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Measuring Consumer Benefits of Food Safety Risk Reductions

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ABSTRACT

Microbial pathogens and pesticide residues in food pose a financial burden to society which can be reduced by incurring costs to reduce these food safety risks. We explore three valuation techniques that place a monetary value on food safety risk reductions, and we present a case study for each: a contingent valuation survey on pesticide residues, an experimental auction market for a chicken sandwich with reduced risk of *Salmonella,* and a cost-of-illness analysis for seven foodborne pathogens. Estimates from these techniques can be used in cost/benefit analyses for policies that reduce food safety risks.

Key Words: contingent valuation, cost of illness, experimental auction market, food safety, risk reduction, *Salmonella.*

The food supply in the United States is generally considered healthy, nutritious, and safe. However, the modern industrial food system may result in undesired or unanticipated outcomes that pose a health hazard for consumers. The Centers for Disease Control and Prevention (CDC) and the Food and Drug Administration (FDA) estimate that, based on reported outbreaks and other epidemiologic data, between 6.5 and 33 million people in the United States become ill from microbial pathogens in their food each year (i.e., bacteria, parasites, viruses, and fungi); of these, up to 9,000 die (Council for Agricultural Science and Technology). Archer and Kvenberg estimate that 2–3% of these foodborne illness cases develop secondary illnesses or complications such as arthritis following some *Salmonella* infections. Pesticide and other farm chemical residues may remain on fruits and vegetables, and prolonged dietary exposure to such chemicals may pose a risk of cancer or other adverse health effects (particularly to children), although evidence suggests that these risks are fairly low (Kuchler et al.). In recent years, there have been some highly publicized outbreaks of foodborne illnesses linked to a variety of foods. In the summer of 1997, 25 million pounds of hamburger potentially contaminated with *E. coli* O157:H7 were recalled. News stories about foodborne disease have been widespread, contributing to rising public concern about the problem.

Consumers make choices about the food products they buy based on a number of factors. In addition to the price of the product, factors such as appearance, convenience, texture, smell, and perceived quality influence

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choices made in the marketplace. In an ideal world, consumers would make consumption decisions with full information about product attributes, and so choose the foods that maximize their well-being. In the real world, there are numerous food-safety information problems which complicate the consumer's decision making. For example, all raw meat and poultry products contain some level of microorganisms, some of which may be pathogens. However, consumers generally do not know the level of foodborne-illness risk, since pathogens are not visible to the naked eye. Aside from some rather obvious indications (e.g., unpleasant odor or discoloration, both of which may be caused by nonpathogenic spoilage microorganisms), there are, in many cases, no clear-cut ways for consumers to determine if there is a health risk from pathogens or other causes (e.g., pesticide residues).

While producers have some information about how safe their product is, such as information about the chemicals used during production or the care taken during butchering of meat, there is no incentive to share that information with consumers. This is because it is difficult to charge a premium for the unobservable increase in safety. This asymmetry in information about food safety between producers and consumers leads to a market failure. The workings of a nonregulated market may yield greater-than-optimal levels of pathogens and farm chemicals in the food supply and excessive human-health risk, which could in turn result in higher levels of illness and mortality. In such a case, the public welfare could be enhanced if society regulated the food industry to reduce the level of foodborne health risks and/or increase consumers' knowledge so they can take personal actions to reduce their risk of exposure to foodborne illness.

The economic issue of concern is how best to achieve the goal of a safer food supply. Although regulations governing food production, processing, distribution, and marketing may create benefits by increasing the safety level of the nation's food supply (i.e., reducing risk of illness), these regulations also can increase producers' costs and potentially raise food prices. The task is to ensure that the regulations maximize the net benefits of increasing food safety, that is, equating the marginal benefits of safer food with the marginal costs of achieving food safety goals.

Faced with the task of estimating benefits where there is market failure or an externality problem, economists have developed several measurement techniques for nonmarket goods, and these techniques fall into two general classes. The first class of techniques values changes in social welfare by using indirect evidence from the marketplace such as the individual's expenditures on related goods and services. One such technique is the cost-of-illness approach. Estimates from this approach can be used as a proxy for a change in expenditures and foregone wages associated with a change in ill-health episodes caused by a specific health risk. Other market-based techniques rely on observed market choices that reveal preferences for a nonmarket good, such as the travel cost method for estimating recreation benefits and the averting expenditure method for estimating values of health risks from environmental hazards. The second class of techniques consists of those that use stated preferences about nonmarket goods. The most widely used of these is contingent valuation. Falling in between these two classes are experimental market techniques, where individual choices made in constructed market situations reveal preferences for a good that usually cannot be directly purchased in the market. We characterize experimental markets as intermediate between market-based techniques and stated preference techniques because the choice situation is artificially created—but the choices are real, not hypothetical.

