AN EXPERIMENTAL APPROACH TO ESTIMATING WILLINGESS-TO-PAY FOR IMPROVEMENTS IN FOOD SAFETY

(Campylobacter in chicken products)

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Abstract: This paper presents the results obtained from two experimental auctions regarding consumer willingness-to-pay (WTP) for food safety improvements. The research found a positive WTP for food safety. However WTP amounts are different when participants bid with objective risk information as compared with the naïve (bid without this risk information. There appears to be no significant difference in WTP regarding different magnitudes of risk reduction.

Key words: Food safety WTP, experimental auction, Campylobacter in chicken products.

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Introduction

Valuing food safety risk is necessary as it facilitates measuring the benefits of risk reduction programs. Given the scarcity of resources, society can benefit from seeking an optimal approach to the reduction of health risk (or in this case food safety risk). Measuring benefits and costs of these programs will aid the decision of which alternative to use. Valuing food safety risk can also provide valuable inputs into the decisions made by individual firms over which food safety management program or technologies to use.

There are different methods to measure reduction in health risk. Kuchler and Golan (1999) have summarised these methods into five categories: cost-of-illness, willingness-to-pay, cost-effective analysis, risk-risk analysis, and heath-heath analysis. Of these five approaches, the first two are termed monetary methods as they assign a dollar value to human life and health.

The cost-of-illness (COI) approach computes the cost of food-borne risk by adding medical costs and productivity loss in terms of earning forgone due to food-borne illness. The value estimated using this approach is considered a partial measure of society's opportunity cost as it has no provision for monetizing pain and suffering or in other words it does not count for the severity of illness (Buzby, Crutchfield). COI is also influenced by many other factors such as the distribution of income, technologies used in medical treatments and health insurance policies.

The willingness-to-pay (WTP) approach measures the resources individuals are willing and able to give up for a reduction in risk. WTP has a good theoretical foundation. It reflects individual preferences for risk reduction. However, the value estimated is sensitive to the characteristics of the study population, the level of risk and type of risk (Kuchler and Golan, 1999). The methods for empirical estimation of WTP measures include:

- Compensating-wage (or reveal preference) method,
- CVM (CVM survey, experimental auction, conjoint analysis),
- Household health production function method,
- Hedonic price method.

Table 1 provides a brief summary of the approaches used for valuing health risk. The main advantages and disadvantages of each approach are also discussed.

In this paper, we use a CVM method to estimate consumer WTP for food safety improvement. The case of Campylobacter in chicken products is chosen as this type of bacteria is one of the major pathogens of concern in New Zealand (McBride and Ball, 2004). The number of Campylobacter infected cases in New Zealand in 1998 was the highest infection type reported with 11503 cases which is more than 5 times

as much as the number of Salmonellosis – the second most common infection reported (Ministry of Health, 2004). Chicken is believed to be the primary source of Campylobacter (others are raw milk and non-chlorinated water). Moreover, research has shown that about 80% of retailed chicken has Campylobacter on it (Center for Diseases Control, 2004). Two experimental auctions are conducted to elicit WTP to pay for a reduction in the Campylobacter level of retailed chicken products in New Zealand (sandwiches are used). More details on the design of the experiments will be discussed in Part III of the paper. The next section provides a brief review of the recent research on consumer WTP for food safety.

Literature Review

The CVM values risk reduction by asking individuals directly about their WTP (or WTA) based on a hypothetical scenario. The method has been increasingly used in valuing food safety risk. Studies ranged from valuing a particular risk to valuing a quality or nutrition attribute (see for example Caswell, 1995). In valuing food safety risk, it is argued that the nature of the risk is also as important as the design of the survey in determining the reliable outcomes of a CV study (Kuchler and Golan, 1999). Studies on mild risk may have a better chance of being understandable then severe and rare risk. Studies of a particular risk cannot be generalised to other risk or food safety risk in general. Due to this reason, studies using CVM to value food safety risk have not played a formal role in benefit-cost analysis of new regulations (Caswell, 1998). In recent years, beside the traditional survey method, a number of studies have used the experimental auction method to estimate WTP for reduction in food safety risk (see for example Shogren et al, 2000). This section briefly reviews the studies using these two methods to value risk reduction.

