Changing Food Safety Risk Perceptions: The Influence of Message Framings & Media Food Safety Information

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Abstract

Human cases of *E. coli O157:H7* infections linked to the consumption of contaminated beef products consistently receive public attention due to their far-reaching health and economic implications. As consumers' risk attitudes and perceptions remain pivotal to beef food safety initiatives, the study seeks to investigate the role of message framings and media food safety information on consumers' valuation of their risk of an *E. coli* food infection, and attitudes towards food safety technologies. Using a nationally representative sample of 1,842 residents across the US, respondents were randomly assigned into six information groups. Findings reveal that message framings, particularly loss-framed messages influence consumers' perceived risks, and attitudes towards food safety interventions. Respondents who received the media story about the plight of a consumer who suffered an *E. coli* infection showed more concern about the risk of an infection, while those who received loss-framed information were in general more accepting of food safety interventions such as vaccines and direct fed microbials. These findings could help the beef industry and policy makers develop effective food safety communication strategies.

1. Introduction

Issues of food safety are of immense concern to consumers as evidenced by the swift consumer reactions anytime there is a media broadcast about contamination of food products. A case in point is the 1996 Cyclospora outbreak which was wrongly attributed to California strawberries that nevertheless depressed strawberry demand and sales by $20 million to $40 million (Powell 1998). In another instance, the Food and Drug Administration's (FDA) announcement of an *E. coli O157* contamination in bagged spinach in September 2006 quickly froze the marketing of spinach; there were no sales of spinach in the US for the next five days, and no sales for an additional ten days in California, a main producing area (Calvin 2007). Calvin (2007) notes that sales of bagged spinach dwindled five months into the spinach *E. coli O157* outbreak, compared to sales the previous year.

Without a doubt, news from the media that raises awareness of compromises in food products reverberate among consumers. Whether the swift consumer reaction to food product contamination translates into positive attitudes towards interventions that reduce, or at best prevent food contamination in the first place is an empirical question. On the issue of prevention of food contamination, the FDA proposed in January 2013 two new food safety rules to help prevent foodborne illnesses (FDA 2013). The proposal intensifies testing for *E. coli O157* in beef and other voluntary food safety guidelines for producers and growers. *E. coli* infections can result in severe health problems such as kidney failure, paralysis or even death. The emphasis on beef is justified, because cattle are a major carrier of the *E. coli O157* strain, with many cases of *E. coli O157* infections in humans traced to the consumption of contaminated beef products. The USDA's Food Safety and Inspection Service (FSIS), for example, reports the recall of approximately 50,100 pounds of raw ground beef products that may have been contaminated with *E. coli O157*:H7 in July 2013, linked to a Kansas beef packing company.

The development of recent pre-slaughter interventions in the beef sector such as vaccinations against *E. coli O157* and the use of DFMss (DFMs) in cattle feed, hold promise for the reduction of *E.coli* related outbreaks. Vaccines against *E. coli O157* in cattle, and DFMs, have been approved for use by the U.S. Department of Agriculture (USDA) and FDA, respectively. Research on the efficacy of these interventions demonstrate that vaccines can reduce *E. coli* bacteria in the shedding of cattle by 80% (Hurd and Malladi 2012), while Brashears (2012) reports at least a 50% reduction of the bacteria on the hides and shedding of cattle given DFMs. Matthews et al. (2013) translate the reduction in *E. coli* bacteria from the use of cattle vaccines to at least an 85% decrease in human infections. As has been the case with similar food safety interventions such as food irradiation, a key challenge remains overcoming potential consumer biases against new technologies, and finding effective ways to inform the public their efficacy. Even though the interventions mentioned are targeted towards cattle, potential consumer leeriness about particularly the use of vaccines against *E. coli O157* might exist, given vocal public concerns about human vaccines and their (debunked) link to autism (DeStefano, Price and Weintraub 2013). Consequently, communicating the advantages of these interventions in a manner that draws broad consumer support is of utmost relevance, as this in turn will send positive signals to cattle producers and might encourage widespread adoption of these technologies.

The persuasive effect of different information framing on consumer behavior has been the subject of growing research. Findings from Kahan et al. (2009) bolster this assertion by showing that the type, source, and framing of information provided to the public affect their attitudes towards new technologies. In addition, Kahneman and Tversky's (1979) prospect theory that finds that people are more sensitive, and attach greater weight, to losses than to gains of the same magnitude, offers new ways of framing food safety related information that may influence its persuasive efficacy. In this context, the main objective of the study is to investigate the role of different information framings on consumers' beef safety risk perceptions, preferences for, and acceptance of the two technologies - cattle vaccines against *E. coli O157* and DFMs. In addition to the above objectives, the study considers the role of consumer characteristics such as prior knowledge of the interventions, trust in institutions and openness to new technologies in influencing perceptions and attitudes towards food safety risks. The experimental design involved six information treatments. Respondents in the first information group, which served as the control, received only general information about *E.coli* and the two technologies. Respondents in the second and third information groups, in addition to general information, received gain-framed and loss-framed information, respectively. The information provided to the survey participants emphasized the potential risk reduction of an *E. coli O157* infection for beef products from cattle treated with the interventions. These benefits associated with reduced risk of an *E.coli* infection, however, were framed either as a potential gain resulting from the consumption of treated beef products or a potential loss associated with forfeiting the choice of treated beef products. A media news story which highlighted the plight of a beef consumer who suffered from an *E. coli O157* infection was also provided to elicit issue involvement among beef consumers, which refers to the degree to which an issue becomes of personal relevance and importance (Petty and Cacioppo, 1979).

2. Literature Review

The intriguing aspects of message framing on consumer attitudes are the different response behaviors observed when comparable but distinct information is provided. Much of the theory about message framing is based on Kahneman and Tversky's (1979) prospect theory. Within the broader context of prospect theory, message framing is the presentation of comparable information in terms of benefits and losses, which may have different effects on behavior. The effect of message framing is achieved when beliefs and behaviors are affected by the presentation of information in a manner that is logically unrelated to the content (Kahan et al. 2009). A number of empirical studies have shown that information provision has a direct bearing on attitudes towards food safety, where responses are gauged from purchasing intentions after information is provided. Schroeter, Penner, and Fox (2001) showed that providing information that emphasizes the benefits of a technology can change risk perceptions and induce a positive purchasing behavior. Similar findings were echoed by Fox, Hayes and Shogren (2002), and Nayga, Aiew and Nichols (2004) about information provision for irradiated food products. Examining the confluence of message framing and consumers' subjective knowledge on food safety choices, Jin and Han (2014) provided information in the form of news articles with different captions. Self-reported prior knowledge was elicited using subjects' responses about the extent of their familiarity to industrial beef tallow and pus milk. They found that respondents with greater subjective knowledge were less influenced by the information framing, while for respondents with little subjective knowledge the framing effect was stronger.

Research findings in a variety of disciplines provide somewhat conflicting evidence as to which of the two message framings, gain-framed or loss-framed messages, have the greatest persuasive effect on individual attitudes and behavior. Dillaway et al. (2011) empirically showed that both negative and positive information had a sustained effect on purchase intentions, although negative information had a longer-term impact in discouraging consumer demand. Gonzach and Karsahi (1995) found that the rate of re-use of a credit card for customers who had discontinued using the card for three months more than doubled among customers who were provided with loss-framed information on the benefits forfeited by not using the card, than for customers who received gain-framed information. In the domain of health, findings from Gallagher and Updegraff's (2012) found that gain-framed messages had a stronger persuasive influence in fostering preventive behavior and measures against illness, such as cessation of smoking and physical activity, than loss-framed messages. In contrast, Abhyankar, O'Connor and Lawton (2008) concluded that loss-framed messages induced a stronger intent to vaccinate children than gain-framed messages. Their study investigated the role of message framing in persuading participants to vaccinate children against measles, mumps and rubella (MMR), and all participants were exposed to either the loss-framed or the gain-framed message. Meyerowitz and Chaiken (1987) reported that loss-framed messages had a stronger persuasive effect in encouraging voluntary breast self-examination.

In addition to message framing, issue involvement has been shown to influence consumer perceptions, attitudes and behavior and reinforces the efficacy of message framings. Issue involvement is the extent to which the attitudinal issue under consideration is of personal importance (Petty and Cacioppo, 1979). Maheswaran and Meyers-Levy (1990) found that negatively-framed messages were more persuasive in having respondents test for coronary heart disease when issue involvement was high, explaining that negatively-framed messages seemed to be accorded greater weights amongst individuals who were more involved with the issue considered. Another study that uniquely incorporates issue involvement is that by Ganzach, Weber and Or (1997), where participants in the study were put in a real or artificial environment before information was provided. The real environment was created such that the issue in the experiments directly concerned participants, while in the artificial environment, the issue concerned other people than the participants themselves. The authors found that gain-framed-framed information had a stronger impact in the artificial environment, and less persuasive in the real environment, and this difference was attributed to issue involvement, which was higher in the real environment than the artificial environment. Nan (2007) introduced the desirability of end-states concept in the study of message frames and health-related behavior. As explained by Nan (2007), a desired outcome from complying with a decision task is the desirable end-state, and the unsuitable outcome from non-compliance is the undesirable end-state. For the desirable end-state, the gain-framed information indicated the desired outcome from complying with the decision task, while the loss-framed information indicated the desired outcome forgone through non-compliance of the decision task. For the undesirable end-state, the gain-framed information showcased the undesired outcome forgone through compliance, while the loss-framed information communicated the undesired end-state to be faced through non-compliance. Findings showed that gain-framed messages were more persuasive, inducing favorable attitudes and intent towards the health behavior. It was also found that, when involvement was low, the gain-framed message had a stronger effect in stimulating a positive intent towards the health behavior. For high involvement, the loss-framed information was found to be more persuasive for favorable intent towards the health behavior.