In this paper, we explore three valuation techniques that are used to measure the benefits of food safety risk reductions, and we present a case study for each: (*a*) a contingent valuation survey on pesticide residues, (*b*) an experimental auction market for a chicken sandwich with reduced risk of *Salmonella*, and (*c*) a cost-of-illness analysis for foodborne pathogens. Estimates from these techniques can be used in cost/benefit analyses for policies that reduce food safety risks.

Contingent Valuation Methods

Contingent valuation (CV) methods include telephone surveys, mail surveys, and personal interviews that elicit consumers' willingness to pay (WTP) for nonmarket goods "contingent" on a given hypothetical scenario. In this hypothetical decision situation, the respondent is willing to pay some money to obtain a level of provision of a nonmarket or public good. In the past few decades, over 1,600 contingent valuation and related publications have measured the benefits of a variety of nonmarket goods (Carson et al.).

CV surveys have been increasingly used to measure consumers' WTP for food safety risk reductions. CV surveys have elicited consumers' WTP for reduced risk from: toxins in shellfish (Lin and Milon), nitrates in drinking water (Crutchfield, Cooper, and Hellerstein), and *Salmonella* in chicken and eggs (Henson). Another survey elicited consumers' WTP for leaner pork produced with porcine somatotropin (pST), a naturally occurring protein which some consumers feel poses a food safety risk (Halbrendt et al.). CV surveys have focused on risk reductions from pesticides in food and have estimated the value of organic produce, certified pesticide residue-free produce, or produce with other pesticide risk reductions. Of these pesticide surveys, several have estimated consumers' WTP for food that is "safer" but that does not have a specified risk reduction (Weaver, Evans, and Luloff; Misra, Huang, and Ott; Ott). Other CV pesticide surveys have estimated WTP for specific risk reductions (Buzby, Ready, and Skees; van Ravenswaay and Hoehn). The case study presented here contributes to this foundation by eliciting consumers' WTP for two different specified risk reductions.

A Contingent Valuation Study Valuing Food Safety

The contingent choice scenario used in the CV survey was designed to reveal WTP for a reduction in exposure to pesticide residues on fresh produce. The respondents were told that they must shop for groceries at either Store A or Store B. These two stores were described as being similar to the stores where the respondents currently shop, with the exception of the fresh produce. Two survey versions were used (I and II). In both survey versions, Store A does not test any of its fresh produce for pesticide residues. Store A therefore represents the typical situation found in most U.S. grocery stores. In survey version I, Store B tests all of its fresh produce and rejects any that does not meet government standards for pesticide residues (this store is denoted here as the "government standards" store). In survey version II, Store B tests all of its fresh produce and rejects any with detectable pesticide residues (this store is denoted here as the "pesticide-free" store). Thus, shopping at Store B reduces or eliminates the amount of pesticide residues to which the consumer is exposed. Apart from this difference, and the associated difference in price, Store A and Store B were described as being identical in all respects, and the produce sold was described as being identical in appearance, freshness, and taste.

Prior to the description of the store-choice scenario, respondents were asked their own subjective belief about the mortality risk from consuming fresh produce from a store like Store A. A visual risk ladder, similar to that used by Loomis and Duvair, showed mortality risks from several more-familiar causes of death, including for example car accidents, accidental falls, lightning, and meteorites. The position of each risk on the ladder was determined by the actual number of deaths caused by that risk each year, per 1 million individuals. These numerical risk estimates also were presented to the respondents, next to the risk ladder. Respondents were asked to rate the mortality risk from pesticide residues on fresh produce as compared to these causes of death, with the answer coded as an index varying from 1–19 (with 1 = lower than the risk of death from a meteorite, and 19 = higher than the risk of death from a car accident). Later in the survey, during description of the store-choice scenario, respondents were given objective estimates of the mortality risk from cancer caused by pesticide residues on fresh produce. For Store A, this was given as one death per 1 million people per year. In survey version I, shopping at the "government standards" store reduced that risk by one-half. In survey version II, shopping at the "pesticide-free" store eliminated the risk completely.

In both versions, respondents were told that Store B was more expensive than Store A, with the weekly difference in cost between the two stores set at one of seven different levels: \$1, \$3, \$5, \$8, \$10, \$15, and \$25. Respondents were reminded that this decision would have no impact on other mortality risks, and were told that cancer caused by pesticide residues on fresh produce probably accounts for less than 1% of all cancer cases. Respondents were asked two valuation questions in sequence. First, they were asked at which store they would shop, given the price difference. Next they were asked the maximum amount they would pay to shop at Store B. Thus, both a dichotomous-choice and an open-ended WTP response were elicited from each respondent.