Studies using CV survey outweigh studies using other methods in measuring food safety risk. For a list of examples of food safety valuation studies see Stenger (2000). CVM survey research emphasized the design of the questionnaire, especially the WTP question so that survey participants can fully understand the hypothetical scenario. Other information of interest includes consumption behaviour, risk experience and perception, and demographic information. For WTP questions, the most important features are the framing of risk information (e.g. relative risk vs. absolute risk) and the magnitudes of risk reduction (e.g. 50% reduction vs. 99% reduction) (see for example Lin and Milon, 1995; Buzby et al, 1995).

Recent studies also suggested the use of multi-version questionnaire so that different elicitation methods (e.g. payment card vs. dichotomous choice) can be used and the sensitivity of WTP to magnitudes of risk change can be tested (Busby et al, 1995).

It was often found that WTP for food safety are positive (Lin and Milon, 1995; Buzby et al, 1995; Henson, 1996; and Stenger, 2000). For example, Lin and Milon (1995) found that WTP for risk reduction in oyster is around 12.5% of the original value. Busby's et al (1995) estimate of WTP for risk reduction associated with pesticide residues in grape fruit ranges from 30% to 140% of the original value.

Table 1. Methods used for valuing health risk

Approaches	Definition	Pros	Cons
Monetary methods			
COI	Value of risk reduction measured by medical costs and wage forgone	Data is straight forward	- No provision for the discomfort suffered by individuals and the effort spent to avoid risk - Lower bound estimate
WTP	Risk reduction is measured by the amount individuals are willing to give up	Theoretical foundation in welfare economics	- Sensitive to population characteristics, types of risk, level of risk
- Compensating wage	Using labour market data on wage differentials for jobs with health risk	Decisions made in market place provide information on wage- risk tradeoffs	- Estimates are based on a restricted population (eg blue-collar males) which could be biased when applied to other groups such as elderly and children
- CVM	Using surveys to ask individuals about their WTP contingent on a hypothetical market/scenario	Hypothetical scenario can be built for any market (risk) of interest	- May be subjected to various biases due to individuals' understanding of the scenarios, risk perceptions and strategic behaviours
- Household health production function method	Using a model in which health is an endogenous variable. Maximising a utility function which include health as a fundamental commodity subject to income-time budget constraint makes it possible to solve for WTP	The model can include health in different roles (commodity, capital, expenditures) then considers relationship between these health variables with COI and WTP for risk reduction	- Difficult to identify all factors that contribute to the production of good health. - Also, quantifying these factors is also difficult as many of them are intangible.
- Hedonic price	Modelling a price of a good based on its characteristics or attributes. The inclusion of health-related attributes allows for estimating WTP for these attributes.	Based on observed behaviours	- Often underestimate WTP as it does not take into account risk facing individuals or the monetary value of the attribute

Table 1. Cont.

Approaches	Definition	Pros	Cons
Non-monetary methods			
Cost-effective analysis	This method counts the number of adverse health outcomes avoided and calculates the cost per adverse outcomes ratio. The lowest ratio implies the most cost-effective option.	May serve as a coarse filter in screening out options for which complex analyses are not worthwhile.	- No theoretical appeal - Not an individual welfare measure - Does not fully account for costs avoided by the program
Risk-risk analysis	This method counts the number of adverse health outcomes avoided and compares with the number caused by program activities. In other words, both desirable and undesirable outcomes are measured in physical terms.	Useful in cases of all-or-nothing decisions. In other words, when there is just one option and decision maker has to decide to take it or to accept the status quo.	- Does not take into account resource scarcity - Requires benefits and costs in physical units
Health-health analysis	Similar to risk-risk analysis but calculates adverse health outcomes caused by programs as a results of transferring income from individuals to government	As income and mortality rate vary inversely policies could be guided toward programs that save poorer lives (opposite to COI and WTP which maybe guided toward saving more affluent lives)	- Need understanding of the relationship between income and morbidity

Sources: Kuchler and Golan (1999)
Buzby (1998)
Arrow et al (1993)
Cropper (1995)

Experimental auctions are relatively new in valuation studies. However, the method has become more popular in WTP research in recent years (see Fox et al, 1995; Dickinson et al, 2003; and Brown et al, 2003). Experimental auctions use the laboratory to sell real goods to real people within a stylised setting (Shogren, 2000). It overcomes some of the shortcomings of the CV survey method by placing the good in something akin to a market situation where money actually changes hands (Buzby et al, 1998).