It can be argued then, that the persuasive effect of either loss-framed or gain-framed information would depend on the issue considered, implying that the impacts are domain specific. This research adds to existing literature by exploring multiple message framings on risk and safety perceptions in food safety, and technologies that enhance food safety. It expands on other studies examining information effects in food safety or food safety technologies (Schroeter, and Penner and Fox 2001; Fox, Hayes and Shogren 2002; Nayga, Aiew and Nichols 2004 and

Kahan et al. 2009) by presenting comparable food safety information as benefit losses and benefit gains associated with a consumption decision, examining the interaction between issue involvement and message framings and their influence on risk perceptions and attitudes.

3. Information Treatments

As discussed in the previous section, the novelty of this study is its design of the information treatments, which is a blend of both gain-framed and loss-framed information, a media story, and combinations of the message frames (gain-frame and loss-frame) and the media story. Based on studies that show that the *E. coli O157* vaccine in cattle could translate into an 85% reduction in human cases of infections (Matthews et al. 2013), the combined effect of both vaccines and DFMs were communicated to respondents as having the potential to reduce human cases of an *E. coli O157* infection by as much as 80%. The study incorporated six information treatments, and each treatment group comprised approximately of 310 respondents. Respondents in the first information group, which served as the control, received only general information about *E.coli* and the two technologies. Respondents in the second and third information groups, in addition to general information, received gain-framed and loss-framed information, respectively. Respondents in the fourth information group received general information along with the media story while those in the fifth and sixth information groups received general information, the media story as well as the gain-framed and loss-framed information, respectively. The gain-framed information was described as follows:

When cattle are vaccinated against E. coli O157 or have DFMs included in their diet, human cases of E. coli O157 infections can be substantially reduced (up to 80%).
When you choose to consume meat products from cattle that have received either of these treatments, you are reducing your risks of an E. coli O157 food infection.
Even if you do not consume beef, you benefit from cattle being vaccinated or fed DFMs. The reduction of E.coli bacteria in cattle, decreases the environmental dissemination of E.coli into irrigation water and onto produce which reduces potential human exposure.

The loss-framed information emphasized the opportunity forgone in reducing the risk of an infection, and was given as follows:

When cattle are vaccinated against E. coli O157 or have DFMs included in their diet, human cases of E. coli O157 infections can be substantially reduced (up to 80%).
When you choose to consume meat products from cattle that have <u>not</u> received either of these treatments, you increase your risks of an E. coli O157 food infection.
Even if you do not consume beef, you face greater health risks when cattle <u>are not</u> vaccinated or fed DFMs. The reduction of E.coli bacteria in cattle, decreases the environmental dissemination of E.coli into irrigation water and onto produce which reduces potential human exposure.
Both information frames included a component that emphasized the private benefit of the interventions, highlighting their environmental relevance, especially for the benefit of those respondents who were not beef consumers. The information design further explored the potential effects of eliciting respondent involvement on risk attitudes and behavior, similar to Maheswaran and Meyers-Levy (1990). This was accomplished with the news story below:

A story published by The New York Times in its October 3, 2009 edition reports the case of Stephanie Smith, a children's dance instructor, age 22, who suffered a severe form of food-borne illness caused by E. coli O157:H7. The illness, which was traced to the hamburger her mom grilled for their Sunday dinner in early Fall 2007, left her paralyzed and at risk of kidney failure.

The media story was included to elicit some degree of issue involvement among respondents, and equally important, to communicate the fact that risk of *E. coli O157* infections could have significant health consequences, even for young, energetic people.

4. Message Framing and Prospect Theory: Conceptual Model

The persuasiveness of message framing has been illustrated in Kahneman and Tversky's (1979) prospect theory which describes the influence of framing preferences in the face of uncertainty and risk. Expected utility theory, assumes that individuals assign probabilities to outcomes when they make decisions to maximize utility, and these decision weights (probabilities) are assumed to be linear. Expected utility theory also makes the assumption that choices are made from an invariant reference point (Sebora and Cornwall, 1995), which means that individuals are interested in absolute rather than relative wealth. Extending the choice invariance argument consequently suggests that preferences are independent of the manner in which they are described. As suggested by Barberis' (2012), an individual evaluates *i* sets of decisions under expected utility theory as:

$$\sum_{i}^{n} p_i U(W + x_i) \qquad (1)$$

where x_i represents the outcome of decision i with probability p_i, W represents current wealth and $U(\cdot)$ is an increasing and concave utility function. Contrary to expected utility theory, prospect theory suggests that the framing of decisions have an influence on preferences and outcomes. For this reason, individuals define utility in terms of deviations from a reference point (as gains and losses). This contrasts with an individual's von Newmann-Morgenstern expected utility, which is defined in terms of initial wealth. Under prospect theory, the decision sets will be evaluated as:

$$\sum_{i}^{n} \pi_i v(x_i) \qquad (2)$$

where $v(\cdot)$ is a value function and π_i are decision weights. To offer a meaningful reference point about potentially reducing the risk of an *E. coli* infection, respondents were informed in the message framings that consuming beef products from cattle treated with vaccines or DFMs significantly reduced this risk by as much 80%. The value function explains the concept of loss aversion, that is, individuals showing greater sensitivity to losses than to gains of the same magnitude (Baberis 2012). That means, the disutility of experiencing losses exceeds the utility derived from gains. This implies that the value function is steeper for losses than for gains, as shown in figure 1.

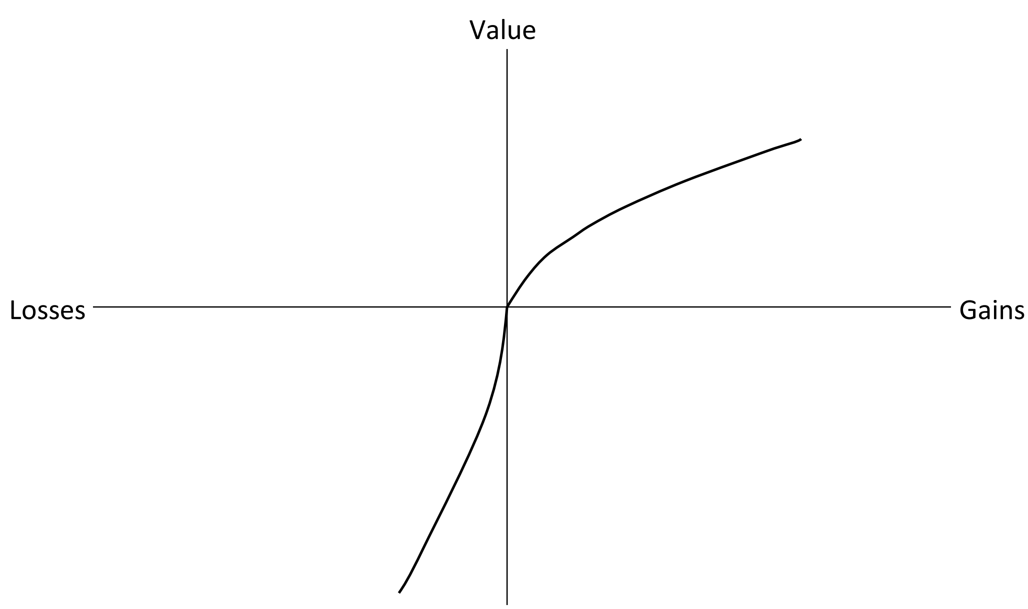

Figure 1. A hypothetical value function

The horizontal axis of the value function indicates the gains or losses from the reduced risk of an *E. coli O157* food infection from beef consumption, while the vertical axis is the value assigned to the reductions in risks. The concavity of the value function in the region of gains and the convexity in the region of loss depicts the concept of diminishing sensitivity. Diminishing sensitivity means that the impact of a marginal change diminishes with increasing distance from the reference point. The decision weights as used in equation 2 are different from the probabilities in expected utility theory. The weights that individuals assign to decisions do not necessarily correspond to their objective probabilities. In prospect theory, individuals tend to overweight smaller probabilities of unlikely outcomes, and place less premium on higher probabilities. Prospect theory thus suggests that individuals are likely to respond differently contingent on how messages are framed, either as losses, or as gains (Abhyankar, O'Connor and Lawton 2008, Gonzach and Karsahi 1995). With the threat of an *E. coli O157* infection present in beef consumption, individuals are expected to evaluate the reduced risk of an infection higher when presented with a loss-framed information than a gain-framed information. This provides the following testable hypotheses for participants who receive the loss-framed information:

1. Safety ratings for meat products from cattle vaccinated against *E. coli O157* are likely to be higher.
2. Safety ratings for meat products from cattle given direct fed microbials are likewise expected to be higher, and finally
3. Lower safety ratings are expected for beef products from cattle that have not been treated with either intervention.

5. Data and Descriptive Statistics

The study had a sample size of 1,879 respondents over 18 years of age, weighted demographically to be a nationally representative sample. Respondents were recruited from the web-panel pool of targeted responders of the GfK Global, a leading online survey firm with a 55,000 member probability-based panel (KnowledgePanel®) designed to be representative of the US population. The survey instrument targeted a total of 2,999 individuals between July and August, 2015. Of this number, 1,879 responses were received, yielding a response rate of 62.7%. To reduce the number of missing values in the entire dataset, missing responses for twenty-one questions and over were deleted per observation, resulting in an eventual sample size of 1,842 respondents. Tables 1, 2 and 3 display the descriptive statistics for the 1,842 respondents in the study.