To answer the dichotomous-choice valuation question, respondents are assumed to choose the store that yields higher utility. We model this utility as:

$$(1) \qquad U_i^A = \epsilon_i^A$$

and

$$(2) \qquad U_i^B = \mathbf{X}_i\beta + \gamma f(P_i) + \epsilon_i^B,$$

where $\mathbf{X}_i$ is a vector of variables describing both individual I and Store B, P_i is the price differential between the two stores faced by individual I, and ϵ_i^A and ϵ_i^B are individual-specific random errors, which we assume follow type I extreme value distribution, so that the parameters β and γ can be estimated using a logit regression. Two forms of $f(P_i)$ were investigated empirically, a linear form and the translocated log form, $\ln(P_i + 1)$. The translocation was set at one so that the price term would vanish as the price differential goes to zero.

Because ϵ_i^A and ϵ_i^B are not observable, the price that sets U_i^A and U_i^B equal is not known for an individual. However, it is possible to calculate the price that sets expected utility from the two stores equal. For the linear form of $f(P_i)$, that price is $-\mathbf{X}_i\beta/\gamma$. For the translocated log form, that price is $\exp(-\mathbf{X}_i\beta/\gamma) - 1$. This price also corresponds to the median compensating variation for the risk reduction across a population of similar individuals.

The Contingent Valuation Survey and Results

The Survey

The survey was administered by mail. A total of 1,800 surveys were mailed out in three waves of 600 each. Addresses were purchased from a commercial mailing list vender. The waves went out in November 1994, February 1995, and May 1995. Each wave followed the Dillman total design method, with a notification letter, a survey packet, a reminder postcard, and a second survey packet to nonrespondents. For the first two waves, all mailings were sent by first-class post. Of these 1,200 surveys, 161 (or 13.4%) were returned as undeliverable or deceased. Of the remaining, 439 were returned, giving an effective response rate of 42.3%. Due to a miscommunication, the third wave of 600 surveys was mailed by bulk-rate post. These had a similar rate of undeliverable addresses (13.3%), but a lower response rate. A total of 188 surveys were returned from the third-wave mailing, for an effective response rate of 36.1%. While the low response rate in the third wave is unfortunate, the incidence of additional nonresponse due to the use of bulk rate did not appear to be correlated with preferences for food safety. A dummy variable for survey wave (wave 3 versus waves 1 and 2) was not significantly related to the response to the valuation question ($\alpha > 0.30$).

There was wide variability in subjective belief about the danger posed by pesticide residues on fresh produce. Four percent of respondents thought that pesticide residues cause more deaths each year than do automobile accidents, while 17% thought that they caused fewer deaths than do meteorites. The median risk index value was 5, which corresponds to a numerical risk of three deaths per million people per year. The mean risk index value was 13.2, which roughly translates to 14 deaths per million people per year. However, translating the risk index values to numerical risks, and then averaging gives roughly 43 deaths per million per year. The skewed nature of the risk index values, and the nonlinear relationship between the risk index and numerical risk estimates make it difficult to characterize the central tendency of subjective beliefs. Nevertheless, it can be stated that most respondents believe the risk to be larger than expert assessments.

Of the 627 returned surveys from the three mailing waves, 22 did not contain a usable valuation response. An additional nine were judged to be protest responses, based on a stated zero WTP for safer food, along with agreement with the statement, "I am concerned about pesticides, but I refuse to pay more for food to avoid them." This left 596 usable surveys for estimation purposes: 289 version I, and 307 version II. The rate of usable responses did not differ significantly across the two survey versions.

Table 1. Logit Regression Results of CV Responses

Variable	Coefficient	*t*-Statistic
ln(*Price* + 1)	−1.441	9.49
Intercept	1.398	2.02
Pesticide-Free	0.1245	0.65
Risk Index	0.0742	3.72
Household Income	0.786E-05	1.88
Education	0.544E-03	0.02
Caucasian	−0.212	0.72
Female	0.451	2.27
Birth Year	0.0061	0.88
No. in Household	−0.0254	0.26
Children in Household	0.487	1.63

Contingent Valuation Survey Results

In order to avoid the effects of possible yea-saying, responses to the valuation questions were interpreted conservatively. Ready, Buzby, and Hu observed that mail survey respondents sometimes contradict themselves when asked both a dichotomous-choice and an open-ended question, and viewed these contradictions as possible evidence of yea-saying behavior. For this study, a respondent was judged to favor Store B only if she or he chose that store in the first valuation question, and then did not state an open-ended WTP less than the price differential described in the contingent-choice scenario. Thus, the elicitation procedure is not a pure dichotomous choice, but includes a consistency check. A total of 366 respondents (61.4%) chose Store B in the initial valuation question. Of these, 101 contradicted themselves in the open-ended follow-up question.