Fox et al (1995) summarised four main advantages of experimental auctions:

1. It truthfully reveals preferences. Given that the method uses Vickery second-price sealed-bid auction mechanism, where the good is sold to the highest bidder at the second highest price, it induces the participants to reveal their actual valuation.
2. As the method uses real food, real money, and repeated market participation, participants receive full information on the products. Replication allows participants to learn from the auction process and thus helps to generate demand revealing behaviours.
3. There is a requirement to eat the food which also reinforces the truth revealing property.
4. There is no nonresponse bias.

Despite these advantages, there are sceptics about the reliability of WTP results produced by experimental auction method. According to Kuchler and Golan (1999), the experimental market is still artificial and contrived, where participants bid with money given to them. Buzby et al (1998) also agreed that there is a great deal more to learn. Nevertheless, the method is considered promising in valuation study (Fox et al, 1995). Further research can help to improve the method by relaxing some of the constraints such as the lack of substitution opportunities and the controllability over food preparation. Moreover, experimental auctions can be used independently or combined with other CV techniques. It could be used as a pre-test stage for a CV survey or combined in a hybrid procedure named CVM-X (Fox et al).

Fox et al (1995) detailed the design of the experiments in which several pathogenic risk reductions are valued. These include Campylobacter, Salmonella, Staphylococus aureus, Trichinella spiralis, and Clostridium perfringens. Their experiments served 4 objectives: (1) To elicit subjective risk probability and WTP based on this risk perception (naïve WTP); (2) To elicit WTP based on objective risk information (informed WTP); (3) To elicit WTP for different risk reduction magnitudes (only for Salmonella); and (4) To test for surrogate bidding (i.e. whether WTP for each pathogen are different from WTP for a combination of all pathogens). It was found that the naïve WTP is significantly different from the informed WTP for most pathogens (except Trichinella spiralis). However results are in favour of surrogate bidding, which means that consumers may respond to the presence of pathogens in food rather than to the levels of individual pathogens. The study found a mean of WTP ranging from 15% to 30% of original price for all pathogens, with WTP for risk reduction in Campylobacter is around 30%.

Experiment Design

The experiments used in this research follow the procedures described in Fox et al (1995). An experiment auction uses an artificial market situation to elicit WTP. The idea is to provide two types of product: one with typical food safety risk (i.e. food bought from a local shop), and one is stringently screened for food safety hazards. Participants are then asked to give their bids for the later product. In our experiments, chicken sandwiches were used. Bids are required in terms of the extra money people are willing to pay for the safety improved product. The auction is Vickery seal-bid and second-price type. Participants do not reveal their bids to others and at the end of each trial the ID of the highest bidder and second highest price bid are revealed. These characteristics are argued to induce the truthful values of WTP (Fox et al, 1995). Also, the trial is repeated, often around 10 to 20 times. This will help participants to be familiar with the process and provide some time for the bids to stabilize. At the end of the auction, a trial is randomly chosen and the highest bidder of that round is the winner who will pay the second highest bid of the round to exchange for the safety improved product. All participants are required to eat their sandwiches before leaving.

Two experiments were conducted in December 2004 at the University of Waikato Management School (NZ). Information about the experiments was sent out to all staff and students of the school with requests for voluntary participants. The first experiment was designed to elicit participant WTP for a 99% reduction in Campylobacter level. The second experiment dealt with a 50% reduction. The experiment procedure was explained carefully to participants before the auction begin. Participants were also required to fill in a form about their demographic characteristics.

In order to examine the difference between naïve bids (bid with participant subjective risk perception) and informed bids (bid with objective risk information), Campylobacter risk information was introduced after round 10 of the experiment. Then the bidding process continued until round 20. As bids tend to stabilize after round 6 (Fox et al, 1995), the mean of bids from round 7 to round 10 and from round 17 to round 20 is taken as a representative for mean WTP. Experiment results are reported in the next section.