Table 1 shows that respondents were open to having vaccines used in animal production, with a mean of 3.03 on a 1 to 5 ordinal scale, and viewed organic production very favorably, with a mean of 3.58. Table 1 further illustrates the relatively moderate to high beef consumption frequency, with consumption frequency of beef steaks at the lower end with a mean of 2.46. Using the four beef consumption variables, a new beef consumption frequency variable was constructed, as an average of all four. In creating the beef consumption index, a high consumption variable was assigned a value of 1 if the consumption average for all four categories was greater than 2.5, otherwise a 0. This was subsequently used in the regression, rather than having all four variables that captured consumption frequency. It is worth noting that respondents perceived the risk of an *E. coli O157* infection through beef consumption to be low. Respondents were not overly concerned about the threat of an *E. coli O157* illness from hamburgers, nor did they think the likelihood of them experiencing an *E. coli O157* infection was high. With means of 2.82 and 2.26 respectively on a 1 to 5 ordinal scale, respondents rated their likelihood of an *E. coli O157* infection through beef consumption much higher, than they were concerned about it, although both means were somewhat low. Though foodborne risk can be argued to be relatively low, this observation is in line with findings by Hayes et al. (1995) about consumer's inclination to downplay the risk of foodborne pathogens. A notable characteristic of the sampled respondents was their limited self-assessed knowledge of *E. coli O157* bacteria, and even more so of animal vaccines. The mean for self-assessed knowledge was 1.79 for vaccines, and even smaller at 1.40 for DFMs. This limited knowledge of animal vaccines is confirmed by the very few respondents who correctly answered that animal vaccines could be used in organic animal production, compared to the large number of those who either did not know or incorrectly answered that vaccines are not allowed. On a 0 to 1 scale, with 1 been a yes for the question, the mean was 0.27, an indication of the very few respondents who chose the 'yes' option (27%). The demographically weighted dataset compared very closely to the US population census data for 2014. Approximately 48% of respondents were males, and about 65% were white. More than half of respondents (58%) had at least a college degree. A small percentage of respondents, about 15%, either worked with farm animals or had family members who did.

Table 1. Variables and Descriptive Statistics

Variable	Description	Mean	Std Dev
Attitudes and safety perception			
Acceptability of vaccines	Acceptability of vaccines in animal production, scale: 1 = totally unacceptable to 5 = totally acceptable	3.03	1.05
Acceptability of organic production	Acceptability of organic production practices, scale: 1 = totally unacceptable to 5 = perfectly acceptable	3.58	0.90
Safe to consume beef, before info	Safety rating of beef, scale: 1 = strongly disagree to 5 = strongly agree	3.65	0.82
Safety of vaccinated cattle, after info	Safety rating of vaccination, scale: 1 = very unsafe to 5 = very safe	3.58	0.90
Safety of DFMs, after information	Safety rating of DFMs, scale: 1 = very unsafe to 5 = very safe	3.45	0.90
Safety of untreated cattle, after info	Safety of untreated cattle, scale: 1 = very unsafe to 5 = very safe	2.50	0.90
Beef consumption			
Ground beef	Frequency of ground beef consumption, scale: 1 = never to 5 = daily	2.93	0.86
Hamburgers at home	Freq. of consuming hamburgers at home, scale: 1=never to 5 = daily	2.65	0.85
Hamburgers at restaurant	Frequency of consuming hamburgers in a restaurant, scale: 1 = never to 5 = daily	2.52	0.84
Beef steaks	Frequency of consuming beef steaks, scale: 1 = never to 5 = daily	2.46	0.81
Risk Perceptions			
Concern of *E. coli O157* illness	scale: 1 = not at all concerned to 5 = extremely concerned	2.26	1.12

Likelihood of *E. coli O157* illness	scale: 1=Very unlikely to 5= Very likely	2.82	1.02
Knowledge – Self assessed			
Knowledge of *E. coli O157* bacteria	Knowledge of *E. coli O157*, scale: 1 = nothing to 4 = a great deal	2.23	0.78
Knowledge of vaccines	Knowledge of animal vaccine, scale: 1 = nothing to 4 = a great deal	1.79	0.81
Knowledge of DFMs	Knowledge of DFMs, scale: 1 = nothing to 4 = a great deal	1.40	0.69
Objective knowledge			
Knowledge of vaccines	Objective knowledge, 1= yes, vaccines can be used in organic production, 0 = no or I don't know	0.27	0.45
Demographics			
Age	Age, in years	47.16	17.28
Male	1 if subject is male; 0 otherwise	0.48	0.5
College	1 if subject has some college education; 0 otherwise	0.58	0.49
Income	Household income, in thousands	73.17	51.9
White	1 if subject’s ethnicity is white; 0 if non-white	0.66	0.47
Family works on farm	1 if subject or family member works with farm animals; 0 otherwise	0.15	0.35

Table 2 displays the means of trustworthiness ratings on a 1 to 5 ordinal scale for 12 institutions as sources of balanced information about food production methods and practices. Respondents had generally high trustworthiness ratings for non-private institutions and associations. Within this group, the American Medical Association and scientist at public and private universities were rated higher at providing credible and balanced information about food production risks. Chains such as Tyson Foods and McDonalds were ranked the lowest as sources of accurate information about food production practices.

Table 2. Trustworthiness of information from institutions[1]

Trustworthiness rating: Institutions	Mean	Std Dev.
U.S. Food and Drug Administration	3.11	1.05
U.S. Department of Agriculture	3.12	0.99
Humane Society of America	3.02	0.99
American Medical Association	3.28	1.00
Scientists at public & private universities	3.13	0.96
The New York Times	2.65	1.00
Fox News	2.54	1.13
ABC News	2.68	0.98
National Producer Associations	2.66	0.97
Tyson Foods	2.41	0.96
McDonalds	2.17	0.97
Chipotle Mexican Grill	2.43	0.95

Table 3 provides information about consumer attitudes towards various food production processes. With a mean of 2.58 on a 1 to 5 ordinal scale, consumers are more comfortable with genetic modification of plants than genetic modification of animals, with a mean of 2.19. A mean of 2.07 demonstrates a moderate to low level of acceptance for animal cloning. Respondents were also less accepting of the use of hormones in animal production which had the second lowest mean at 2.17, after animal cloning.

[1] Ratings of trustworthiness are used in a subsequent factor analysis

Table 3. Acceptance of food production processes[2]

Acceptance ratings	Mean	Std Dev
Use of antibiotics in animal production	2.71	1.05
Genetic engineering / modification of plants	2.58	1.11
Genetic engineering / modification of animals	2.19	1.03
Food irradiation	2.57	1.01
Animal cloning	2.07	1.03
Use of hormones in animal production	2.17	0.95

Figures 2 and 3, illustrates consumer safety ratings of vaccines and DFMs, respectively. Beef products from cattle treated with vaccines and DFMs were rated safe or very safe by the majority of respondents, under all information treatments, as shown in figures 2 and 3. For both interventions, at least 40% of respondents in all groups rated meat products from cattle treated with vaccines or DFMs as safe or very safe. More than half of all respondents rated meat products from cattle treated with the two interventions as safe or very safe.

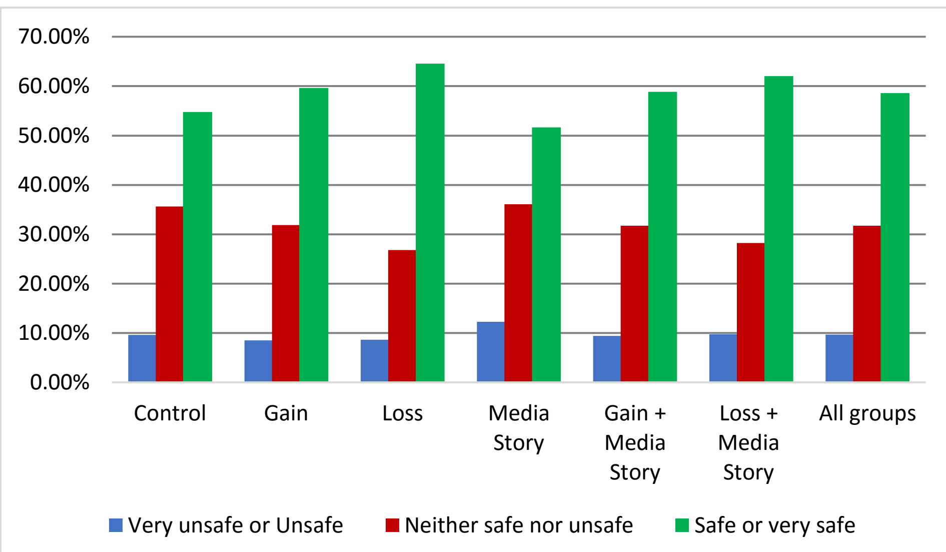

Figure 2. Safety rating of meat products from vaccinated cattle

[2] Ratings are used in a subsequent factor analysis

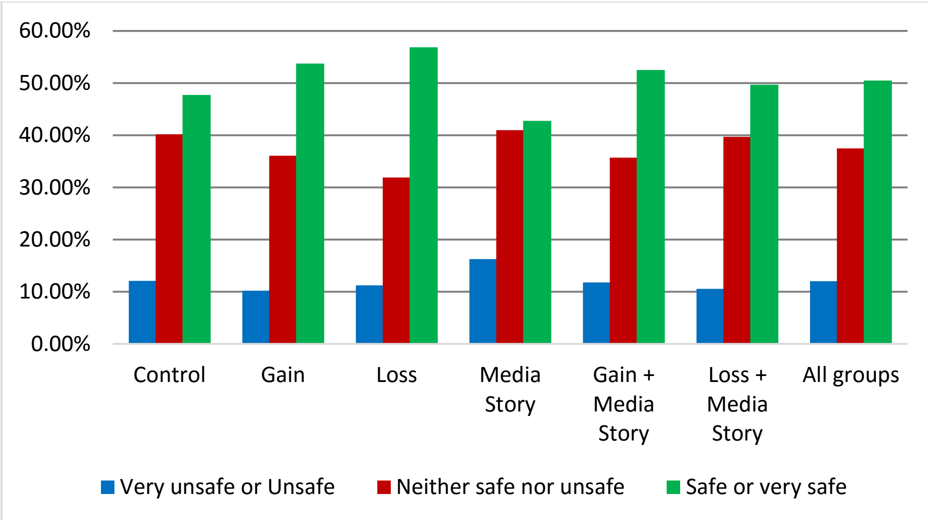

Figure 3. Safety rating of meat products from cattle treated with DFMs

An interesting finding was respondents' very strong safety rating for beef products from cattle not treated with any of the interventions, before any information was provided. These high ratings plummeted sharply after respondents had been exposed to information about the two treatments, and the general risk of an *E. coli O157* infection, in their respective information treatment groups. Figure 4 shows that nearly half of all respondents initially affirmed beef consumption as safe or very safe, contrasting the barely 10% of all respondents as shown in figure 5, who considered beef products not treated with the safety interventions as not very safe, after information was provided.

