H7 is not restricted to cattle but has been found in other farm animals suggesting that the transmission vectors may be more extensive than initially thought.

The media has highlighted lingering doubts as to whether American consumers are being protected from foodborne illnesses. Fearing loss of public trust, many have become concerned about the lack of resolution in the E. coli O157:H7 outbreak investigation and some lawmakers have demanded that the investigation be brought to an end. Moreover, some lawmakers have voiced concerns that the food safety regulatory system needs reexamination. For example, New York Senior Senator Schumer (2006) contends that there is a serious weakness in federal agencies, stemming from understaffing. After the events of the 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 contends that the monitoring of fruits and vegetables are years behind efforts to protect meat and poultry leaving much to be desired. The Senator 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 non-meat food products. 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-1990's, the USDA stepped up enforcement efforts, which are credited with reducing the frequency of E. coli outbreaks in meat and poultry (Schumer, 2006).

Comparatively, the FDA's efforts to protect fruits and vegetables from contamination have been limited, and they have reduced the number of produce inspections dramatically. In 2005, the FDA conducted 4,573 on-site inspections of agricultural processing facilities. In 2006, they are only expected to complete 3,400, a 25 percent drop. By contrast, the USDA conducts the same number of inspections in a matter of days (Schumer, 2006). Food inspections have dropped from 50,000 in 1972 to less than 4,500 in 2005. This means that U.S. food processors are inspected on average about once every 10 years. 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, 2006). The reasoning behind not placing inspectors in the produce industry is that most produce is consumed in fresh rather than processed form unlike in the, for example, meat industry. Also, most of the contamination reported in food supply is associated with meat, with sporadic cases being associated with produce.

A common concern in the public mind given the recent *E. coli* and other successive outbreaks that followed in a short period is that the regulatory agencies may want to be involved more in order to improve the actual and perceived food safety problems. Given the perceived shortcomings of the regulatory agencies, the state of California where spinach outbreak originated is in process of enacting changes in food safety regulation to safeguard the consumer

(Krauter, 2007). This is evidenced by a statement attributable to acting regional director for the U.S. Food and Drug Administration 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 need for establishing mandatory good agricultural practices across the industry (Krauter, 2007).

This may be true and applicable to California; elsewhere the farm lobby argues in favor of self-regulation. The farm lobby argues that mandatory regulatory approach will be too expensive and will end up hurting many of the small-scale producers. In result, as the green leafy produce industry pushes for a self-regulating approach, the consumer may be favoring a mandatory approach. As this debate goes on, there seem to be no consensus even amongst the farm lobby (Brubaker, 2007).

There is a strong feeling that change may come soon, as observed by Van Goethem (2007). 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 on the US food supply. Although the U.S. food supply is one of the safest in the world, the green leafy produce industry should not wait in the wake of another E. coli lettuce outbreak, the industry should introduce initiatives towards safer produce supply before the legislation of food safety directives by the government regulators. The produce industry should learn from the meat and dairy industry that for strategic reasons of keeping and ensuring repeated sales, food safety is paramount (Van Goethem, 2007). All producers, processors, distributors, and users within the fresh produce supply chain need to be cognizant of food safety from farm to table. A brief to the Congress (Geoffrey, Becker, and Porter, 2007) indicates that there is a substantial possibility of bring food safety regulatory agencies under one umbrella. The regulatory system has been criticized on 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.

Highly publicized food safety incidents affect consumer perceptions, leading to changes in food purchasing patterns (Buzby, 2001; Calvin, Avendano, and Schwentesius, 2004). The experience of the Mexican green onion hepatitis A in 2003, and the recent *E. coli* and salmonella outbreaks that led to recalls of varying magnitudes are an indicator that consumers may be skeptical of the safety of the food supply. 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 of safety of the 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. In this regard, we examine food safety perceptions as they extend the debate and provide information that will contribute to policy making, and benefit to the green leafy produce industry in the marketing and development and adoption of food safety strategies.

Survey Methods and the Empirical Model

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.

Computer Assisted Telephone Interviews (CATI) 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 non-business numbers were contacted using a 12 call-back 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 attempt, 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%, with a resulting sampling error of ± 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.

During the telephone interview, survey participants were asked to reveal their views on fresh produce food safety. In addition they were also asked to reveal 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. Responses to some of the questions in the survey were not usable for analysis thus excluding some respondents from the sample during empirical analysis. As a result of excluding these respondents, a total of 782 completed surveys were used for empirical analysis.