A model predicting store choice was estimated using logit regression. Explanatory variables in the regression included household income, years of schooling completed by the respondent, respondent's sex (female = 1), ethnicity (Caucasian = 1), year of birth (with 1900 = 0), number of people living in the household, whether the household contains children under the age of 18, and the respondent's subjective rating of the mortality risk from pesticide residues on fresh produce, as measured by an index scaled from 1 to 19. Missing data for individual variables were set equal to sample means. A dummy variable for survey version (version II = 1) was also included in the regression.

The translocated log transformation of price outperformed a linear-price model as measured by model log-likelihood. Table 1 presents the parameter estimates for the translocated log model. Price differential was a significant determinant of store choice, with higher price differentials favoring Store A, the cheaper store. The regression results also showed that respondents giving a higher subjective risk rating, higher income respondents, and females were more likely to choose Store B. The first two findings would be expected; the last is interesting but not required by theory. The other demographic variables were not significant, though there were some interesting interactions, which we explore further below. The coefficient on the dummy variable for survey version II was positive, as would be expected, but was not significant.

Model estimates of median and mean WTP

Table 2. CV Estimates of Willingness to Pay per Week for Safer Produce ($)

Store Type	Median	95% Confidence Interval	Mean	95% Confidence Interval
Government Standards	5.31	4.30 / 6.63	8.36	7.14 / 9.62
Pesticide-Free	5.88	4.81 / 7.24	8.91	7.69 / 10.20

for safer food are presented in table 2, along with 95% confidence intervals constructed by the simulation method described by Krinsky and Robb. We focus here on median WTP, as it represents the price differential at which expected utility for the two stores is equal. For an average individual (with $\mathbf{X}_i$ set at sample means), that value is $5.31 per household per week for the government standards store, and $5.88 for the pesticide-free store. These two values are not significantly different (t = 0.65). It is also of interest to investigate how this value varies across individuals with different characteristics. For example, for a respondent born in 1940, with no children at home, the estimated WTP to shop at a store that meets government standards is $4.49 per week. For a respondent born in 1960, who does have children at home, the estimated WTP is $7.38, and the difference between these two estimates is statistically significant (t = 2.15). Thus, even though neither year of birth nor presence of children is individually significant, their joint contribution can be.

Discussion of the CV Results

Two related issues are of concern with the CV results. First, the valuation responses are statistically insensitive to the size of the risk reduction associated with shopping at Store B, although the direction of the difference follows the prediction of theory. Second, the WTP values seem large relative to other empirical estimates of the value of a mortality risk reduction. Both of these results may be related to respondents paying more attention to the qualitative aspects of the scenario than to the quantitative aspects.

Regarding the issue of the scope of the safety improvement, it seems clear that respondents either were unable to interpret and process the quantitative information about the risk reduction, or ignored that information. In the two survey versions, switching to the store that meets all government standards reduces risks by one-half. Switching to the store with no detectable residues completely eliminates the risk. However, these risk estimates are conjectural. We were unable to locate a toxicologist who was willing to give such policy-specific estimates. It may well be that meeting all government standards reduces the risk essentially to zero. If respondents believe this, then they may not see any benefit from going to a store that employs even stricter criteria.

With regard to the size of the WTP values, some simple math shows that these numbers are big relative to the risks. From these numbers, the value of a premature death is calculated at either $204 million (using the value for the store that meets government standards) or $113 million (using the value for the store that has no detectable residues). Either estimate far exceeds common estimates from studies that look at wage differentials associated with job risk (e.g., $3–$7 million, according to Viscusi). However, it may be that respondents did not believe our posited mortality risk of one out of 1 million persons per year. The mean subjective risk given by respondents was 43 deaths per 1 million people per year. Using this risk estimate gives an estimated value of a premature death of either $4.8 or $2.6 million. These figures are more consistent with previous estimates of the value of a premature death.

Unfortunately, we cannot give guidance on which set of values is more correct for our respondents, or whether their value lies somewhere in between. At a minimum, we must question our ability to impose a detailed hypothetical scenario that differs quantitatively from the beliefs held by respondents. Our results are consistent with respondents who believe that: (*a*) the risk from pesticide residues on fresh produce sold in a typical store is fairly large, and (*b*) if all government regulations are met, that risk is effectively eliminated. Under those assumptions, the estimated value of a premature death is $2.6 million, which falls within the range of available estimates from other studies.

Experimental Auction Markets

Food safety is, as described above, a nonmarket good primarily because of high information costs and/or asymmetry. Contingent valuation of food safety overcomes the information problem by providing objective assessments of health risk. Valuation of food safety in experimental markets attempts to go one step further—eliminating the informational deficiency *and* placing the good in something akin to a market situation where money changes hands. Application of experimental valuation to food safety is relatively new. The first published studies originate from authors at Iowa State University in the 1990s (Shin et al.; Shogren et al.; Fox et al. 1995; Hayes et al.). The technique has been applied to a number of other food characteristics including pork attributes (Melton et al.), reductions in pesticide risk (Roosen et al.), and the use of bovine growth hormone in milk production (Fox).