Results

Table 2. Subjective vs. Objective Risk, Naïve vs. Informed WTP

Experiment	Annual prob. Of illness		Informed & Naïve Bids	Difference	Mean Tests: Ho: $R_{17-20} = R_{7-10}$ H1: $R_{17-20} \neq R_{7-10}$	
	Objective	Subjective	Mean	Mean	t-test	Wilcoxon
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exp. 1	1/294	1/414	$R_{17-20} = 1.00$ (0.51) $R_{7-10} = 0.53$ (0.30)	0.47 (0.50)	7.28***	6.16***
Exp. 2	1/294	1/64	$R_{17-20} = 1.69$ (1.11) $R_{7-10} = 1.51$ (1.15)	0.18 (1.10)	1.27	2.31**

Note: Standard deviation in bracket; ** and *** denote significance at 95% and 99%

Table 3. Test for mean difference between 2 experiments (99% vs. 50% risk reduction)
Ho: $(R_{17-20})^1 = (R_{17-20})^2$; H1: $(R_{17-20})^1 \neq (R_{17-20})^2$

Exp. 1	Exp. 2	Difference	t-test	Wilcoxon
Mean WTP	Mean WTP			
$R_{17-20} = 1.00$ (0.51)	$R_{17-20} = 1.69$ (1.11)	0.69 (1.22)	0.83	0.87

Note: Standard deviation in bracket

Table 4. Participant Demographic Statistics

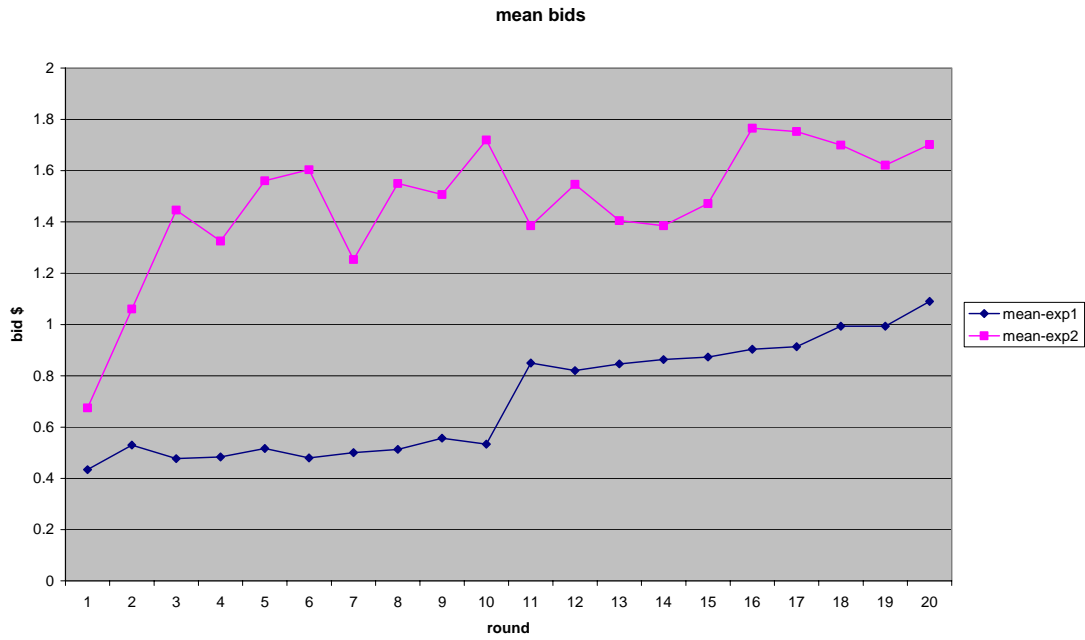|	Experiment 1	Experiment 2
Age (Mean)	42 yrs	48 yrs
Gender	53% male; 47% female	43% male; 57% female
Ethnic Group	60% European; 7% Maori & Pacific Islanders; 33% Asian	64% European; 7% Maori & Pacific Islanders; 29% Asian
Education	7% Secondary; 20% Tertiary; 73% Postgraduate	14% Secondary; 14% Tertiary; 72% Postgraduate
Annual Income (Mean)	$36,000	$35,000
Foodborne Illness	67% Yes (20% Chicken); 33% No	57% Yes (13% Chicken); 43% No
Subjective Risk	1/414	1/64