To provide justification for dichotomizing the safety perception, preliminary analysis on raw data was carried out. Table 1 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 about 8. Similarly, when the raw data is considered in percentile terms, a consistent pattern emerges with the rating for canned and frozen spinach being relatively higher than bagged or loose types. The lower percentile (i.e., 25% of the respondents) rated bagged spinach at about 5, while rating canned and loose spinach at 7. When that rating across the types of spinach were combined, about 60% of the respondents rated bagged and loose spinach as completely safe, with about 73% of them rating canned and frozen spinach as safe. Thus, initial variable structure was based on raw frequencies for a natural "breaking point" and the Mann-Whitney non-parametric test was conducted to determine whether the aggregation of categories resulted in a loss of information. The test revealed no loss of information by 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 "*safe*" and "*not safe*", thus the intermediate category of "somewhat safe", will not result into "*somewhat*" consumption. The test iteratively assembles the initial categories before collapsing them into the new $N=n_a+n_b$ category (*not safe at all* and *somewhat safe*) in the case of not safe. The N measures are ranked in an ascending order, and the rankings returned to the original samples in the place of the raw measures so that n_a is the "*not safe at all*" category and n_b is the "*somewhat safe*" category. We also define T_A as the sum of n_a ranked in category A, T_B as the sum in n_b ranked in category B, and T_{AB} as the sum of N ranked in groups A and B. The Mann Whitney test is based on the Z test which is defined as:

$$Z = \frac{(T_{obs} - \mu_T) \pm .5}{\sigma_T} \quad (1)$$

where T_{obs} is the observed value for either T_A or T_B ; μ_T is the mean of the corresponding sampling distribution of T, σ_T is the standard deviation of the sampling distribution, and 0.5 is used as a correction for continuity (with -0.5 used when $T_{obs} > \mu_T$ and +0.5 used when $T_{obs} < \mu_T$. The calculated symmetric Z value is 0.6817 with a P value of .05. This value suggests that the "*not safe at all*" and "*somewhat safe*" categories of food safety are not statistically different from one another. Thus, we conclude that no information is lost by collapsing them into one category.

Table 1: Combined Categories % Respondents, Means and Percentiles: Various Spinach Types

	Bagged fresh spinach	Loose fresh spinach	Canned spinach	Frozen spinach
Mean	7.05	7.19	8.02	7.95
Percentiles				
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
Collapsed Categories	0-5	6-8	8-10	
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

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 safety rating ranged between 8 through 10, *i.e.*, "*completely safe,*" and 0 if the response was either "*somewhat safe*" rating ranging between 6 and 8, and "*not safe at all*," i.e., rating ranging between 0 and 5.

The rationale for including the explanatory variables in the empirical model is on the assumption that they have a potential to influence an individual's perceived food safety. The model explanatory variables in the empirical model include food recall awareness, food contamination/contaminant knowledge; nature of the resulting illness, trust in food safety related institutions, and the demographic variables. The awareness variable is included in the model, on the assumption that, the incident that involved the spinach contamination was widespread in scope and possibly, its memory may affect the view the public has on food safety in general and particularly, the safety of fresh produce.

Trust in regulatory institutions/agencies[1] 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 in their capability in ensuring food supply safety, then there would be a greater likelihood of rapid restoration of consumer trust in the safety 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 about *E. coli* contamination may indicate how the differences in knowledge on food supply chain issues may play into the perceived public food safety. It is assumed that the higher the individual knowledge, the better placed that individual is in interpretation of information that effectively may lead to better judgment of food safety (Table 2). Gender is used to distinguish whether males or females have differing views on food safety. For example, since women carry out most of the food shopping and cooking, they are assumed to view food safety differently. The age variables represent possible differences in perception towards 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 could also indicate a broader knowledge base and awareness of current events, leading to differences in food safety perceptions.

