Can Survey-based Scenarios Measure Consumer Values for Improved Food Safety?

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Valuing incremental improvements in food safety remains a methodological challenge. First, policy makers and food safety experts would like to value changes in objective measures of food safety risk. However, studies using stated preference approaches to elicit WTP measures have found that respondents' baseline assessments of risk differ significantly from those provided by food safety experts and that respondents seem insensitive to the magnitudes of objective risks stated within WTP scenarios. In response, studies valuing reductions in risk have focused on alternative methods of conveying risk information (e.g., risk ladders, 'dot' diagrams, etc.). However, risk communication may not be the only explanation for why survey (subjective) risk assessments differ from objective. Some alternatives may include: improper or vague description of the commodity, use of a scenario that is viewed with skepticism by the respondent, ignoring the respondents' perceived ability to self-defend or use of a scenario that allow respondent to express altruistic behavior. Poor execution in survey instrument design could lead to questionable welfare estimates and to insensitivity in willingness to pay (WTP) estimates for risk reductions. Indeed, some have questioned the potential for state preference instruments to produce valid and reliable WTP estimates for changes in risk.

As a result, current estimates of food safety improvements rely on the annual costs of foodborne pathogens in terms of medical, productivity and premature death (e.g., USDA uses this approach). Importantly these approaches miss the disutility (pain and suffering) associated with foodborne illnesses (Table 1). Although these utility losses may be relatively small on an individual basis, the fact that over 3 million cases occur annually would lead us to expect that current estimates of the benefits of food safety improvements vastly underestimates the true benefits. Using stated-preference approaches to elicit consumers' willingness to pay for improvements in food safety can be theoretically consistent but practically difficult. For example, often these approaches generate WTP responses that are inconsistent in their reaction to changes in the scope of the risk change. This paper highlights the results from a long-term CDC funded study aimed at designing and testing stated preference approach to valuing food safety risks.

Methods

To answer the above, we administered a mail survey to two nationally representative samples of US adults (18 years or older) from August 5 – December 12, 2005.

Sampling and survey administration

A total of 8,500 surveys were mailed out to a random sample of individuals to help ensure a national cross-section of respondents. Two separate mailings were sent. The first mailing consisted of a total of 5,000 surveys with two non-responder follow-up mailings. The second mailing consisted of a total of 3,500 surveys with two non-responder follow-up mailings.

In the first mailing, half of the mailings included an enclosed monetary incentive, while the other half did not enclose money but mentioned that a check would be sent upon receipt of the survey. Additionally, the incentive amount was randomly varied across the amounts of $1, $2, or $5. While this experiment was valuable for the conduct of public opinion research, the goal of the second mailing was primarily project completion, and as such all mailings used the optimal combination found from the first mailing, namely, an incentive of $2 enclosed in the envelope. In total 3,511 individuals returned completed surveys; the response rate for this study was calculated to be 49%, (3,511 completes/ 8,500 sent out - 1,274 undeliverable and ineligible). In general our resulting sample of survey respondents is relatively representative of the characteristics of the U.S. adult population (Table 2). Our sample is slightly older, more likely to be white and have slightly higher income.[1] As with the FDA survey data, we find that most individuals are unfamiliar with *Listeria* but most appear to be well-informed about *E. coli*.

Survey instrument design

The mail survey instrument consisted of 49 questions in eight sections. Section I elicited respondents' opinions about the safety of foods[2] prepared at home (as opposed to restaurants, etc.). Section II focused on respondents' prior knowledge of pathogens. In Section III, respondents were asked questions designed to measure their opinion of the safety of either ready-to-eat hotdogs or raw hamburger.[3] In Section IV we asked respondents about their household's experience with foodborne illness from foods prepared in their home. Section V contained questions asking respondents how they prepared food for themselves and their household, in general, and on how they handled and prepared either ready-to-eat hotdogs or raw hamburger. Section VI contains questions aimed at measuring respondents' WTP for foods that varied in their food safety risks. In Section VII we presented respondents a hypothetical government-sponsored

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[1] With respect tot the differences in average incomes, the income categories are different in the two surveys. In our survey the upper category is $250,000 and above; whereas, in the FDA survey the upper category is $150,000 and above. As a result, the FDA income mean may be biased downward.