Figure 1. Mean bids (Experiment 1 and 2)

mean bids

Figure 2. Experiment 1 - Bid Details

experiment 1 - 99% risk reduction
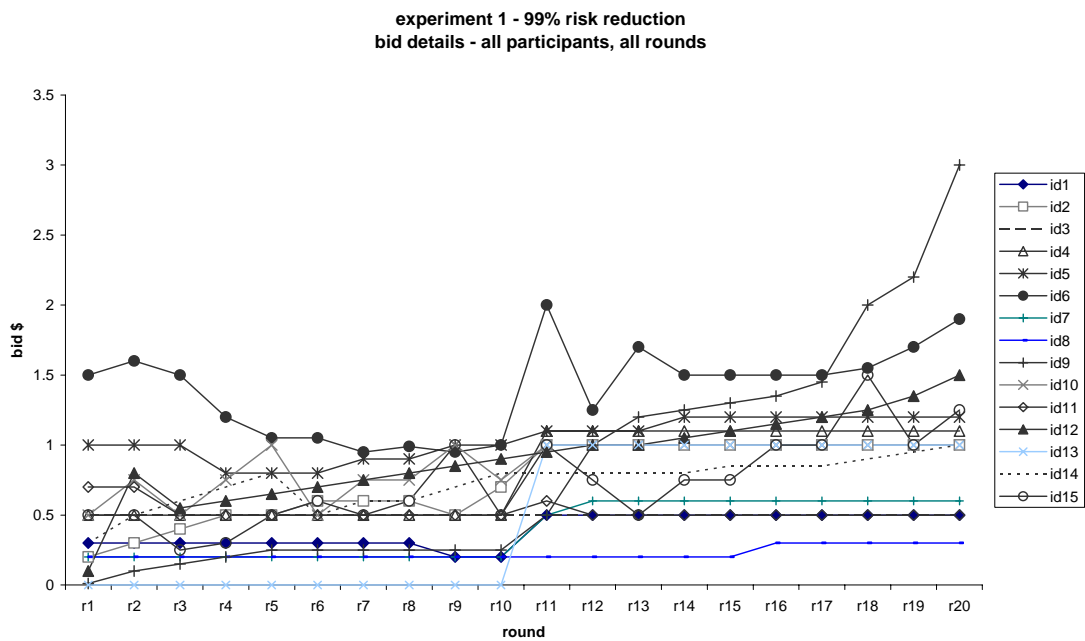**bid details - all participants, all rounds**
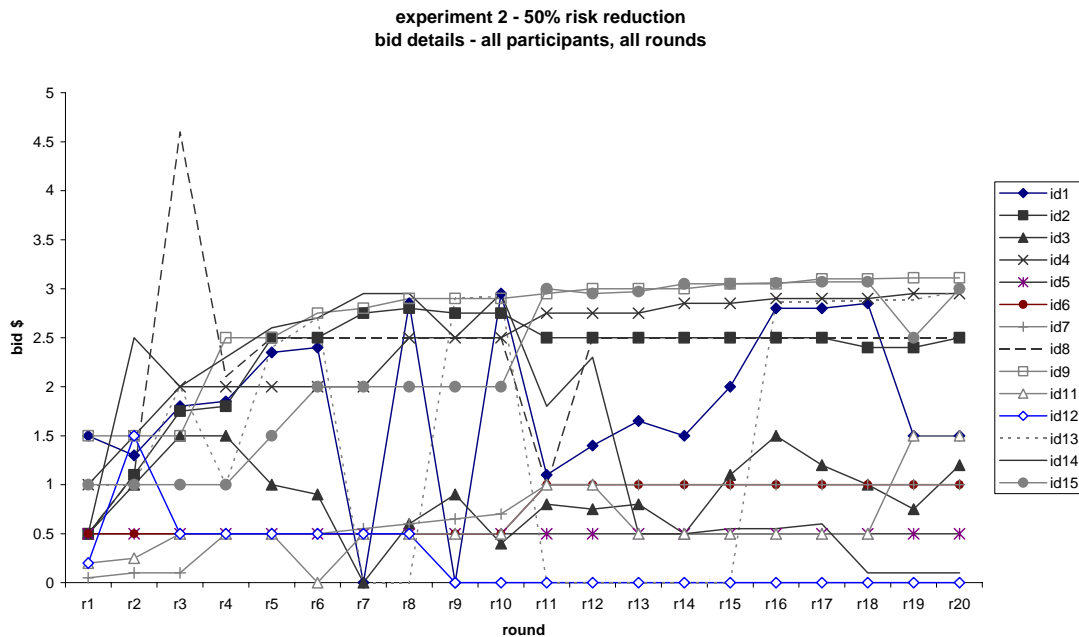
Figure 3. Experiment 2 – Bid Details