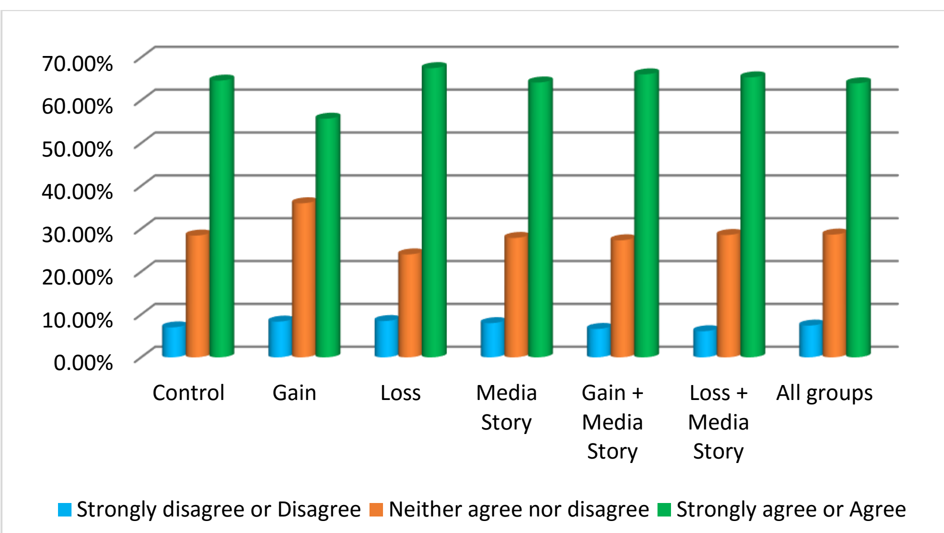

Figure 4. Safety rating of beef products from untreated cattle, before information exposure

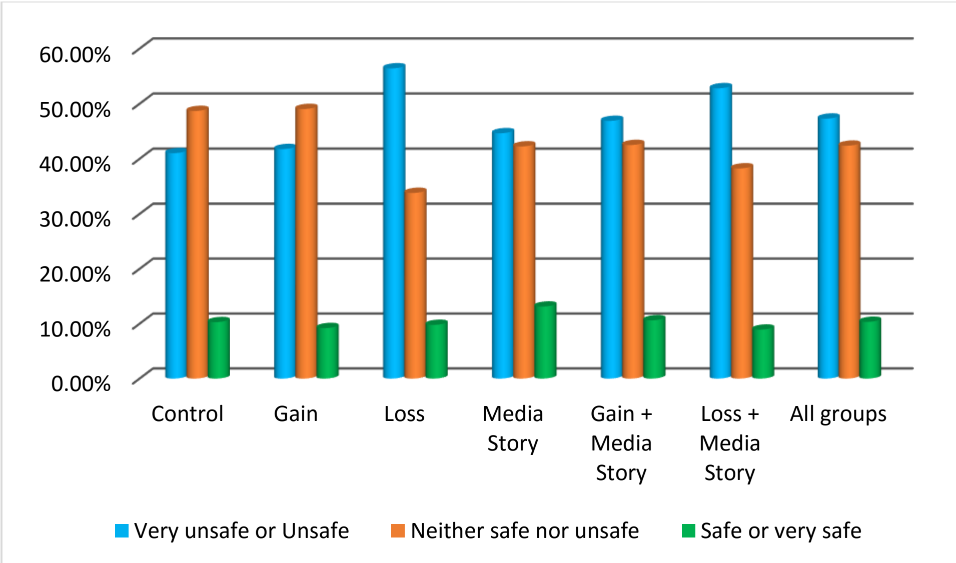

Figure 5. Safety rating of beef products from untreated cattle, after information exposure

6. Theoretical Model

To examine the role of information and other consumer characteristics that influence risk perceptions of *E. coli O157* illness, as well as attitudes towards beef food safety technologies, the ordered probit model was utilized. Following Cameron and Trivedi (2010) and Wooldridge (2010), y_i is individual *i's* response for integer values *1, 2, 3… J.* The ordered probit model for *y* given *x* is modeled from a latent variable *y**, which is unobserved. The vector $\boldsymbol{x_i}$ is assumed to be relevant individual characteristics that explain risk perceptions or attitudes toward the new safety technologies. For individual *i*, the latent variable is specified such that:

$$y_i^* = \boldsymbol{x}_i'\boldsymbol{\beta} + u_i, \qquad i = 1, \dots, n$$
$$u_i \sim N(0,1) \tag{3}$$

where β is a *k* x *1* column vector. Assuming unknown threshold values of $\alpha_1 < \alpha_2 < \dots \alpha_{J-1}$, the following relationship between the latent variable, y_i* and the observed variable, y_i, can be defined as:

$$\begin{aligned} y_i &= 1 \quad if \ -\infty < y_i^* \leq \alpha_1 \\ y_i &= 2 \quad if \ \alpha_1 < y_i^* \leq \alpha_2 \\ y_i &= 3 \quad if \ \alpha_2 < y_i^* \leq \alpha_3 \\ &\vdots \\ y_i &= J \quad if \ \alpha_{J-1} < y_i^* \leq \infty \end{aligned} \tag{4}$$

The threshold values are assumed not known because the actual index that leaps an individual from one threshold to another is unknown, and different for every individual. More generally, an ordered model for *m* alternatives is specified as:

$y_i = J \; if \;\; \alpha_{J-1} < y_i^* \;\leq\; \alpha_{J,} \quad J = 1, \ldots\ldots, m$

where $\alpha_1 = -\infty \; and \; \alpha_m = \infty$

Since u_i is distributed standard normal, the conditional distribution of *y* given *x* is derived from the probabilities as:

$$\begin{aligned} P(y_i = J) &= P(\alpha_{J-1} < y_i^* \;\leq\; \alpha_J) \\ &= P(\alpha_{J-1} < \boldsymbol{x_i'\beta} + u_i \;\leq\; \alpha_J) \\ &= P(\alpha_{J-1} - \boldsymbol{x_i'\beta} < u_i \;\leq\; \alpha_J - \boldsymbol{x_i'\beta}) \\ &\;\;\vdots \\ &= \Phi(\alpha_J - \boldsymbol{x_i'\beta}) - \Phi(\alpha_{J-1} - \boldsymbol{x_i'\beta}) \end{aligned} \tag{5}$$

The dependent variables for the probit model as used in this study involve 3 point ordinal scales, and so following equation 3, the probabilities for the ordinal outcomes are:

$$\begin{aligned} P(y_i = 1|x) &= P(\boldsymbol{x_i'\beta} + u_i \leq \;\; \alpha_1) \\ &= P(u_i \leq \;\; \alpha_1 - \boldsymbol{x_i'\beta}\,) \\ &= P(u_i \leq \;\; \alpha_1 - \boldsymbol{x_i'\beta}\,) \\ &= \Phi(\alpha_1 - \boldsymbol{x_i'\beta}) \\ &= 1 - \Phi(\,\boldsymbol{x_i'\beta} - \alpha_1) \end{aligned}$$

(6)

$$\begin{aligned} P(y_i = 2|x) &= P(\alpha_1 < \boldsymbol{x_i'\beta} + u_i \;\leq\; \alpha_2) \\ &= P(\alpha_1 - \boldsymbol{x_i'\beta} < u_i \;\leq\; \alpha_2 - \boldsymbol{x_i'\beta}) \\ &= \Phi(\alpha_2 - \boldsymbol{x_i'\beta}) - \Phi(\alpha_1 - \boldsymbol{x_i'\beta}) \\ &= \Phi(\boldsymbol{x_i'\beta} - \alpha_1) - \Phi(\boldsymbol{x_i'\beta} - \alpha_2) \end{aligned}$$

$$\begin{aligned} P(y_i = 3|x) &= P(\boldsymbol{x_i'\beta} + u_i > \;\; \alpha_2) \\ &= P(u_i > \;\; \alpha_2 - \boldsymbol{x_i'\beta}\,) \\ &= 1 - \Phi(\alpha_2 - \boldsymbol{x_i'\beta}) \\ &= \Phi(\boldsymbol{x_i'\beta} - \alpha_2) \end{aligned}$$

where Φ is the standard normal cumulative distribution function (CDF) of u_i. From the sample (y_i, x_i, $i=1,.....,n$), the log-likelihood function can be specified:

$$LogL = \sum_{i=1}^{n} In[P(y_i)] = \sum_{i=1}^{n} In\left[\Phi\left(\alpha_J - \boldsymbol{x}_i'\boldsymbol{\beta}\right) - \Phi\left(\alpha_{J-1} - \boldsymbol{x}_i'\boldsymbol{\beta}\right)\right] \qquad (7)$$

Maximization of the log likelihood function is done with respect to the β and the threshold parameters ($\alpha_1, \alpha_2, \ldots, \alpha_{J-1}$) through an iterative procedure in order to arrive at the maximum likelihood estimates (MLEs). The sign of the parameters, β, in the ordered probit regression gives an indication of the direction of the latent variable, y_i*, and whether it increases or decreases with a regressor. The more informative marginal effects show the change in probability of choosing an alternative when the predictor variable changes by one unit. The marginal effect of the probability that option J is chosen when a predictor variable x_r changes by one unit is expressed as:

$$\frac{\partial P(y_i=J)}{\partial x_{ri}} = \boldsymbol{\beta}_r[\ \Phi(\alpha_{J-1} - \boldsymbol{x}_i'\boldsymbol{\beta}) - \Phi(\alpha_J - \boldsymbol{x}_i'\boldsymbol{\beta})] \qquad (8)$$

Whereas the signs of the regression coefficients indicate an increase or decrease in the dependent variable with respect to the predictors, marginal effects offer a more meaningful interpretation of the probability change when predictors increase by one unit. Hence, the marginal effects for all regressions are reported in addition to the coefficients. These (marginal effects) are evaluated at the mean of the predictor variables, and for this study, the third outcome (last category) in each regression using the *margins* argument in STATA 14.