[1] 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 2: Descriptive Statistics

Variable	Description of Variable	Mean	Std. Dev
FEMALE	1 = respondent is female; 0 = male	0.57	0.50
YOUNG	1= age less than 35 years; 0 = otherwise	0.22	0.41
MIDAGE	1 = age is between 35 and 54 years; 0 = otherwise	0.48	0.50
MATURE*	1 = age 55 or higher; 0 = otherwise	0.31	0.46
B_HISCHOOL	1 = Below High school level of education; 0 = otherwise	0.32	0.47
TWO_YRCLG	1 = some two year college education; 0 = otherwise	0.27	0.44
FYRCLG_AB*	1 = four year college education or higher; 0 = otherwise	0.41	0.49
INCLT_35	1 = (annual) income below $35,000; 0 = otherwise	0.26	0.44
INC35_75	1 = (annual) income between $35,000 and $75,000; 0 = otherwise	0.41	0.49
INC_AB75*	1 = (annual) income greater than $75,000; 0 = otherwise	0.33	0.47
WHITE	1 = respondent is white (Caucasian); 0 = otherwise	0.82	0.39
TRUST_FDA	1 = respondent trusts the FDA to ensure food safety of the U.S food supply; 0 = otherwise	0.61	0.49
TRUST_USDA	1 = respondent trusts the USDA to ensure food safety of the U.S food supply ; 0 = otherwise	0.64	0.48
TRUST_CDC	1 = respondent trusts the CDC to ensure food safety of the U.S food supply; 0 = otherwise	0.69	0.46
SKEP_FCORP	1 = respondent is skeptical about the Food companies to ensure food safety of the U.S food supply; 0 = otherwise	0.47	0.50
SKEP_GROCER	1 = respondent is skeptical about the grocery stores to ensure food safety of the U.S food supply; 0 = otherwise	0.38	0.48
SKEP_GVT	1 = respondent is skeptical about the state government to ensure food safety of the U.S food supply; 0 = otherwise	0.50	0.50
TRUST_ORGFARM	1 = respondent trusts the organic farmers to ensure food safety of the U.S food supply; 0 = otherwise	0.61	0.49
TRUST_CONFARM	1 = respondent trusts the conventional farmers to ensure food safety of the U.S food supply; 0 = otherwise	0.56	0.50
QECOLI	1 = respondent identified the spinach contaminant correctly; 0 = otherwise	0.86	0.35
COR_SMPO	Respondent correctly identified the symptoms for E-coli illness(average score)	1.64	0.57
INCOR_SM	Respondent incorrectly identified the symptoms for E-coli illness(average score)	2.85	0.81
ECOLIOQU	Respondent correctly answered knowledge questions related to the spinach e-coli contamination	3.37	1.52
HEARD_RECALL	Respondent heard about food recalls in general	3.00	1.04

Notes: Asterisk implies that the variable was dropped during estimation to avoid dummy variable trap.

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

$$FOODSAFE_i = \beta_0 + \beta_1 FEMALE + \beta_2 YOUNG + \beta_3 MIDAGE \beta_4 B\_HSCHOOL + \beta_5 TWO\_YRCOLG + \beta_6 WHITE + \beta_7 INCLT\_35 + \beta_8 INC35\_75 + \beta_9 TRUST\_DFDA + \beta_{10} TRUST\_USDA + \beta_{11} TRUST\_CDC + \beta_{12} SKEP\_FDCORPS + \beta_{13} SKEP\_GROCER + \beta_{14} SKEP\_SGVT + \beta_{15} TRUST\_ORGFARM + \beta_{17} TRUST\_CONFARM + \beta_{18} COR\_SYMPOT + \beta_{19} INCOR\_SYMPOT + \beta_{20} ECLIOQUIZ + \varepsilon \quad (10)$$

where the variables are defined and listed in Table 3. The asterisk is assigned to the variable's reference category against which the influence of other categories on food safety perception is measured.

Table 3: E.coli objective questions Quiz	**True**	**Likely true**	**Likely false**	**False**
Most people infected with E. coli 0157: H7 die as a result of the infection. Would you say this is ..				
All people are equally susceptible to E.coli infection. Would you say this is ..				
Contamination with E. coli can come from animal waste. Would you say this is ..				
All food that is cooked to 120 degrees Fahrenheit is safe to eat. Would you say this is ..				
Bagged spinach marked as "Triple washed" is certain not to have any E. coli. Would you say this is ..				
You can catch E. coli from an infected person through their coughing or sneezing. Would you say this is ..				