Advantages of Experimental Markets

Regardless of how well a contingent valuation survey is designed and executed, participants are still aware that they are valuing a hypothetical scenario. The absence of market discipline (i.e., a budget constraint) can create an environment conducive to questionable responses, and the literature contains several examples of inconsistencies such as lack of responsiveness to the scope and scale of benefits. In our contingent valuation case study, we found some evidence of scope insensitivity and some inconsistencies between the discrete-choice and open-ended values.

Valuation in the lab offers some advantages in valuing food safety risk reductions. First, experimental markets feature real monetary payments, forcing respondents to consider their budget constraints. Second, revelation of truthful values is encouraged through a requirement to consume one of the "risky" products being valued and through the use of an incentive-compatible auction mechanism. The auction mechanism typically used is the Vickrey second-price auction in which the highest bidder obtains the product being auctioned for a price equal to the second-highest bid. By first participating in a candy bar auction, participants are familiarized with the procedure and learn that truthful revelation of value is the dominant strategy. A third potential advantage is that selection bias directly related to the good can be minimized by recruiting for a "generic consumer study."

There is some debate regarding the use of single- or repeated-trial experimental auctions. With repeated trials, participants are informed up front that only one of a number of rounds of bidding will be binding. Repeated trials with market feedback allow individuals the opportunity to appraise their own preferences and beliefs in light of the information generated by the market. However, proponents of a one-shot design argue that repetition may affect the incentive-compatible properties of the second-price auction because it allows for the development of intra-group competition. An advantage of repetition is that it allows for the injection of new information (e.g., about risk), and examination of its effect on values. One study suggests that repetition does not result in significant bias (Roosen et al.) but, at this point, no compelling evidence exists to prefer one approach over the other. The laboratory setting accommodates both approaches, but a repeated valuation exercise would be unrealistic in a survey setting.

Limitations of Experimental Markets

Obvious limitations on experimental valuation are the higher costs per respondent and the necessary geographic restrictions on samples. The time commitment required of subjects is substantially greater than that for a survey, thereby requiring some level of financial compensation to reduce sample selection effects. It is possible, of course, that participation payments may affect revealed values—an issue we address below. Another limitation compared to surveys is that, at least up until now, experiments have been restricted to valuing deliverable goods.

Finally, the experimental environment is artificial and contrived, but no more so than the hypothetical scenario presented in a survey. In fact, since external distractions are eliminated in the laboratory, respondents can give undivided attention to the valuation issue. Given the potential benefits and limitations, it appears that experimental valuation can best be used as a complement to the survey method. In this context, Fox et al. (1998) describe the use of an experiment as a means of calibrating hypothetical survey values.

An Experimental Auction Market Valuing Food Safety

Methodology

In this study, we elicit willingness-to-pay values for reductions in *Salmonella* risk from a sample of 50 undergraduate students at Kansas State University. The procedure replicates the experiments described in Fox et al. (1995), and is identical in all respects except for: (*a*) the level of payment to participants; (*b*) the simultaneous valuation, in one treatment, of a second good; and (*c*) the use of 10 repeated trials instead of 20. Subjects were enrolled in an agricultural marketing class, and the experiment was conducted during a class period to facilitate reduced payment of subjects without involving significant participation bias effects.

The experiment had three parts. In part one, identification numbers were assigned and demographic information collected. In part two, subjects participated in a candy bar auction with repeated trials in order to learn the procedure and the incentive for truth revelation. In part three, participants were endowed with a Type I chicken sandwich and allowed to bid for an upgrade to a Type II chicken sandwich. The following descriptions were provided:

- Type I: This food has a typical chance of being contaminated with the foodborne pathogen *Salmonella*; i.e., it has been purchased from a local source.
- Type II: This food has been subject to stringent screening for *Salmonella*. There is a one in 1 million chance of getting salmonellosis from consuming this food.

Following the fifth trial, additional information was provided that described symptoms of salmonellosis and informed participants that the odds of contracting salmonellosis from their typical Type I sandwich was one in 137,000. Following the tenth trial, a drawing determined the binding trial. The highest bidder in the binding trial paid the appropriate price to exchange his/her Type I sandwich for the Type II—then all participants consumed their sandwiches.

Participants were allocated at random to one of four groups, each with 12 or 13 individuals. Each group represented one replication within a 2 × 2 treatment matrix. The treatments were: (*a*) level of payment—$0 or $3, and (*b*) the introduction of simultaneous bidding for a second good—an upgrade from a plain pencil to a KSU souvenir pencil. Here, we will focus on the sensitivity of values to the participation payment. Note that in the experiments reported in Fox et al. (1995), all participants were paid $18.