7. Empirical Model

7.1 Factor Analysis

Factor analysis was used to reduce the dimensionality of responses relating to trustworthiness of institutions, and acceptance of non-conventional production technologies, displayed in Tables 2 and 3, respectively. The sets of questions for trustworthiness and preferences for new production technologies arguably have underlying latent constructs that are not directly observable, hence the factor analysis procedure. The choice between principal component analysis and factor analysis was carefully weighed for these two sets of variables. Although the two procedures share similar variable reduction mechanisms, factor analysis assumes a latent construct in explaining the covariation in the observed variables, while principal component analysis makes no such assumptions (Hatcher 1994; Dunteman 1989). Factor analysis has been used in past studies to develop risk constructs (Schroeder et al. 2007; Tonsor, Schroeder and Pennings 2009). The factor analysis model can be specified by the matrix equation:

$$x = \Lambda f + \eta \qquad (9)$$

Where x is a p x 1 vector of observed variables, f is an m x 1 vector of factors, which is a random component common to all original variables, η is a p x 1 vector of specific factors and finally, Λ is a p x m matrix of factor loadings. The common factor, f, is independently and identically distributed i.i.d. (0,1), and the specific factor, η_j is independently distributed with mean 0 and variance Ψ_j for j=1,…..,p. The covariance matrix of x, noting that the covariance of f is an identity matrix is thus:

$$\Sigma = \Lambda\Lambda' + \Psi \qquad (10)$$

Λ and Ψ are consequently estimated using the covariance matrix, and this is achieved with the maximum likelihood procedure.

7.2 Econometric Model

7.2.1 Risk Perceptions and Media Story

To investigate the role the media story and consumer characteristics play in influencing consumer risk perceptions about *E. coli O157* infections and attitudes towards the new beef safety interventions, the ordered probit was employed to model ordinal dependent variables. For the first model, the dependent variable was the concern about becoming ill from bacteria such as *E. coli O157* when consuming hamburgers. The dependent variable for the second model was the perceived likelihood of becoming ill from such harmful bacteria when consuming hamburgers. To avoid having just a few observations at the tails of the 5-point scale for both models, the first and last two categories were condensed, providing a 3 point scale. For the first model, the eventual 3 point ordinal scale was: not at all concerned or slightly concerned, somewhat concerned, and very concerned or extremely concerned. For the second model, the scale used was: very unlikely or unlikely, neither likely nor unlikely, and likely or very likely. The survey instrument was designed to expose half the participants first to the media story that narrated the plight of the young woman who suffered an *E. coli O157* infection. At this point in the survey, participants had not read any of the message frames (gain-framed or loss-framed messages) in their respective treatments. For this reason, a dummy variable called *"involve"* was created with a value of 1 corresponding to the participants who read this story, and 0 for the other half who had not. Assuming the existence of a latent variable, $y*$, as the unobserved measure of consumers' perceived likelihood of an *E. coli O157* infection, the model is specified as:

$$\begin{aligned} y_i^* = \beta_{j0} &+ \beta_1 know\_ecoli_i + \beta_2 know\_vac_i + \beta_3 know\_dfm_i \\ &+ \beta_4 org\_antibiotic_i + \beta_6 org\_vacc_i + \beta_7 org\_horme_i \\ &+ \beta_8 high\_trust_i + \beta_9 low\_trust_i + \beta_{10} acp\_vac_i \\ &+ \beta_{11} acp\_org_i + \beta_{12} other\_tech_i + \beta_{13} high\_cons_i \\ &+ \beta_{14} safe\_beef_i + \beta_{15} fam\_work_i + \beta_{16} age_i \\ &+ \beta_{17} college + \beta_{18} income_i + \beta_{19} white_i + \beta_{20} male_i \\ &+ \beta_{21} involve_i + u_i \end{aligned} \tag{11}$$

β_{jo} is the intercepts for the two non-base categories in each regression.

Our hypothesis is that the signs of the coefficients in both models would be similar because we expect that factors that influence concern about the risk of an infection will also heighten one's sense of vulnerability. Anticipating the signs of the coefficients for the knowledge variables were not very obvious. While it could be argued that having sufficient knowledge of *E. coli* bacteria would get consumers concerned about possible infections, prior knowledge about animal vaccines and their effectiveness may lead consumers to diminish the likelihood of such infections. In a similar vein, having *objective knowledge of vaccines*, for respondents who correctly answered that vaccinations are permitted in animal organic production, is expected to lower perceived likelihood of, and concern about *E. coli O157* infections. The *high trust* variable is expected to have a positive sign, as consumers who are confident about information from public and some private institutions are likely to be more attentive to issues of foodborne illnesses from these sources. The *high trust* variable resulted from the factor analysis procedure for the variables related to trustworthiness of select institutions and associations in providing balanced information on food risks. The *acceptance of animal vaccines* variable is expected to have a negative sign for both models; as vaccines against *E. coli O157* have had limited adoption by beef producers. The *other technologies* variable, also condensed from the second factor analysis procedure from original variables such as antibiotic use, irradiation and genetic modification, is expected to have a positive sign. The *safe-beef* variable is expected to have a negative sign. Quite intuitively, if consumers are of the opinion that consuming beef is safe, they will anticipate that the threat of bacterial infection from beef consumption is not a very likely outcome. It was hypothesized that having a family member who works with farm animals, or the respondent themselves, would lead to a higher concern for, and perceived likelihood of an *E. coli O157* infection, as such consumers may have a better understanding of the production process and possible bacterial contamination of meat products. The signs of the demographic variables are largely uncertain, although a college education, as well as higher incomes are predicted to have negative signs. The *involve* dummy is anticipated to have a positive sign, to suggest that the provision of such media food safety information fosters greater awareness about the inherent risk of contamination.

7.2.2 Information framings and attitudes towards new technologies

Following exposure to the information treatments, consumer attitudes towards the new beef safety enhancing technologies were elicited. Respondents rated the safety of meat products from cattle vaccinated against *E. coli O157*, cattle with DFMs included in their diet, and cattle that did not undergo either intervention. These questions had the same ordinal responses, from 1 = very unsafe to 5 = very safe. Because too few responses fell into the first and last categories, the first and last two categories were condensed to give a 3 point ordinal scale. Each information group had been exposed to a different information by the time they completed these sets of questions. This made it possible to evaluate the effects of the different information framings on consumer attitudes towards the beef safety interventions. Having a control group not provided with any of the information framings allows meaningful comparisons to be made on the effects of each type of information. Using the responses from these set of questions as the dependent variable following equation 11, the ordered probit model, assuming the presence of a latent variable, y^*, is specified as:

$$\begin{aligned} y_i^* = \beta_{j0} &+ \beta_1 know\_ecoli_i + \beta_2 know\_vac_i + \beta_3 know\_dfm_i \\ &+ \beta_4 org\_antibiotic_i + \beta_6 org\_vacc_i + \beta_7 org\_horme_i \\ &+ \beta_8 high\_trust_i + \beta_9 low\_trust_i + \beta_{10} acp\_vac_i \\ &+ \beta_{11} acp\_org_i + \beta_{12} other\_tech_i + \beta_{13} high\_cons_i \\ &+ \beta_{14} safe\_beef_i + \beta_{15} fam\_work_i + \beta_{16} age_i \\ &+ \beta_{17} college + \beta_{18} income_i + \beta_{19} white_i + \beta_{20} male_i \\ &+ \beta_{21} info_i + u_i \end{aligned} \quad (12)$$

where $info_i$ = $gain\_info_i$, $loss\_info_i$, $involve\_info_i$, $loss\_inv_i$ and $gain\_inv_i$. β_{jo} is the intercepts for the two non-base categories in each regression. y_i* represents responses from safety ratings for meat products from (i) cattle vaccinated against *E. coli O157*, (ii) cattle fed DFMs and (iii) untreated cattle. The '$info_i$' variables are dummy coded for the different information framings, versus the control group. With conflicting findings from literature about gain- or loss-framed information been more persuasive under different contexts and domains (Meyerowitz and Chaiken 1987; Ganzach, Weber and Or 1997; Gallagher and Updegraff 2012), the expectation is that either of these information framings could have a strong persuasive influence on the perceived safety of meat products from cattle given the technologies, compared to untreated cattle. In general, all the information dummies are expected to have a positive sign except for the dummies associated with the dependent variable *cattle not treated with either of the beef safety interventions*.

8. Results and Discussion

8.1 Factor Analysis

The factor analysis procedure was used to reduce the trustworthiness variables, and variables relating to acceptance of food production practices to a smaller number of factors which were subsequently used in the regressions. In choosing the optimum number of factors, the eigenvalue greater than 1 rule was followed. Since factor analysis uses standardized data which has a variance of 1 for each standardized variable, an eigenvalue of a factor greater than 1 indicates that the factor explains more variability than the original variable. The procedure resulted in two factors for the trustworthiness variables, as shown in Table 4. Both factors had eigenvalues greater than 1, and cumulatively explained about 99% of the variation in the data. To enhance the interpretability of the factors, the varimax orthogonal rotation of the factor axes was utilized to maximize the variance of the squared loadings, thus providing large or small loadings for each variable. The factor loadings reported in Table 4 have been rotated using varimax. Variables with factor loadings less than 0.3 are by convention not considered as contributing much in explaining the factor (Knafl and Grey 2007). In the case of Table 4, such loadings less than 0.3 were blanked out. Regarding the interpretation of the variables, trustworthiness for the FDA, USDA, Humane Society of America, American Medical Association, scientists at public and private universities, the New York Times and ABC News load heavily on the first factor. Because these variables were generally rated high as trustworthy sources of information, as shown in Table 2, the first factor was named '*high trust'*. Conversely, the other variables that loaded heavily on factor 2 such as Fox News, Tyson Foods and McDonalds were rated low by respondents as trustworthy sources of information, also shown in Table 2. Factor 2 was consequently named '*low trust'*.

Performing factor analysis on the variables relating to acceptance of other agricultural production practices yielded only one factor, as displayed in Table 5. This factor had an eigenvalue of 3.19, which meant that it explained much of the variability among this set of variables than any one of the original variables. The proportion of variability explained was approximately 100%. Since all variables capturing the acceptance of the listed food production practices loaded heavily on the lone factor, the factor was named '*other technology*'.