Empirical Results

The maximum likelihood (ML) estimates of the model coefficients, the marginal effects on the dependent variable, and the associated t-ratios are reported in Tables 4a-d. Also reported in these tables are the log-likelihood functions of the unrestricted and the restricted (i.e., all slope coefficients are zero) model 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 percent) respondents perceived bagged fresh spinach as safe, with 303 (39 percent) respondents perceiving it as not safe. In the case of loose fresh spinach, 491 (63 percent) respondents perceived it as safe, while 291 (37 percent) respondents viewed it as unsafe. Those numbers in case of canned and frozen spinach increased to 609 (78 percent) and 597 (76 percent) for safe and 173 (22 percent) and 185 (24 percent) for not safe perception, respectively.

Among the demographic variables, it can be seen from Tables 4a-d that the coefficients of *YOUNG* and *MIDAGE* are negative and statistically significant at 10 percent level or lower in three models, i.e., bagged and loose fresh spinach types, and the frozen spinach type model. The estimated coefficients suggest that relative to older consumers (55 years or older), the middle and young respondents (age 54 or less) are more likely to perceive fresh bagged, loose, and frozen spinach as unsafe. Only with the exception of the loose fresh spinach model, the coefficient of *BHSCHOOL (*below high school level of education) variable is negative and significant at 10 percent or lower level across the bagged, canned and frozen spinach types. In addition, the coefficient on the *TWO_YRCLG* (two years of college education) variable was negative and significant at 5 percent level for the frozen spinach. The results suggest that respondents with two year college education and/or less compared with those with four year college education or more are more likely to perceive bagged fresh spinach, canned and frozen types of spinach as not safe.

Table 4a: Maximum Likelihood Estimates of Model Coefficients and Marginal Effects				
	Model Coefficients on Safety Perception: Bagged Spinach			**Marginal Effects on Safety Perception: Bagged Spinach**
	Coefficient	t-ratio	p-value	Marginal Effect
Constant	-0.0300	-0.05	0.96	-
FEMALE	-0.0338	-0.20	0.84	-0.01
YOUNG	-0.5382	**-2.26**	**0.02**	**-0.13**
MIDAGE	-0.3356	**-1.70**	**0.09**	**-0.08**
B_HISCHO	-0.5411	**-2.53**	**0.01**	**-0.13**
TWO_YRCL	-0.2043	-0.96	0.34	-0.05
WHITE	0.7608	**3.45**	**0.00**	**0.18**
INCLT_35	-0.6587	**-2.73**	**0.01**	**-0.16**
INC35_75	-0.2899	-1.46	0.14	-0.07
TRUST_FDA	-0.2196	-0.92	0.36	-0.05
TRUST_USDA	0.5807	**2.39**	**0.02**	**0.14**
TRUST_CDC	0.2048	0.89	0.37	0.05
SKEP_FCORPS.	-0.6401	**-3.01**	**0.00**	**-0.15**
SKEP_GROCER	0.0251	0.12	0.91	0.01
SKEP_GVT	-0.1678	-0.73	0.47	-0.04
TRUST_ORFARM.	0.1377	0.66	0.51	0.03
TRUST_CONVFARM	0.5282	**2.35**	**0.02**	**0.12**
COR_SMPOT	-0.0489	-0.33	0.75	-0.01
INCOR_SMPOT	0.0046	0.04	0.97	0.00
ECOLIOQUIZ	0.1429	**2.52**	**0.01**	**0.03**
LL	-446.18			
Restricted LL	-522.06			
Chi-Square	151.78			
DF	19			
McFadden's R^2	0.15			
% Correct prediction	69%			
	PREDICTED			
ACTUAL	0	1	Total	
0	144	159	303	
1	85	394	479	
TOTAL	229	553	782	