Experimental Auction Results

Figure 1 shows the average bid at each of the 10 trials for Groups 1 and 2 in which participants bid only for safer chicken. On average, the mean bid is 25¢ higher for the group receiving the $3 payment. This difference is significant at the 10% level in trials 5, 7, and 8, and at the 1% level in trials 9 and 10. Similarly, for Groups 3 and 4 in which participants simultaneously bid for the pencil upgrade, the average bid was, on average, 17¢ higher for the group receiving the payment, but the difference was significant only in trial 2 at the 10% level. Differences in the mean bid were not significant in the first trial. Using the trial 1 bid as a dependent variable whose variation

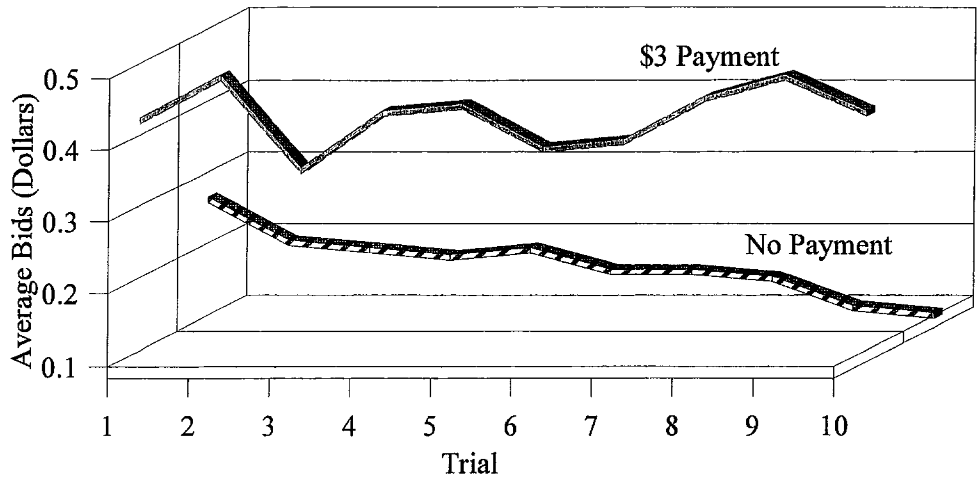

Figure 1. Comparison of average bids for a reduction in *Salmonella* risk

is explained by participant characteristics (gender, having had food poisoning) and treatment effects (payment, bidding on a second good), the coefficient on payment is positive ($\beta = 0.11$) but not significant ($t = 1.18$). However, using the average bid over trials 8, 9, and 10 as the dependent variables shows a positive ($\beta = 0.28$) and statistically significant ($t = 2.56$) effect for the $3 payment.

Since our sample is small and nonrandom, we cannot conclude with any reasonable degree of confidence that payment results in an upward bias. It is certainly possible that other unobserved differences in participant characteristics account in part for the difference in bid levels. In the original study, Fox et al. (1995) reported bids for the same reduction in *Salmonella* risk for four groups of undergraduate students. In the final trials of those experiments, the average bid for groups in Arkansas and Massachusetts exceeded $1, significantly greater than the approximately $0.55 average bids of groups in Iowa and California. Those differences could not be attributed to payment level since all participants received $18.

It is also important to note that, since our experiment was conducted during a class period, our subjects had zero opportunity cost for participating. Therefore, it seems reasonable to hypothesize that they may have been likely to regard their $3 payment as "found money." Conversely, subjects recruited from the general population may be more likely to view payment as compensation for expenses incurred. In that context, it remains an open question as to whether or not payment influences bids. If future studies find that it does, researchers may need to rely on alternative methods of compensation (e.g., charitable donations on the subject's behalf) which may be less likely to affect values.

Focusing on our quantitative results, we note that the average informed bid (over trials 6–10) for *Salmonella* risk reduction for individuals receiving the $3 payment was $0.54, very similar to that of the Iowa and California groups mentioned above. For participants receiving no payment, the average informed bid was $0.32.

Cost-of-Illness Analysis Technique

The cost-of-illness technique has been used to obtain partial estimates of annual costs of acute foodborne illnesses and select secondary complications by estimating the present value of lifetime medical costs and lost productivity (i.e., lost income and household production caused by the illness) (Buzby et al.). Although cost-of-illness analyses are less supported by economic theory than are contingent valuation and experimental auction techniques, they have been useful in food safety policy making. A case in point is the Food Safety and Inspection Service's (FSIS's) Pathogen Reduction/Hazard Analysis and Critical Control Point (HACCP) system regulation for federally inspected meat and poultry slaughter and processing plants ("Pathogen Reduction . . . ," *Federal Register*) that used cost-of-illness estimates to represent the benefits of the rule, as did the seafood HACCP rule ("Procedures for Safe and Sanitary Processing . . . ," *Federal Register*).