[2] There are many things that could make a food unsafe to eat (for example, chemicals). Respondents were told in the survey that we were only interested in food safety problems caused by germs, such as bacteria, viruses or other types of microorganisms

[3] Note there are two different survey 'bases' that correspond to the two foods studied in Section VI: hamburger and hotdogs. Although many of the questions are the same across the survey bases there are some differences. Section III is exactly the same except for specification of the food. Section V, with questions relating to specific food-handling practices, differs across the two foods.

food safety program used to elicit their willingness to pay for the program. Section VIII was dedicated to socio-economic and household health-status questions.

Section VI is the basis of this paper. Here respondents were asked questions related to their current or latent[4] buying of either hotdogs or raw hamburger and then presented a food-choice scenario. The food-choice scenario has four key dimensions: pathogen type (*Listeria* or *E. coli*), food type (hotdogs or raw hamburger), the amount of pathogen information provided to respondents (with or without additional information about *Listeria*) and the processing treatment (either electron beam[5] or ethylene gas processing). Thus, a design featuring 16 permutations is possible; however, the chosen design features an orthogonal subset of six permutations that allows the testing of several key main effects. Specifically, the design allows us to estimate WTP for food safety risk while controlling for the effects of the food processing method used, the type of pathogen and food, or the amount of information presented about the pathogen.

In the food-choice scenario some respondents were first presented background information about a *L. monocytogenes* because *Listeria* contamination and its effects are relatively unknown among American consumers.[6] Respondents were then provided (objective) information, both as text and as a graphic, showing the likelihood that the food product (either hotdogs or hamburger) is currently contaminated by one of the two pathogens (OBJU). The randomly assigned objective level of contamination provided for the status quo product was either: 10, 20, 30 or 40 percent. We then asked respondents to

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[4] Latent demand for the food was elicited by asking those respondents who currently do not purchase the food product whether they would consider buying the product if they could be assured that the product would not contain food pathogens.

[5] Also known as irradiation

[6] According to unpublished results from the U.S. Food and Drug Administration's Food Safety Survey, in 2006 *Listeria* was only familiar to 33 percent of U.S. adults whereas *E. coli* was familiar to 86 percent of U.S. adults.

imagine they had purchased the food product they typically buy and store, handle and cook it the way they normally do and asked them to indicate, on a scale from 0 to 100 percent, how likely they thought it was that they would get sick after eating the product. Responses to this question provide us the respondent's subjective evaluation of the safety of the status quo, untreated, product (SUBJU).

Respondents were then provided background information about one of two different treatments (electron beam or ethylene gas) that could be used by the food industry to reduce levels of food pathogens. They were then provided (objective) information, both as text and as a graphic, showing the likelihood that the food product would be contaminated after being processed with the food safety treatment (OBJT). The level of contamination provided for the treated product was either: 5, 10, 15, 20, 25, 30 or 35 percent; the level of contamination for the treated product was randomly assigned with the condition that the level of contamination for the treated product was always at least five percent less than the level of contamination for the status quo product. Again, we asked respondents to imagine they had purchased the treated food product and stored, handled and cooked it the way they normally do and then asked them to indicate, on a scale from 0 to 100 percent, how likely they thought it was that they would get sick after eating the treated product. Responses to this question provide us the respondent's subjective evaluation of the safety of the treated product (SUBJT).