Table 4b: Maximum Likelihood Estimates of Model Coefficients and Marginal Effects				
	Model Coefficients on Safety Perception: Loose Spinach			**Marginal Effects on Safety Perception: Loose Spinach**
	Coefficient	t-ratio	p-value	Marginal Effect
Constant	-0.4542	-0.75	0.45	-
FEMALE	0.0690	0.41	0.68	0.02
YOUNG	-0.4177	**-1.77**	**0.08**	**-0.10**
MIDAGE	-0.1655	-0.85	0.40	-0.04
B_HISCHO	-0.2965	-1.38	0.17	-0.07
TWO_YRCL	-0.1900	-0.90	0.37	-0.04
WHITE	0.8865	**4.06**	**0.00**	**0.21**
INCLT_35	-0.7260	**-3.03**	**0.00**	-0.17
INC35_75	-0.1631	-0.82	0.41	-0.04
TRUST_FDA	-0.1321	-0.56	0.58	-0.03
TRUST_USDA	0.4147	**1.71**	**0.09**	**0.10**
TRUST_CDC	0.1829	0.80	0.43	0.04
SKEP_FCORPS.	-0.6610	**-3.10**	**0.00**	**-0.15**
SKEP_GROCER	0.0554	0.26	0.80	0.01
SKEP_GVT	-0.1562	-0.67	0.50	-0.04
TRUST_ORFARM.	0.0202	0.10	0.92	0.00
TRUST_CONVFARM	0.5440	**2.41**	**0.02**	**0.12**
COR_SMPOT	-0.0735	-0.49	0.62	-0.02
INCOR_SMPOT	0.0747	0.71	0.48	0.02
ECOLIOQUIZ	0.1624	**2.86**	**0.00**	**0.04**
LL	-446.48			
Restricted LL	-516.18			
Chi-Square	139.41			
DF	19			
McFadden's R^2	0.14			
% Correct prediction	69%			
	PREDICTED			
ACTUAL	0	1	TOTAL	
0	125	166	291	
1	79	412	491	
TOTAL	204	578	782	

Table 4c: Maximum Likelihood Estimates of Model Coefficients and Marginal Effects

	Model Coefficients on Safety Perception: Canned Spinach			**Marginal Effects on Safety Perception: Canned Spinach**
	Coefficient	t-ratio	p-value	Marginal Effect
Constant	1.0416	1.46	0.14	-
FEMALE	0.4651	**2.33**	**0.02**	**0.07**
YOUNG	-0.3785	-1.36	0.17	-0.06
MIDAGE	-0.0841	-0.35	0.72	-0.01
B_HISCHO	-0.4461	**-1.74**	**0.08**	**-0.07**
TWO_YRCL	-0.3281	-1.26	0.21	-0.05
WHITE	0.9945	**4.14**	**0.00**	**0.17**
INCLT_35	-0.7677	**-2.73**	**0.01**	**-0.12**
INC35_75	-0.1381	-0.55	0.58	-0.02
TRUST_FDA	-0.0916	-0.33	0.74	-0.01
TRUST_USDA	0.0514	0.18	0.86	0.01
TRUST_CDC	0.5026	**1.95**	**0.05**	**0.08**
SKEP_FCORPS.	-0.8881	**-3.44**	**0.00**	**-0.12**
SKEP_GROCER	0.1701	0.64	0.52	0.02
SKEP_GVT	-0.8915	**-3.21**	**0.00**	**-0.13**
TRUST_ORFARM.	-0.2936	-1.19	0.24	-0.04
TRUST_CONVFARM	0.1609	0.60	0.55	0.02
COR_SMPOT	0.3414	**1.99**	**0.05**	**0.05**
INCOR_SMPOT	-0.1856	-1.47	0.14	-0.03
ECOLIOQUIZ	0.1846	**2.71**	**0.01**	**0.03**
LL	-337.92			
Restricted LL	-413.25			
Chi-Square	150.66			
DF	19			
McFadden's R^2	0.18			
% Correct prediction	80%			
	PREDICTED			
ACTUAL	0	1	TOTAL	
0	47	126	173	
1	33	576	609	
TOTAL	80	702	782	

Table 4d: Maximum Likelihood Estimates of Model Coefficients and Marginal Effects

	Model Coefficients on Safety Perception: Frozen Spinach			**Marginal Effects on Safety Perception: Frozen Spinach**
	Coefficient	t-ratio	p-value	Marginal Effect
Constant	1.1199	1.59	0.11	**-**
FEMALE	0.2515	1.30	0.19	0.04
YOUNG	-0.5770	**-2.09**	**0.04**	**-0.10**
MIDAGE	-0.4287	**-1.83**	**0.07**	**-0.07**
B_HISCHO	-0.4885	**-2.00**	**0.05**	**-0.08**
TWO_YRCL	-0.0852	-0.33	0.74	-0.01
WHITE	1.0795	**4.65**	**0.00**	**0.20**
INCLT_35	-0.6758	**-2.47**	**0.01**	**-0.12**
INC35_75	-0.0966	-0.40	0.69	-0.02
TRUST_FDA	-0.3300	-1.21	0.23	-0.05
TRUST_USDA	0.5851	**2.10**	**0.04**	**0.10**
TRUST_CDC	0.3859	1.51	0.13	0.06
SKEP_FCORPS.	-0.5623	**-2.25**	**0.02**	**-0.09**
SKEP_GROCER	0.0304	0.12	0.91	0.00
SKEP_GVT	-0.4439	**-1.65**	**0.10**	**-0.07**
TRUST_ORFARM.	0.1698	0.71	0.48	0.03
TRUST_CONVFARM	0.0706	0.27	0.79	0.01
COR_SMPOT	0.3701	**2.20**	**0.03**	**0.06**
INCOR_SMPOT	-0.3371	**-2.68**	**0.01**	**-0.05**
ECOLIOQUIZ	0.0839	1.28	0.20	0.01
LL	-356.10			
Restricted LL	-427.83			
Chi-Square	143.47			
DF	19			
McFadden's R^2	0.17			
% Correct prediction	79%			
	PREDICTED			
ACTUAL	0	1	TOTAL	
0	50	135	185	
1	30	567	597	
TOTAL	80	702	782	