Estimating the Costs of Foodborne Illness and Premature Death

Cost-of-Illness Estimates

Cost-of-illness estimates are calculated from the number of annual foodborne-illness cases and deaths; the number of cases that develop secondary complications; and the corresponding medical costs, lost productivity costs, and other illness-specific costs, such as special education and residential-care costs. In this case study, for each foodborne illness, cases were divided into four severity groups: (*a*) those who did not visit a physician, (*b*) those who visited a physician, (*c*) those who were hospitalized, and (*d*) those who died prematurely because of their illness. For some of the pathogens, a fifth severity group was used for patients who develop select secondary complications from the acute illness. For each severity group, medical costs were estimated for physician and hospital services, supplies, medications, and special procedures unique to treating the particular foodborne illnesses. Such costs reflect the number of days/treatments of a medical service, the average cost per service/treatment, and the number of patients receiving such service/treatment.

Most people with foodborne illnesses miss only one or two days of work. This lost productivity is approximated by wage rates, published by the Bureau of Labor Statistics. However, some patients die and some develop complications that prevent them from ever returning to work. The total cost of lost productivity is the sum for all individuals affected, including the patients and, in the case of ill children, their parents or paid caretakers.

Calculating the Value of a Premature Death

We used two different approaches as proxies for the foregone earnings of someone who dies prematurely or who is unable to ever return to work because of his/her foodborne illness (table 3). The first approach focuses primarily on lost productivity using a combination of human capital and WTP estimates developed by Landefeld and Seskin. Human-capital estimates are the value in today's dollars of an individual's lifetime stream of income if the illness had not occurred. The human capital estimates are increased by a multiplier that captures people's WTP to avoid death, as reflected in life insurance premiums. These estimates of the value of a premature death range, depending on age, from roughly $15,000 to $2,037,000 (in 1996 dollars). The major limitation of this approach is that it does not fully consider the value that individuals may place on (and pay for) feeling healthy, avoiding pain and suffering, or using their free time. Because the approach does not cover all of these valuable aspects of health, it is generally thought to understate the true societal costs.

The second set of estimates uses less conservative values based on the "risk premium" revealed in labor markets through the higher wages employers must offer to induce workers to take jobs with injury. Viscusi compared wage differences in 24 labor market studies and found that the extra wages associated with the increased overall hazard of one death from risky jobs are between $3 million and $7 million (in 1990 dollars). Several regulatory agencies, such as the FDA, use either Viscusi's range of estimates or the $5 million midpoint when analyzing the benefits of proposed public-safety rules. For our second set of cost estimates (table 3), we used the $5 million estimate, regardless of the age of the patient. We used both approaches here because economists have not reached a consensus on which estimates to use, though they may now be leaning toward the labor market approach.

High Costs of Foodborne Illness: Analysis Results

We performed cost-of-illness analyses on seven pathogens which are found on some meat

Table 3. Estimated Annual Costs of U.S. Foodborne Illness, 1996

Pathogen, Acute Illness, and Complication	Foodborne Illness Estimates		Estimated Foodborne Illness Costs, Assuming:	
	No. Cases	No. Deaths	Human Capital Approach[a]	Labor Market Approach[b]
Bacteria			------ ($ bil., 1996) ------	
Campylobacter jejuni or *coli*				
Campylobacteriosis	1,100,000–7,000,000	110–511	0.7–4.4	1.2–6.7
Guillain-Barré syndrome	293–2,681	6–53	0.1–1.3	0.4–3.4
Subtotal	N/A	116–564	0.8–5.7	1.6–10.1
Clostridium perfringens				
C. perifringens intoxications	10,000	100	0.1	0.5
Escherichia coli O157:H7				
E. coli O157:H7 disease	16,000–32,000	40–80	0.05–0.1	0.1–0.2
Hemolytic uremic syndrome[c]	800–1,600	23–46	0.1–0.2	0.2–0.4
Subtotal	N/A	63–126	0.16–0.3	0.3–0.7
Listeria monocytogenes[d]				
Listeriosis	928–1,767	230–485	0.12–0.26	1.2–2.3
Complications	22–41	0	0.03–0.05	0.1–0.2
Subtotal	N/A	230–485	0.1–0.3	1.3–2.4
Salmonella (non-typhoid)				
Salmonellosis	696,000–3,840,000	870–1,920	0.9–3.6	4.8–12.3
Staphylococcus aureus				
S. aureus intoxications	1,513,000	454	1.2	3.3
Parasite				
Toxoplasma gondii[e]				
Toxoplasmosis	260	40	0.04	0.1
Complications	1,560	0	3.28	7.7
Subtotal	N/A	40	3.3	7.8
Total	3,300,000–12,400,000	1,900–3,700	6.6–14.5	19.6–37.1

Notes: N/A = not applicable. Subtotals and totals may not add due to rounding; totals are rounded down to reflect the uncertainty of the estimates.