Table 2 reports the experiment results on the means of naïve bids and informed bids. For experiment 1, the mean of naïve bids (R_{7-10}) is \$0.53 and of informed bid (R_{17-20}) is \$1. The t-test and Wilcoxon test for mean difference show a significant difference between the naïve bid and the informed one. This difference clearly reflects the feature that participants in general underestimate the risk of Campylobacter in chicken (subjective risk of 1/414 vs. objective risk of 1/294). Results of experiment 2 however are different. Results show that participants in experiment 2 in general overestimate the risk. However the mean of informed bids is slightly higher than the mean of naïve bids. Nevertheless, the t-test does not show any significant difference between the two means. Also, mean WTP of experiment 2 is somewhat higher than that of experiment 1 despite that the risk reduction level is higher with experiment 1 (99% vs. 50%). However both t-test and Wilcoxon test do not show any significant difference between mean WTP of the two experiments (See Table 3).

It is possible that the difference between the results of the two experiments can be traced back to participant demographic characteristics as shown in Table 4. In general, the mean age of experiment 2's participants is higher than that of experiment 1's (48 years vs. 42 years). Experiment 2 also has a higher proportion of female participants and a higher percentage of secondary school education. Details of bids are given in Figures 2 and 3.

Conclusion

Experiment results showed a positive WTP for food safety improvement. The results also suggested that there is a difference between naïve bid and informed bid. However the size of the difference is dependent on participant perception of risk as well as their understanding of the risk involved. Experiment 1 showed that when participants underestimate the risk their WTP increases once risk information is disclosed. Experiment 2 however seems to suggest that participant understanding of risk also play an important role in determining their WTP. Also, participant demographic characteristics could have strong influence on WTP. Future research should be able to examine the relationship between consumer demographic characteristics and WTP once there is sufficient data.

The findings of the experiments will be used to guide the design of a large scale survey on WTP to pay for food safety improvement of Campylobacter in chicken products. WTP for different risk reduction magnitudes (e.g. 50% vs. 99%) can be examined further by using a multi-version questionnaire (See Buzby et al, 1998).

Experimental auctions are helpful in that they use real goods and real money to elicit WTP. However due to the hypothetical setting, factors such as participant understanding of the auction procedure and risk information may have an influence on the results. Other factor such as the winning factor (when one wants to win the auction) could have influence as well. Given this situation, results found could be treated as the upper bound estimations of WTP.

References

Arrow, K., Solow, R., Portney, P. R., Leamer, E. E., Radner, R., and Schuman, H. (1993). *Report of the NOAA Panel on Contingent Valuation*. Available from NOAA website http://www.noaa.gov/

Brown, J., Cranfield, J., and Henson, S. (2003). *Misassessed risk in consumer valuation of food safety: an experimental approach*. Paper presented at the American AEA Anuual meeting, Montreal, Canada.

Buzby, J. C., Skees, J. R., and Ready, R. C. (1995). Using contingent valuation to value food safety: a case study of grapefruit and pesticide residues. In Caswell J. A. (ed) *Valuing Food Safety and Nutrition*, Food Marketing Policy Center, University of Connecticut, available from Regional Research Project NE-165 website http://www.umass.edu/ne165/about.html

Buzby, J. C., Fox, J. A., Ready, R. C., and Crutchfield, S. R. (1998). Measuring Consumer benefits of food safety risk reductions. *Journal of Agricultural and Applied Economics*, 30(1), pp. 69-82.