The final question of this section then asked the respondent to assume they went to their usual food store to buy the food product. In addition to a package they have bought in the past, they find a package of the treated product. They were told to assume that both food products look the same and that the food product they typically buy is not treated. They were also told what the price of the treated food was relative to the price of their current product. The randomly assigned increase in price for the treated product was drawn from the following set: $0.10, $0.15, $0.20, $0.25, $0.30, $0.40, $0.50, $0.60, $0.80, $1.00, $1.20 and $1.60. Respondents were then asked to choose one of three actions: choose the food treated with the pathogen-reducing technology; choose their usual (untreated) food or choose to stop buying the food altogether.

Data analysis

The primary goal here is to estimate respondents' reactions to perceived changes in the food's safety linked to the use of specific food-safety technologies. However, before modeling this process we first examined the descriptive statistics of people's evaluations of risk. Here the mean objective risk provided to respondents for the untreated and treated products is 30 and 15 percent contamination levels, respectively. However, individuals' mean subjective evaluations of their likelihood to get sick are 10 percent for the untreated food and five percent for the treated food. That subjective evaluations would be smaller conforms to the idea that individuals understand that they can reduce their risk of getting sick through defensive activities (e.g., being a careful shopper, being vigilant in handling and cooking); at least in the range of contamination levels studied here, individuals seem to transform objective levels of contamination to subjective illness likelihoods in a 3/1 ratio.

We then dug further by examining the relationship between subjective risk levels and people's choices of action (Table 3). We find that most respondents made choices that are inline with their risk perceptions. However, we do find two anomalies; some individuals state they would choose the treated, higher priced, product even though their likelihood of getting sick is unchanged.[7] Worse some individuals make this choice while also stating that they thought the treated product was riskier (although only 1.7 percent of respondents made this choice/risk combination). These choice/risk combinations seem to indicate irrational behavior. There are two possible explanations for the former choice/risk combination; one is that individuals were correct in writing down their risk evaluations and made an incorrect choice, the other possibility is that individuals were incorrect in recording their risk evaluations and made a correct choice.

To determine which of these is more likely we first compared the responses to all the other questions in the survey between individuals in the "chose the treated food yet feel the treated food carries the same risk as untreated food" group and the two other possible groups ("chose the treated food and feels the treated food is safer" and "chose the untreated food and feels the treated food carries the same risk as untreated food"). We find no significant differences between responses from the problem group and those who "chose the treated food and feel the treated food is safer" whereas we find several significant differences between responses from the problem group and those who "chose the untreated food and feel the treated food carries the same risk as untreated food".

What the above seems to indicate is that individuals in the problem group made the right choice but did not record their risk evaluations correctly. One possibility to explain this is that respondent's rounded their subjective risk evaluations. This is problematic when the perceived risks between the treated and untreated foods are similar – they may get rounded to the same risk response. One way to circumvent this rounding issue is to adjust the problem group risk responses to the untreated food through the use

[7] That some choose the untreated food even though they rate it as less risky is explained by the fact that the treated food is always more expensive.

of a prediction model that estimates the relationship between the subjective risk response for the untreated food and a vector of individual-level responses (e.g., product attributes, socio-economic characteristics, health risk perceptions, pathogen knowledge, food borne illness experience, shopping and handling practices) using data from the “chose the treated food and feel the treated food is safer” group. Although not a perfect approach, our problem group becomes smaller when using the adjusted choice/risk combination data (Table 4).

We now estimate the following model:

$$C_{ik} = \alpha_0 + \alpha_1 \text{PRICE}_{ik} + \alpha_2\text{GAS}_{ik} + \alpha_3\text{HAM}_{ik} + \alpha_4\text{ECOLI}_{ik} + \alpha_5\text{INFO}_{ik} + \alpha_6\text{RISK}_{ik} + \alpha_7 \text{RISK}^2_{ik}$$

where C_{ik} is a dummy variable denoting individual i’s choice of the kth action (k = TREATED (buy food treated with a new food processing technology) or UNTREATED (buy typical untreated food)); 1 denotes the action was chosen, 0 otherwise.[8] PRICE is the price of the treated product relative to the individual’s typical product. GAS is a dummy variable denoting whether the product treatment used ethylene gas (coded as 1) as opposed to electron beam processing (coded as 0). HAM is a dummy variable denoting the food product was hamburger (coded 1) as opposed to hotdogs (coded 0). ECOLI is a dummy variable denoting whether the pathogen on the food was *E. coli* (coded 1) as opposed to *Listeria* (coded 0). INFO is a dummy variable denoting whether a person responding to a scenario asking about *Listeria* contamination was provided additional information about the pathogen (coded 1) as opposed to no additional information (coded 0).