The coefficient of *FEMALE* variable is positive and significant at 5 percent level only with respect to canned spinach, suggesting that female respondents are more likely to perceive canned spinach as safe for consumption than male respondents. Similarly, Caucasians were more likely to perceive the four types of spinach as safe for consumption compared to other racial groups. The coefficient on *Caucasian* was positive and significant at 5 percent or lower in all the four models. The sign of the estimated coefficient suggests that white respondents perceived spinach as more safe, irrespective of the type.

The relationship between income and consumers' safety perception was strong and significant across all the four models. The coefficients of *INCLT_35* (income less than 35,000 dollars annually) is negative and significant at 5 percent or lower across the four models. The sign of the estimated coefficient suggests that, relative to those with annual household income of $75,000 or more, respondents with incomes of 35,000 dollars or less are more likely to perceive the four types of spinach as unsafe for consumption.

The estimated coefficients suggest that trust in private and public institutions associated with food safety have significant influence on individual's food safety perceptions. This is demonstrated by the public trust on those regulatory agencies dealing with food safety, i.e., FDA, USDA and CDC. Coefficients for *TRUST_USDA* and *TRUST_CDC* were positive and significant; however, the coefficient for *TRUST_FDA* was negative and insignificant. Trust in the United States Department of Agriculture (*TRUST_ USDA)*, was positive and significant at 10 percent level or lower in three models relating to fresh bagged and loose spinach and the frozen type. Trust in the Centers for Disease Control and Prevention (*TRUST_CDC*) was positive and significant at 5 percent with respect to canned spinach. Yet, the results suggest that food safety perception was not related to respondents' trust in FDA, but rather with USDA and CDC. Thus, respondents who trust in 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 types spinach as safer for consumption.

The coefficients for skepticism variables show how mistrust of institutions along the food supply chain might affect safety perceptions in a contamination event. Overwhelmingly, the coefficient *SKEP_FCORP* was negative and significant at less than 5 percent level of significance in all the four models relating to spinach types. Respondents who were skeptical about state governments (*SKEP_GVT*) capability to safeguard the food supply were more likely to perceive canned and frozen types of spinach as unsafe compared to those respondents who were not skeptical. Interestingly, the results show that trust in organic farmers (*TRUST_ORGFARM*), was not related to food safety perception. Trust of conventional farmers to safeguard the food supply was only significant with respect the fresh spinach types.

Correct identification of the *E-coli* symptoms by many of the respondents was positive and significant at 5 percent for both canned and frozen spinach. The sign on the coefficient on *CORR_SYMPOT* variable suggests that, respondents who correctly identified the right symptoms *E. coli* sickness were more likely that those who did not to perceive canned and frozen spinach as safe for consumption. On the other hand, incorrect identification of the symptoms was negative and significant only with respect to the frozen spinach. Thus, it was 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, the sign of the coefficient was positive and significant suggesting that those with greater and more accurate knowledge about the *E. coli* contamination were more likely to perceive the four types of spinach as safe for consumption.