[a] The Landefeld and Seskin approach is basically a human capital approach, increased by a willingness-to-pay multiplier, and estimates the cost of a premature death, depending on age, to range from roughly $15,000 to $2,037,000 in 1996 dollars.

[b] This labor market approach values the cost of a premature death at $5 million.

[c] Hemolytic uremic syndrome (HUS) is characterized by kidney failure. HUS following foodborne *E. coli* O157:H7 infections causes 44–90 acute illness deaths and 33–62 chronic illness deaths.

[d] *Listeria monocytogenes* includes only hospitalized patients because of data limitations.

[e] *Toxoplasma gondii* includes only toxoplasmosis cases related to fetuses and newborn children who may become blind or mentally retarded. Some cases do not have noticeable acute illness at birth, but develop complications by age 17. Does not include all other cases of toxoplasmosis. Another high-risk group for this parasite is the immunocompromised, such as patients with AIDS or cancer.

and poultry (i.e., *Campylobacter jejuni, Clostridium perfringens, E. coli* O157:H7, *Listeria monocytogenes, Salmonella, Staphylococcus aureus,* and *Toxoplasma gondii*) (table 3). In 1996, there were an estimated 3.3 to 12.4 million U.S. cases of the foodborne illnesses from these seven pathogens, and up to 3,700 associated deaths. Using the Landefeld and Seskin human capital/WTP approach for the cost of a premature death, total annual costs for the seven foodborne illnesses and select secondary complications (in terms of medical costs and costs of lost productivity) in 1996 dollars ranged between $6.6 billion and $14.5 billion.

Using the $5 million estimate of the cost of a premature death from the labor market studies increases total annual costs to between $19.6 billion and $37.1 billion.

Both sets of estimates undervalue the true costs of foodborne illnesses to society, however, because the analyses cover only seven of the more than 40 different foodborne pathogens believed to cause human illnesses. Estimated costs would also increase if the costs for all secondary complications linked to foodborne illnesses were included. These estimates primarily include medical costs and lost productivity. Total costs would increase if we include other societal costs, such as pain and suffering, travel to medical care, and lost leisure time.

The wide range of costs is largely due to uncertainty about the true number of annual foodborne illness cases and associated deaths. Many people sick with diarrhea do not visit a doctor, and even if they do, most will not have a stool culture taken—let alone have the specific test necessary to identify the pathogen that caused the illness. The lab test may not find the pathogens. Even if a particular pathogen is implicated, not all culture-confirmed foodborne illnesses are reported to the CDC, and these illnesses may not be traced back to a particular food source. Therefore, most foodborne illnesses go unrecorded. Better data could help narrow the ranges of cases and deaths, and could provide information to calculate the costs of other foodborne pathogens. Knowledge on the extent and severity of these illnesses is still growing, and estimates need to be updated as better data become available.

Conclusion

This paper has presented examples of how different techniques can be used to evaluate the costs of foodborne illness and the benefits to society of increasing the safety of the food supply. To many economists, contingent valuation or experimental economics are preferred to cost-of-illness studies, since they are (theoretically) grounded in individual preferences and measure changes in well-being directly. However, cost-of-illness methods have some appeal because they present economic costs in a straightforward manner easily understood by decision makers, and they represent real costs to society (as opposed to hypothetical costs ginned up from synthetic markets. Both expenditure-based and preference-based valuation techniques can play a role in cost/benefit analyses to better allocate limited government resources.

In some cases, the choice of valuation methodology is irrelevant if benefits (or costs) dominate the cost/benefit calculus. In their study of the benefits of the new HACCP pathogen reduction rule, Crutchfield et al. used a sensitivity analysis which calculated the benefits of HACCP using the cost-of-illness approach. They found the benefits of pathogen reduction associated with this rule to be between $1.9 to $171.8 billion over 25 years, depending upon the choice of valuation for premature death (Landefeld and Seskin versus Viscusi) and upon the effectiveness of HACCP (the degree to which the new rule would reduce pathogen levels, illness, and death). The costs of HACCP were put at $1.1–$1.3 billion over 25 years. Not all public policy choices are as clear cut as this, of course. There may be some situations where the benefit/cost calculation will be sensitive to the valuation methodology, and where choice of one tool over another may yield a different conclusion as to the desirability of some public policy affecting food safety.

Economics has much to contribute to understanding food safety issues because of the nonmarket nature of food safety, the wide array of available analytic tools currently being used by economists, and the need for participation by economists in multidisciplinary and interagency food safety research. Economic analyses can reduce the misallocation of societal resources by identifying data gaps, prioritizing food safety problems, and estimating the marginal costs and benefits of alternative public and private control strategies. Economic analyses also can identify the distributional impacts of foodborne illness and control measures. The cost/benefit requirement ensures that economics is incorporated into political decision making and, in turn, provides a strong demand for economic research.

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