Table 4. Factor Loadings after varimax, rotation for trustworthiness

Trustworthiness rating	**Factor 1**	**Factor 2**
	high_trust	*low_trust*
U.S. Food and Drug Administration	0.8058	
U.S. Department of Agriculture	0.8039	
Humane Society of America	0.5396	
American Medical Association	0.7603	
Scientists at public and private universities	0.6706	
The New York Times	0.6533	
Fox News		0.5482
ABC News	0.6289	0.3762
National Producer Associations	0.3744	0.5578
Tyson Foods		0.7325
McDonalds		0.7511
Chipotle Mexican Grill		0.5685
Eigenvalues	4.97405	1.17502
Variance explained	0.6048	0.3889
Cumulative Variance explained	0.6048	0.9936

(blanks represent absolute loading < 0.3)

Table 5. Factor loadings after varimax rotation, for acceptance of food production methods

Level of acceptance	**Factor 1**
	other_technology
Use of antibiotics in animal production	0.6262
Genetic engineering/genetic modification of plants	0.7813
Genetic engineering/genetic modification of animals	0.8476
Food irradiation	0.6333
Animal cloning	0.696
Use of hormones in animal production	0.7646
Eigenvalues	3.19102
Variance explained	1.0632
Cumulative Variance explained	1.0632

8.2 Influence of media story on the perceived risk of *E. coli O157* infection

Results from the first sets of the ordered probit regressions show the influence of providing different information framings on consumers' perceived risk towards *E. coli O157* infections, and safety perceptions of the pre-slaughter interventions.

Table 6 displays results for factors and consumer characteristics that explain perceptions about the risk of foodborne infection from *E. coli O157*. Specifically, concern about an *E. coli O157* infection and perceived likelihood of an infection were the dependent variables for these regressions. Recall that half of all respondents had been exposed to the media story about the young woman who suffered an *E. coli O157* infection before the questions about concern and likelihood of an infection were completed. This enabled the influence of the media story on risk perceptions about *E. coli* food infections to be empirically determined. A number of variables were significant in both regressions, and many were consistent with the *a priori* expectations. The dummy variable, *involve*, was significant at the 2% level for the regression with the *concern* dependent variable, but not significant for the regression about the likelihood of becoming ill from an *E. coli O157* infection.

Table 6. Ordered probit results of concern about, and perceived likelihood of an *E. coli* infection

	Concern about *E. coli* illness				Likelihood of an *E. coli* infection			
	Coefficient	**Robust Std. Err.**	**P>|z|**	**Marginal effect**	**Coefficient**	**Robust Std. Err.**	**P>|z|**	**Marginal effect**
Knowledge								
know_ecoli	0.0529	0.0553	0.3380	0.0084	0.0880	0.0486	0.0700	0.0267
know_vac	0.0146	0.0595	0.8060	0.0023	**-0.1299**	0.0540	0.0160	**-0.0395**
know_dfm	0.0835	0.0693	0.2280	0.0133	0.0913	0.0654	0.1630	0.0277
org_antibiotic	**-0.2732**	0.1358	0.0440	**-0.0435**	**-0.2433**	0.1182	0.0390	**-0.0739**
org_vacc	0.0995	0.1039	0.3380	0.0159	0.0205	0.0929	0.8250	0.0062
org_hormone	**0.5042**	0.1538	0.0010	**0.0803**	**0.4289**	0.1466	0.0030	**0.1303**
Trust								
high_trust	**0.0924**	0.0407	0.0230	**0.0147**	0.0564	0.0365	0.1230	0.0171
low_trust	0.0621	0.0432	0.1510	0.0099	0.0067	0.0395	0.8660	0.0020
Attitudes towards tech								
acp_vac	**-0.1357**	0.0468	0.0040	**-0.0216**	**-0.1629**	0.0417	0.0000	**-0.0495**
acp_org	-0.0249	0.0393	0.5270	-0.0040	-0.0241	0.0377	0.5230	-0.0073
other_tech	-0.0662	0.0506	0.1910	-0.0105	-0.0221	0.0445	0.6190	-0.0067
Consumption & Safety								
high_cons	0.1112	0.0777	0.1520	0.0177	0.1054	0.0713	0.1390	0.0320
safe_beef	**-0.3653**	0.0536	0.0000	**-0.0582**	**-0.2043**	0.0479	0.0000	**-0.0621**
Demographics								
fam_work1	-0.0418	0.0971	0.6670	-0.0067	-0.0225	0.0846	0.7910	-0.0068
age	0.0037	0.0020	0.0660	0.0006	0.0000	0.0018	0.9790	0.0000
college	**-0.1875**	0.0739	0.0110	**-0.0299**	**-0.1939**	0.0666	0.0040	**-0.0589**
income	**-0.0025**	0.0007	0.0010	**-0.0004**	-0.0003	0.0006	0.6310	-0.0001
white	**-0.4664**	0.0742	0.0000	**-0.0743**	**-0.2923**	0.0681	0.0000	**-0.0888**
male	**-0.1609**	0.0685	0.0190	**-0.0256**	**-0.1371**	0.0625	0.0280	**-0.0417**
Information								
involve	**0.1614**	0.0667	0.0150	**0.0257**	0.0371	0.0601	0.5370	0.0113
/cut1	-1.5245	0.2747			-1.8371	0.2519		
/cut2	-0.5672	0.2697			-0.8121	0.2489		

(Variables in bold are significant at the 5% level or lower)

Having read the media story, respondents were more likely to report that they were very concerned about an *E. coli O157* illness, but did not think there was a higher likelihood of becoming ill when they consumed beef products. Perhaps, the generally low incidences of foodborne illness may have given the impression that *E. coli O157* infections from beef consumption are not such a likely outcome for many consumers, albeit the issue remains concerning, as highlighted by the media story. Many of the knowledge variables were not significant, but consumers who incorrectly answered that growth hormones could be used in organic production practices were 8 percentage points more likely to be concerned, and 13 percentage points more likely to report a higher likelihood of an *E. coli O157* infection. Consumers who trusted the accuracy of information from sources such as the USDA, FDA and scientists in public and private universities were more likely to report been very concerned about *E. coli O157* illness. In terms of attitudes towards new technologies and factors that relate beef consumption and safety, the results suggest that consumers more accepting of vaccine usage in animal production, and those who were generally of the opinion that beef consumption is safe, were also less concerned, and did not think they had a higher likelihood of becoming ill from foodborne illness. Nearly all demographic variables other than *age*, and whether the respondent or a family member worked with farm animals, were significant. For the remaining significant demographics, consumers with college education or higher, high income, *white* and *males* were less concerned, and thought they were less likely to suffer illnesses from an *E. coli O157* infection from beef consumption.

8.3 Influence of information and consumer characteristics on safety perceptions

To further investigate the role of information on perceptions of safety for the two food safety enhancing technologies, ordered probit regressions were ran which compared the five groups of respondents, differentiated by the information they received in the survey instrument, with the control group. After each respondent had been exposed to their respective information frame, they were asked to rate the safety of cattle vaccinated against *E. coli O157*, cattle fed DFMs, and then untreated cattle that had neither of these interventions.

Before examining the results from the ordered probit models, a test of the difference in safety rating for meat products from cattle vaccinated against *E. coli O157*, fed DFMs, and given no intervention were considered for each of the information treatments, compared to the control group. The results from the Wilcoxon rank sum test, also known as the Mann-Whitney two-sample statistic, are shown in Table 7. The Wilcoxon rank-sum test is the non-parametric option to the two-sample *t*-test, and uses the equality of the medians, rather than the means. The Wilcoxon rank-sum test was used because of the non-normality of the three variables of interest, tested using the *sktest* option in STATA 14. From Table 7, it can be seen that participants in the loss-framed information group provided a higher rating for the safety of meat products from vaccinated cattle, and cattle fed DFMs, compared to the control group, with a statistical significance at the 10% level. For the same loss-framed information group, the rating for meat products from cattle without any of the interventions was lower, compared to the control group, with a statistical significance of 1%. The difference between the gain-framed with media story group and the control, for the safety rating of DFMs was moderately significant at the 10% level. Likewise, there was a moderate statistical significance for the difference in safety rating of meat products from cattle vaccinated against *E. coli O157*, between the loss-framed with media story, and the control group, and a significance level of approximately 2% for the difference in safety rating of untreated cattle for these two groups. The effect of information was notably more pronounced for consumers in the loss-framed group, and to some extent the loss-framed with media story group. The gain-framed information group and the media story groups do not seem to differ significantly from the control group, even though the gain-framed with media story group was moderately significant for the difference in safety rating for meat products from cattle given the DFMs intervention. These findings may provide useful cues in terms of how future food safety information is approached and disseminated.