[8] To focus on individuals who are in the market, for this analysis, we drop individuals who stated they would stop buying the food altogether; these individuals only make up six percent of all observations.

In the model we used several different measures of risk. We used both the objective risk we provided to the respondents and the subjective evaluations of risk respondents gave us. We also ran two variants of the model; one model variant was linear in risk while in the other we added a quadratic terms to identify any non-linear relationship between WTP and risk changes. One method to identify whether the WTP estimates moved proportionately to changes in risk (passes the scope test) is to examine if the α_7 coefficient is significantly different from zero.

Given that each individual chooses one action from a choice set of two actions we estimate the models as a discrete-choice logit. The estimated equation parameters with appropriate variable coding can be used to provide estimates of household's mean WTP for changes in food safety risk while holding all other modeled variation constant. Multiplying mean WTP by the total number of households in the US (down weighted by six percent to only include households in the hamburger and hotdog market) gives us an estimate of aggregate WTP for changes in food safety risk.

Results

Before we examine the model estimates we examine various tests of the various models (i.e., objective versus subjective risks; adjusted versus unadjusted subjective risks). The models using subjective risks perform better than the model using objective risks on several fronts (Table 5). In terms of overall fit, the full model has a lower Schwarz's Bayesian Criterion[9] and a significantly larger log likelihood value. Comparing the model using the adjusted subjective risk assessments with the unadjusted subjective risk data indicates the adjusted risk assessments perform better.

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[9] When comparing models with different numbers of parameters the model with the lowest SBC is considered best (SAS 2003)

As expected, the impact of PRICE is negative and significant (Table 6). This indicates that higher prices for treated foods would primarily increase people's desire to buy their current untreated food. The impact of GAS is also negative and significant. Thus, the use of ethylene gas as a treatment option (relative to the use of irradiation) causes individuals to, on average, reduce their consumption of treated foods. The coefficient of HAM indicates that consumer reactions to food technologies are dependent upon the type of food; people are more likely to buy treated hamburger relative to their reaction to treated hotdogs. The non-significance of the *E. coli* and INFO parameters indicates that consumer reactions to the technologies are unaffected by the specific pathogens of *E. coli* or *Listeria*, or that the reactions to *Listeria* contamination are impacted by additional information about the pathogen. As expected, an increase in the perceived level of risk decreases the likelihood the consumer chooses the product; the insignificance of the coefficient on the squared risk term suggests that respondents react proportionally to the changes in subjective risk (i.e., the WTP estimates should pass the scope test).

The WTP estimates for risk changes are reasonable (pass the laugh test); we find households are WTP about $0.18 for a three-percent improvement in subjective risk (Table 7); this translates into a 10 percent reduction in objectively stated risk. For comparison, note that a similar change in a hamburger's fat content generates market prices varying about $0.80. Aggregating up, we find that a 10 percent objective change in risk is worth about $6.6 billion annually for just two food products (Table 8). This compares with USDA's current estimate of $6.9 billion for reducing the risk of foodborne illness *from all food products.*

Conclusions

The regression equation worked extremely well; all of the parameter estimates match our prior expectations and, importantly, the WTP estimates meet the scope test with respect to changes in subjective risks assessments. As a result, stated-preference approaches show promise as a reliable and valid method to valuing changes in food safety, at least when the issue can be framed as private choice behavior, one controls to the risk reducing treatment and uses subjective versus objective risk assessments. One point that deserves much more scrutiny is the issue of respondents rounding their risk assessments. Use of interactive approaches (web-based, phone with mail, interview, experimental) or mail with extensive probes may be in order. At a minimum, the scenario design needs to consider including a prompt to respondents to not round their risk assessments.