Caswell, J. A. (1995) (ed). *Valuing Food Safety and Nutrition*, Food Marketing Policy Center, University of Connecticut, available from Regional Research Project NE-165 website http://www.umass.edu/ne165/about.html

Caswell, J. A. (1998). Valuing the benefits and costs of improved food safety and nutrition. *The Australian Journal of Agricultural and Resource Economics*, 42(4), pp. 409-424.

Center for Diseases Control. (2004). Campylobacter Infections. Retrieved January 2004 from the CDC web site: http://www.cdc.gov/ncidod/dbmd/diseaseinfo/campylobacter_g.htm

Cropper, M. L. (1995). Valuing food safety: which approaches to use? In Caswell J. A. (ed) *Valuing Food Safety and Nutrition*, Food Marketing Policy Center, University of Connecticut, available from Regional Research Project NE-165 website http://www.umass.edu/ne165/about.html

Dickinson, D. L., Hobbs, J. E., and Bailey, D. V. (2003). *A comparison of US and Canadian Consumers' willingness to pay for red-meat trace*ability. Paper presented at the American AEA Anuual meeting, Montreal, Canada.

Fox, J. A., Shogren, J. F., Hayes, D. J., and Kliebenstein, J. B. (1995). Experimental auctions to measure willingness to pay for food safety. In Caswell J. A. (ed) *Valuing Food Safety and Nutrition*, Food Marketing Policy Center, University of Connecticut, available from Regional Research Project NE-165 website http://www.umass.edu/ne165/about.html

Hammitt, J. K., Graham, J. D. (1999). Willingness to pay for health protection: Inadequate sensitivity to probability? *Journal of Risk and Uncertainty*, 8, pp. 33-62.

Henson, S. (1996). Consumer willingness to pay for reductions in the risk of food poisoning in the UK. *Journal of Agricultural Economics*, 47(3), pp.403-420.

Kuchler, F., and Golan, E. (1999). *Assigning value to life: comparing methods for valuing health risks*. ERS/USDA report No. 784, available from ERS website http://www.ers.usda.gov/publications/Aer784/

Lin, J. C. -T. and Milon W. J. (1995). Contingent valuation of health risk reductions for shellfish products. In Caswell J. A. (ed) *Valuing Food Safety and Nutrition*, Food Marketing Policy Center, University of Connecticut, available from Regional Research Project NE-165 website http://www.umass.edu/ne165/about.html

Lipton, D. W., Wellman K., Sheifer I. C., and Weiher R. F. (1995). *Economic Valuation of Natural Resources: A Guidebook for Coastal Resources. Policymakers*. NOAA Coastal Ocean Program Decision Analysis Series No. 5 http://www.mdsg.umd.edu/Extension/valuation/handbook.htm

McBride, G. B. & Ball A. (2004). Human health risk profiles for sewage discharges. *Risk Analysis IV*.

Ministry of Health. (2004). Food-borne Illness. Retrieved January 2004 from the MOH web site: http://www.moh.govt.nz/foodborne.html

Shogren, J. F., Shin, S. Y., Hayes, D. J., and Kliebenstein, J. (1994). Resolving differences in willingness to pay and willingness to accept. *American Economic Review*, 84, pp. 255-270.

Shogren, J. F., Stamland, T., Cherry, T. L., and Crocker. T. D. (2000). *Valuing pathogenic risk: methods, skill, and rationality*. Paper presented at the conference on valuing health benefits from food safety, Sept 14-15, University of Maryland, USA.

Stenger, A. (2000). Experimental valuation of food safety: application to sewage sludge. *Food Policy*, 25, pp. 211-218.

Teisl, M. F., Roe, B., Boyle, K. J., Riggs, T. L., and Herrmann, M. J. (2001). *Understanding how respondents view food safety risks: implications to the design of willingness-to-pay experiments*. Available from the Association of Environmental and Resource Economists website, http://www.aere.org/meetings/0106workshop.html