Table 7: Tests of differences in beef safety ratings after information, with Wilcoxon significance test

	Ho: Safety rating (Treatment group) – Safety rating (Control group) = 0					
	Vaccinated		DFMs		No intervention	
Treatment	**Mean Diff**	**Prob > |z|**	**Mean Diff**	**Prob > |z|**	**Mean Diff**	**Prob > |z|**
Gain vs Control	3.65 - 3.52 = 0.13	0.1559	3.54 - 3.39 = 0.15	0.1413	2.56 - 2.60 = -0.04	0.7619
Loss vs Control	3.66 - 3.52 = 0.14	0.0564	3.50 - 3.39 = 0.11	0.0518	2.34 - 2.60 = -0.26	0.0023
Media Story vs Control	3.46 - 3.52 = -0.06	0.1876	3.31 - 3.39 = -0.08	0.1661	2.57 - 2.60 = -0.03	0.4034
Gain + Media S vs Control	3.59 - 3.52 = 0.07	0.3635	3.49 - 3.39 = 0.1	0.0884	2.51 - 2.60 = -0.09	0.504
Loss + Media S vs Control	3.62 - 3.52 = 0.10	0.0855	3.45 - 3.39 = 0.06	0.2923	2.43 - 2.60 = -0.17	0.0116

Table 8 reports results from the ordered probit regression, on the perceived safety of cattle vaccinated against *E. coli O157* for the different information framings. The dependent variable was the safety rating of meat products from cattle treated with vaccines against *E. coli*

O157. Starting with the knowledge variables, two of the six variables considered were found to be significant. Consumers who were knowledgeable about the *E. coli O157* bacteria were more likely to rate beef products from vaccinated cattle as safe. Also, consumers who incorrectly answered that growth hormones could be applied in organic production were less likely to rate vaccinated cattle as safe. Such consumers were 19 percentage points less likely to rate beef products from cattle vaccinated against *E. coli* O157 as safe, which was significant at the 1% level. It is not too difficult to see through some skepticism about food production by consumers who hold this opinion, who may consequently be doubtful about the role of vaccinations in making beef products safer. A notable outcome from the results was the significance of the *high_trust* variable at the 1% level. In effect, consumers who have high confidence in the accuracy of information from public and private sources, as well as popular media outlets such as the New York Times, were more likely to stake a safety claim for meat products from vaccinated cattle. Such respondents were 8.6 percentage points more likely to rate beef products from vaccinated cattle as safe. Considering attitudes toward other technologies, a greater acceptance of animal vaccines and organic practices in food production was associated with a higher safety rating of meat from vaccinated cattle. The variable that captured acceptance of other technologies such as genetic modification and food irradiation was not significant in the model. Consumers who were of the opinion that eating beef is safe, were also more likely to report greater safety for meat from vaccinated cattle, and this was significant at the 1% level. Such consumers were approximately 14 percentage points more likely to report meat products from vaccinated cattle were safe or very safe. For demographics, *age* was the only significant variable, at the 1% level. The marginal effect was however very small, at 0.0038. While this is indicative of low probability, older consumers were associated with a higher likelihood of reporting products of vaccinated cattle as safe.

On the information front, both loss-framed and gain-framed information groups had statistically significant coefficients at the 5% level, while the loss-framed with media story group was statistically significant at the 10% level. Compared with the control group therefore, consumers who were exposed to the loss-framed information were 12.7 percentage points more likely to report that meat products from vaccinated cattle are safe, compared to 9.8 percentage points from the gain-framed group, and 8.4 percentage points for the loss-framed with media story group. The loss-framed information was therefore, the most pronounced in priming consumers to rate meat from vaccinated cattle as very safe. It should be noted that none of the information framings directly mentioned the safety of meat products after an intervention. Rather, they highlighted the significant reduction of the risk of *E. coli O157* infections for meat from cattle that undergo the pre-slaughter treatments. This outcome may be similar to findings reported by Meyerowitz and Chaiken (1987), who used loss-framed and gain-framed information in a domain other than food. They found that loss-framed information which emphasized the risk of a tumor going undetected in an early stage if breast self-examination was not done, had a stronger persuasive effect, than the gain-framed information. These results also agree with Maheswaran and Meyers-Levy (1990), who found that negatively framed messages had a stronger persuasive effect when issue involvement is high. In this instance, although the information effect for the loss-framed with media story group was significant at the 10% level, its coefficient was still less than the loss-framed or gain-framed groups. This may not be very surprising, as results from Table 6 also showed that exposure to the involvement story affected consumer concern about an *E. coli O157* infection, but not their perceived likelihood of becoming ill.

Table 8. Ordered probit results, safety rating of cattle vaccinated against *E. coli O157*

	Coefficient	**Robust Std. Err.**	**P>|z|**	**Marginal effect**
Knowledge				
know_ecoli	**0.1270**	0.0568	0.0250	**0.0485**
know_vac	-0.0342	0.0634	0.5900	-0.0131
know_dfm	-0.1194	0.0716	0.0950	-0.0456
org_antibiotic	0.2075	0.1455	0.1540	0.0792
org_vacc	0.1078	0.1129	0.3400	0.0411
org_hormone	**-0.4949**	0.1753	0.0050	**-0.1889**
Trust				
high_trust	**0.2260**	0.0420	0.0000	**0.0862**
low_trust	0.0069	0.0441	0.8770	0.0026
Attitudes towards tech				
acp_vac	**0.2420**	0.0476	0.0000	**0.0923**
acp_org	**0.0807**	0.0408	0.0480	**0.0308**
other_tech	0.0784	0.0504	0.1200	0.0299
Consumption & Safety				
high_cons	-0.0432	0.0789	0.5840	-0.0165

safe_beef	**0.3589**	0.0505	0.0000	**0.1370**
Demographics				
fam_work1	0.0279	0.1064	0.7930	0.0106
age	**0.0101**	0.0021	0.0000	**0.0038**
college	0.0992	0.0750	0.1860	0.0378
income	0.0008	0.0007	0.2760	0.0003
white	0.1210	0.0744	0.1040	0.0462
male	-0.0803	0.0711	0.2580	-0.0306
Information				
loss_info	**0.3338**	0.1192	0.0050	**0.1274**
gain_info	**0.2566**	0.1145	0.0250	**0.0979**
involve_info	0.0066	0.1168	0.9550	0.0025
loss_inv	0.2195	0.1199	0.0670	0.0837
gain_inv	0.1281	0.1151	0.2660	0.0489
/cut1	1.5359	0.2926		
/cut2	2.8859	0.3058		

(Variables in bold are significant at the 5% level or lower)

Table 9 displays consumer characteristics and the impact of message framing on safety ratings of meat products from cattle treated with DFMs. The dependent variable was safety ratings of meat products from cattle given DFMs. An expected finding with the knowledge variables was the statistical significance of consumers' reported knowledge of DFMs. This was significant at the 1% level of significance. Quite remarkably, the coefficient for this variable is negative, suggesting that a higher self-reported knowledge of DFMs was associated with a lower safety rating for meat from cattle fed with the probiotic additive. Consumers who knew a great deal about DFMs were 7.4 percentage points less likely to rate beef products from cattle given this intervention as very safe from *E. coli O157*. Some of the questions that may arise, in trying to explain this result, may perhaps relate to the efficacy of DFMs in reducing *E. coli O157* bacteria in cattle, compared to vaccines. As Brashears (2012) noted, DFMs, more specifically Lactobacillus acidophius NP51, reduced *E. coli O157* on the hides and shedding of cattle by at least 50%, compared to Hurd and Malladi's (2012) report of an 80% reduction of *E. coli O157* bacteria in cattle when vaccines are used. While DFMs are effective against *E. coli O157*, it perhaps may have been viewed as less effective than vaccines. The other knowledge variable which was significant was *org_vacc*. Consumers who correctly answered that vaccines could be used in organic production processes were 9 percentage points more likely to give a higher safety rating for meat products from cattle given DFMs. Some of the other significant variables were *high trust*, *acceptance of vaccines, acceptance of organic practices* in food production, and *acceptance of other technologies*, all of which were positively related with higher safety ratings. A higher trust in some public and private institutions as accurate sources of information was associated with a higher likelihood of rating meat products from cattle treated with DFMs as safe. The other significant variables also indicate that consumers who were more accepting of the vaccines, organic production and genetic modification, among others, were also more likely to rate meat products very safe from cattle fed DFMs. The *safe_beef* variable was significant at the 1% level, and positive. With a marginal effect of 0.1305, consumers who were of the opinion that it was safe to consume beef, were also 13.1 percentage points more likely to rate beef products from cattle fed DFMs as very safe.

Results from the effect of the demographic variables were very insightful in explaining consumer characteristics that influenced safety ratings. Even though significant at the 10% level, consumers who worked with farm animals, or had a family member working with farm animals were more skeptical about the safety of meat products from cattle given DFMs, and were 6.9 percentage points less likely to rate meat products from cattle treated with this intervention as safe. Comparable to results on the safety rating of vaccinated cattle, each year of age increased the likelihood of reporting such meat products as very safe, and this was significant at the 1% level. Another interesting result from the demographic variables was that of *college*, which was significant at the 1% level. Consumers who had a college degree or higher were 8 percentage points more likely to report that meat products from cattle given the DFMs' intervention was safe, compared to those with lower educational backgrounds. This may suggest consequently, that providing useful educational material may be effective as a strategy for disseminating information about DFMs. The rest of the significant demographic variables were *white* and *male*, both significant at the 1% level of significance. Caucasian consumers, compared to consumers of other ethnic backgrounds were more likely to suggest a higher safety rating. Females, rather than males, were also more likely to express a higher safety rating of meat products from this intervention, at 8.7 percentage points higher.

Regarding the message framing variables, both loss-framed and gain-framed dummies were significant at the 2% level of significance. The coefficient of the loss-framed dummy was marginally higher than that of the gain-framed dummy, and so was the marginal effect.

Compared to the control group, consumers who were exposed to the loss-framed message were 11.53 percentage points more likely to rate meat products from cattle that underwent the DFMs intervention as very safe. Similarly, consumers in the gain-framed group were 11.25 percentage points more likely to rate such meat products as very safe. These results further highlight the persuasive effects of message framing on perceptions. For this setting, these findings suggest that both loss-framed and gain-framed messages were equally persuasive in their impact, about the safety of meat products from cattle treated with DFMs. Although there is more empirical evidence about the persuasiveness of loss-framed messages, gain-framed messages have been sometimes seen as more persuasive (Gallagher and Updegraff 2012).The issue involvement dummy was not significant, neither were the groups that were exposed to both loss-framed and gain-framed with the media story group. While the issue involvement group is not particularly surprising with its non-significance, expectations were that a combination of the media story with either the loss-framed or the gain-framed information groups would have yielded some statistical significance. On its own, the media story seem to hold little sway in affecting perceptions and attitudes about safety, as also seen in Table 7. While it may have drawn attention to the risk of contaminations, it did not influence consumers' evaluation of safe meat products either through vaccines or the application of DFMs.