Given our results, current estimates grossly understate the benefits of food safety programs; and also give undue priority to foodborne illnesses that result in mortality. Future work needs to expand the types of foods studied; particularly uncooked foods like spinach, lettuce, scallions or food-away-from-home consumption that provide the respondent fewer opportunities to self defend. Finally, one needs to examine the issue of additivity of values across pathogens (i.e., examine the potential embedding problem).

Of course, one should be mindful of the hypothetical nature of the experiments. First, using survey approaches may have allowed respondents to evaluate the information more fully, and with potentially fewer distractions, than they would in an actual purchase setting. Second, externally validated experiments indicate that when respondents do not face a real budget constraint they are not as sensitive to price differences as they are in real markets.

References

SAS (Statistical Analysis Software). (2003), *Goodness of Fit Statistics*, *SAS 9.1.3 Documentation* SAS Institute Inc., Cary, NC.

Table 1. ERS cost estimate: *Salmonella*

	No medical visit; survived	Medical visit; survived	Hospitalized then died	Total
Cases	1,224,547	172,225	415	1,397,187
Costs ($1,000)				
Medical*	0	177,831	3,333	181,164
Productivity	58,116	31,062	218	89,396
Disutility	0	0	0	0
Premature death	0	0	2,116,692	2,116,692
Total cost	58,116	208,893	2,120,243	2,387,252

Table 2. Characteristics of sample

Categories	Our sample	FDA survey
Percent male	47	47
Average age	53	47
Average years of education	14	14
Percent white	82	72
Average household income	$67,600	$61,000
Percent knowing about *E. coli*	87	84
Percent knowing about *Listeria monocytogenes*	23	29

Table 3. Choice by subjective risk evaluations (unadjusted)

	% Stating	Distribution of choice for each risk group	
		Treated	Untreated
Treated food is safer	43	60%	40%
Treated food has same risk	48	39	61
Treated food is riskier	9	21	79

Table 4. Choice by subjective risk evaluations (adjusted)

	% Stating	Distribution of choice for each risk group	
		Treated	Untreated
Treated food is safer	54	68%	32%
Treated food has same risk	38	22	78
Treated food is riskier	8	21	79

Table 5. Tests of alternative models

	Log-likelihood	R-square	Swartz Bayesian Criterion	Willingness to Pay
Objective risk used	-1695	0.03	3404	0.01
Subjective risk used				
Unadjusted	-1599	.09	3252	.0485
Adjusted	-1408	.14	2871	.0636

Table 6. Estimates coefficients from discrete-choice modeling

Variable	Estimated coefficients[a]	
	Linear model	Non-linear model
Intercept	-0.21	-.33
PRICE	-0.97***	0.98***
Use of ethylene gas (GAS)	-0.25***	-0.25***
Hamburger (HAM)	0.24**	0.26**
E. coli (ECOLI)	0.08	0.09
Pathogen information provided (INFO)	0.18	0.12
Perceived contamination baseline (SUBJ)	-0.06***	-0.06***
Square of Perceived contamination baseline ($SUBJ^2$)		-0.0002

a * denotes significant at the 0.10 level; ** denotes significant at the 0.05 level; *** denotes significant at the 0.01 level

Table 7. Household mean willingness to pay for food safety

Reduction in risk	Linear	Non-linear
One	0.07	0.06
Five	0.34	0.31
10	0.68	0.61

Table 8. Aggregate willingness to pay for safer hotdogs & hamburger

Point reduction in risk	If non-additive	If additive
5	$3.3 billion	$6.6 billion
10	$6.6 billion	$13.2 billion
15	$9.6 billion	$19.2 billion
ERS estimate for four pathogens*		$6.9 billion

* *Campylobacter Salmonella E. coli* O157 and non-O157 and *L. monocytogenes*