The estimated marginal effects of the independent variables (presented in Table 4a-d) show that respondent's objective *E. coli* knowledge, identification of the correct disease symptoms, public trust on institutions dealing with food safety, age, education, income and gender influence food safety perceptions. Respondents who are skeptical (vs. those who are not skeptical) about the ability of food corporations to safeguard the food supply were between 9 and 15 percent less likely to perceive the four types of spinach as unsafe. On the other hand, individuals trusting of USDA to safeguard the food supply were between 10 and 14 percent more likely to perceive the spinach types as safe for consumption, relative to those who do not trust USDA. While those with strong objective *E. coli* knowledge were between 3 and 4 percent more likely to do the same. White consumers were between 17 and 21 percent 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 percent less likely to perceive the four types of spinach as safe. Similarly, respondents with high school or lower levels of education were 7-13 percent 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 percent more likely than their male counterparts to perceive canned spinach as safe. The model summary statistics presented in the lower panels of Tables 4a-d indicate that all three models have significant explanatory power. McFadden's R^2 estimates are between 0.14 and 0.19 which are quite reasonable for a cross-section data. The estimated models successfully predicted between 69 percent and 80 percent of responses.

Conclusions

This paper examines public perceptions on food safety particularly relating to spinach which was subject of countrywide recall in 2006. The results suggest that food safety perceptions may be related to the type of the product; in this context the results indicate that 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 resulting illnesses may lead to the public perceiving that all food may be unsafe for consumption.

The results indicate that accurate knowledge on the contaminant and symptoms of the resulting illness may contribute to exercising a balanced judgment on the safety of the particular food product. Results further indicate that females and Caucasians judged the four types of spinach as fit for consumption. This result contrasts with views held by young people, people with education below high school and those belonging to the lower incomes groups, who viewed the four types of spinach as unsafe. Trust in institutions through which food passes and regulatory agencies were 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. On the other hand, 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. The study calls for efforts toward public education and outreach efforts on overall food safety targeting the youth, low income groups and those with education below high school. 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.

This study has contributed to the emerging literature on food safety, particularly in modeling public views on the safety of the food they eat. We however note that the study is based on data collected after a widely-publicized food recall; this may have biased the responses. In general, the information generated will inform policy makers, farmers and marketers that contamination can occur anywhere. There is need for preventing or minimizing such occurrences as they have a bearing impacting overall food demand. However, given the scope of the survey data, not all foods are covered; the consumer may likely perceive those other foods outside this set differently. We suggest, therefore, that future studies incorporate public opinions regarding a larger spectrum of foods.

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APPENDIX

Conceptual Framework

We examine the impact of a food recall incident on public food safety perceptions. The Lancaster (1966a, b) model provides a natural 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.

$$U = U(z_1, z_2, \cdots, z_m) \qquad (1)$$

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. A rational individual is assumed in this model. 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 commodity 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 that 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}, respectively. However, these utility levels are not directly observable. The observable variables are the product attributes a (*a* = *S*, *NT*)[3] and a vector of individual characteristics (*x*). The random utility model assumes that the utility derived by individual i from the perceived safety a (a = S, *NS*) can be expressed as:

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

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 ε_{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 ε 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 basis of perceived safety is given by:

$$p_i = prob(\varepsilon_{NS} - \varepsilon_S < V_s - V_{NS}) = prob(\varepsilon < V_s - V_{NS}) \qquad (3)$$

[3] The subscripts denote safe and not safe, respectively.

Describing the density function of ε by f (ε), the above probability is given by:

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

where Z_i is an indicator variable that equals 1 when the term inside parenthesis 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 absence of food safety. In order to empirically implement the above conceptual framework, it is assumed that ε_{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 ε_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, β-coefficients (along with their t-ratios) and the marginal effects were obtained by using the software package LIMDEP (Econometric Software, 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 homogenous 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 one 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:

$$Z_i = \boldsymbol{\beta}'\mathbf{X} + \nu_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik} + \nu_i, \quad \text{i} = 1, 2, \ldots, \text{n} \qquad (5)$$

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

$$P_i = F\left(Z_i\right) = F(\beta_0 + \sum_{j=1}^{k} \beta_j x_{ij}) = F(\boldsymbol{\beta}\mathbf{X}_i) = \frac{1}{1 + \exp\left(-\boldsymbol{\beta}\mathbf{X}_i\right)} \qquad (6)$$

The estimated β-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:

$$\partial P_i / \partial x_{ij} = \left[\beta_j \exp\left(-\boldsymbol{\beta}\mathbf{X}_i\right)\right] \Big/ \left[1 + \exp\left(-\boldsymbol{\beta}\mathbf{X}_i\right)\right]^2 \qquad (7)$$

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:

$$\partial P_i / \partial x_{ij} = P\left(x_{ij} = 1\right) - P\left(x_{ij} = 0\right). \qquad (8)$$