Table 9. Ordered probit results, safety rating of cattle fed DFMs

	Coefficient	**Robust Std. Err.**	**P>|z|**	**Marginal effect**
Knowledge				
know_ecoli	0.0774	0.0535	0.1480	0.0309
know_vac	0.0572	0.0588	0.3300	0.0228
know_dfm	**-0.1842**	0.0690	0.0080	**-0.0735**
org_antibiotic	-0.1928	0.1309	0.1410	-0.0769
org_vacc	**0.2323**	0.1011	0.0220	**0.0926**
org_hormone	-0.2136	0.1647	0.1950	-0.0852
Trust				
high_trust	**0.1794**	0.0410	0.0000	**0.0715**
low_trust	-0.0618	0.0436	0.1570	-0.0246
Attitudes towards tech				
acp_vac	**0.1705**	0.0455	0.0000	**0.0680**
acp_org	**0.0875**	0.0394	0.0260	**0.0349**

other_tech	**0.1568**	0.0469	0.0010	**0.0625**
Consumption & Safety				
high_cons	-0.0374	0.0750	0.6180	-0.0149
safe_beef	**0.3274**	0.0489	0.0000	**0.1305**
Demographics				
fam_work1	-0.1719	0.0985	0.0810	-0.0685
age	**0.0078**	0.0020	0.0000	**0.0031**
college	**0.2030**	0.0706	0.0040	**0.0809**
income	0.0004	0.0007	0.5690	0.0002
white	**0.2456**	0.0714	0.0010	**0.0979**
male	**-0.2192**	0.0667	0.0010	**-0.0874**
Information				
loss_info	**0.2892**	0.1148	0.0120	**0.1153**
gain_info	**0.2821**	0.1083	0.0090	**0.1125**
involve_info	-0.0567	0.1089	0.6030	-0.0226
loss_inv	0.1132	0.1092	0.3000	0.0451
gain_inv	0.1660	0.1091	0.1280	0.0662
/cut1	1.2739	0.2766		
/cut2	2.6878	0.2916		

(Variables in bold are significant at the 5% level or lower)

Having rated the safety of meat products from cattle treated with the two pre-slaughter interventions, respondents then rated their perceptions about the safety of meat products from cattle not treated with any intervention, with results displayed in Table 10. The objective here was to have respondents assess the safety of "conventional" meat products from untreated cattle, having been informed about interventions that would make these products safer, and the real risk of *E. coli O157* infection, however small, when consuming beef. The dependent variable was the safety of meat products from untreated cattle.

The knowledge variables did not seem to play a role on the dependent variable, as none of the variables in this category were significant. For the trust variables, consumers who held a high degree of trust for information from public and private agencies and associations were also more likely to report a lower safety rating. This was significant at the 1% level. Interestingly, the *low_trust* variable was significant at the 5% level, and positive. Consumers who cast doubts about information from sources such as Fox News, Tyson Foods and McDonalds, were more likely to report that meat products from cattle not treated with interventions were safe. These outcomes amplify the relevance of the sources of information regarding these interventions. When such information is provided from sources that consumers have little trust in, it could derail its chances of broad acceptance. For attitudes towards other food production technologies, consumers who were accepting of the use of animal vaccines were less likely to rate beef from untreated cattle as safe. The *acp_org* variable, and variables related to *other technologies* such as irradiation and genetic modification, were both significant at the 1% level, and positive. This means that both variables were associated with a higher rating of beef products from untreated cattle. It can be explained that one's acceptance of organic production practices would be associated with high safety ratings for untreated cattle. Granted, that consumers in this category support and purchase organic products, they may be less accepting of further interventions in beef production that make it less natural, thus rating beef products from untreated cattle as very safe. Acceptance of other technologies (such as irradiation and genetic modification) was associated with a high safety rating of meat products from untreated cattle. Although significant at the 10% level of significance, consumers who were frequent beef consumers, as seen from the *high_cons* variable, were about 2 percentage points less likely to rate meat products from untreated cattle as safe. Interestingly, those who thought beef products were safe anyway, were also more likely to rate products from untreated beef as safe, at 2.6 percentage points more.

A number of the demographic variables were significant. Consumers who worked with farm animals, or had family who worked with farm animals were more likely to rate products from untreated cattle as very safe. This outcome can be juxtaposed with the earlier finding about consumers in this category who did not think that meat products from cattle fed DFMs were any safer. Consistent with previous results, older consumers were less likely to rate meat products from untreated cattle as very safe, although this was significant at the 10% level, with a very small marginal effect. The remaining demographic variables that were significant were *income* and *male*, both having a higher likelihood of rating meat products from untreated cattle as very safe. For this result and the previous findings with DFMs, females have tended to be more concerned about food safety than males. Males, in this case were 2.5 percentage points more likely to rate meat products from untreated cattle as safe.

Turning to the information framings, the loss-framed and the loss-framed with media story dummies were the only statistically significant variables, both at the 1% level. Consumers in the loss-framed group were 5 percentage points less likely to report that meat products from untreated cattle were very safe, compared to the control group. Similarly, consumers in the combined loss-framed with media story group were 4.5 percentage points less likely to affirm that meat products from untreated were very safe. Consistent with previous results, the loss-framed information was the more effective, in priming consumers about the potential risks of *E. coli O157* contamination in meat products from cattle that have not undergone any pre-slaughter interventions. While Maheswaran and Meyers-Levy (1990) suggests that negative information (a close variant of the loss-framed information) is more persuasive when involvement is high, they did not decompose the information effects into negative-framed only information, and negative-frame with involvement. The magnitudes of the loss-framed, and the loss-framed with media story dummies are fairly comparable in this case, even though the coefficient for the loss-framed information dummy was higher.

Table 10. Ordered probit results, safety rating of untreated cattle, after information provision

	Coefficient	**Robust Std. Err.**	**P>|z|**	**Marginal effect**
Knowledge				
know_ecoli	-0.0970	0.0515	0.0600	-0.0157
know_vac	0.0656	0.0563	0.2440	0.0106
know_dfm	0.0340	0.0656	0.6040	0.0055
org_antibiotic	-0.0174	0.1236	0.8880	-0.0028
org_vacc	0.1070	0.0939	0.2550	0.0173
org_hormone	-0.1723	0.1640	0.2930	-0.0278
Trust				
high_trust	**-0.2158**	0.0391	0.0000	**-0.0348**
low_trust	**0.0779**	0.0389	0.0450	**0.0126**
Attitudes towards tech				
acp_vac	**-0.1274**	0.0427	0.0030	**-0.0206**
acp_org	**0.1321**	0.0368	0.0000	**0.0213**
other_tech	**0.1775**	0.0438	0.0000	**0.0287**
Consumption & Safety				
high_cons	-0.1259	0.0702	0.0730	-0.0203
safe_beef	**0.1649**	0.0438	0.0000	**0.0266**
Demographics				
fam_work1	**0.1996**	0.0901	0.0270	**0.0322**
age	**-0.0036**	0.0019	0.0570	**-0.0006**
college	0.0505	0.0687	0.4620	0.0082

income	**0.0014**	0.0007	0.0280	**0.0002**
white	0.0625	0.0709	0.3780	0.0101
male	**0.1520**	0.0651	0.0190	**0.0245**
Information				
loss_info	**-0.3117**	0.1043	0.0030	**-0.0503**
gain_info	-0.0445	0.1017	0.6620	-0.0072
involve_info	-0.0504	0.1050	0.6310	-0.0081
loss_inv	**-0.2782**	0.1058	0.0090	**-0.0449**
gain_inv	-0.1102	0.0991	0.2660	-0.0178
/cut1	0.4897	0.2519		
/cut2	1.9005	0.2549		

(Variables in bold are significant at the 5% level or lower)

9. Conclusions

The study explored the influence of gain and loss-framed information, a media food safety story intended to elicit respondent involvement, and a combination of the message framings and the media story, on consumers' risk perceptions, and their attitudes towards interventions that reduce *E. coli O157* contamination in beef.

Respondents were grouped into five information framings, the first been the control group that received no information to help tease out the impact of information provided. The inclusion of the media story was intended to elicit issue involvement, following Maheswaran and Meyers-Levy (1990) who created high and low involvement groups by varying the degree to which the subject matter affected participants. The media story about the children's dance instructor who succumbed to an *E. coli O157* infection and subsequently suffered paralysis, was to draw attention on the existing risk of *E. coli O157* contamination in beef products. It appears that the media story was not the most effective in impacting consumers' perceived risk of *E. coli O157* infection. At best, such information nudges consumers and gets them concerned about beef contamination, as noted from the results. However, the media information did not influence consumers' perceived likelihood of an infection when consuming beef. This outcome may tie in with Hayes et al.'s (1995) observation about consumers tending to underestimate or downplay the risk of foodborne pathogens, influenced largely by their predispositions than factual information. Consumers possibly underestimate their vulnerability to infections when provided with such stories.

A significant finding was the persuasive influence of both gain-framed and loss-framed information, but particularly loss-framed information in priming consumers about rating the safety of meat products higher when animals undergo additional food safety interventions. Some areas of interests to policy makers from this outcome could be the general effectiveness in communicating the benefits of food safety interventions in terms of the potential risk they reduce, which was the case for both gain-framed and loss-framed information. Apart from presenting the benefits of risk reduction, it is possible that the private environmental benefit included in the message frames also resonated with consumers, even if they were not beef consumers. Given that previous studies had found loss-framed messages to be more effective when issue involvement is high (Maheswaran and Meyers-Levy 1990 and Ganzach, Weber and Or 1997), it was somewhat surprising that the loss-framed with issue involvement group was not more persuasive than the loss-framed only group, in terms of affirming the safety of meat products from animals treated with the two technology. Potential issues of consideration here are whether providing too much information actually boomerangs and leaves consumers either too puzzled or uninterested, as opposed to providing more succinct information. Another twist could be that the media story, as alluded to previously, may not necessarily have made consumers think of themselves as any more susceptible to *E. coli O157* infections. An additional finding that may prove useful was the fact that consumers who had at least a college degree were more confident about the safety of the less known intervention, DFMs. This opens an avenue for consumer education for new food safety interventions. In conclusion, information matters. From the empirical findings, this study shows that while 'sensational' news' stories about the plight of other consumers may be viewed as an isolated case, providing information that emphasize the potential benefits a consumer forgoes in minimizing their risk, influences safety perceptions for food safety technologies.

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