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Swedish Consumers´Willingness-to-Pay for Food Safety

- a Contingent Valuation Study on Salmonella Risk

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Abstract

This paper examines the value to Swedish citizens of reducing the risk for salmonella bacteria in chicken filet. The contingent valuation (CV) study is based on the results of a postal questionnaire that was distributed to 2 000 randomly selected Swedish citizens aged 18-74. The valuation format used is a stated preference double bounded dichotomous choice.

We employ the non-parametric Turnbull Lower Bound method in combination with Monte Carlo simulations to obtain lower bound estimates of the mean and median values of expected willingness-to-pay (WTP) for reducing the risk for salmonellosis, as well as values of a statistical case (VSC) and a statistical life (VSL). We find a VSC of between SEK 121 045 (110 297–131 814) and SEK 182 966 (167 915–197 896) depending on the format used (values in parentheses constitute a 90 percent confidence interval). VSL values of SEK 13.3 million and 48.3 million are estimated using different formats, but neither estimation is statistically significant.

Since this is the first Swedish study on WTP for food safety, mean and median values of VSL and VSC cannot be directly compared with previous results, but the values obtained are in line with comparable Swedish studies on WTP for traffic safety as well as with international studies related to food safety.

We do not find any strong linkage between WTP and income, age or gender. Scale sensitivity seems to depend on which model is chosen, while household size, risk perception ability and perceived Quality Adjusted Life Years (QALY:s) lost seem to be strong predictors of WTP.

1 Introduction

Substantial societal resources are being spent annually to prevent the emergence and spread of zoonotic and other foodborne diseases. For example, to prevent the spread of salmonella, Swedish public authorities spend in the range of SEK 50 and 90 million each year (SJV 2007), which does not include more or less compulsory investments at the producer level. Naturally, these expenses can only be justified if they can be shown to provide greater benefits to society in relation to the costs than other, alternative, measures. However, benefits are generally harder to appreciate than costs, and thus far no reliable estimates of the value of food safety have been provided in Sweden. This article fills this patent void, using survey data to obtain monetary estimates of risk reductions related to salmonella in chicken filet.

The basic economic problem is as follows. Due to budget constraints, consumers cannot choose their consumption unrestrictedly, but have to make trade-offs between all goods and services they value. From a hedonic viewpoint, this fact also applies to attributes of goods, which should be equivalently balanced in order to yield the highest possible individual satisfaction.

Applying this principle to food, consumers have to make trade-offs between all the different attributes associated with food, including taste, appearance, quality, brand name, accessibility, price and food safety. By studying how these trade-offs are made, it is possible to value each attribute with regard to its rate of substitution with any of the other attributes. Generally, for convenience, the price is used as a common yardstick to value the other attributes (Antle, 1995).

If markets function normally, these valuations can be carried out directly by studying demand and supply patterns on an aggregated level. However, if markets for some reason fail to provide the optimum level of a good or an attribute, the researcher has to rely on alternative techniques in order to obtain relevant monetary values.

Food safety is an attribute with many features that makes it a candidate for market failure. Firstly, information about the level of safety is clearly asymmetric in nature, with producers generally having more knowledge than consumers. Further, food safety is often described as either an *experience attribute* or a *credence attribute*, which means that consumers cannot determine the risk before consumption (if at all) (Antle 1995). Thirdly, even if all information were symmetric and complete, a utility-maximizing choice would require that consumers be able to appreciate all the safety information provided and to translate it into a relevant probability of obtaining either of several potential different adverse health states. Empirical studies have indicated, however, that humans possess only a bounded rationality in this regard, implying that only limited parts of the information provided will actually be processed (Simon, 1990). All these factors suggest that a market solution will not be able to provide the optimum level of food safety in a society, so that market prices will no longer appropriately reflect consumer and societal preferences (Golan et al., 2005).

Thus, in order to obtain monetary estimates of food safety programs aimed at reducing food-related risks, one has two rely on alternative methods. Broadly, two potential methods exist: the *revealed preference* (RP) method in combination with benefits transfers and the *stated preference* (SP) method. In the RP method consumer decisions on existing markets are used to obtain estimations of WTP and its corollaries in risk valuation studies, VSC and VSL. The method has primarily been applied to labour markets, where wages for jobs with differing mortality risks have been used to calculate implicit values of risk reductions (Viscusi and Aldy, 2003). If calibrated appropriately, these values can then be applied to other markets using benefits transfering techniques. The SP method, on the other hand, relies on the generation of a hypothetical market for the good or attribute in question. The main benefit of the SP method is that it is completely customizable to fit the needs of the researcher. Empirically, however, it has been shown that this hypotheticality in and by itself may produce a bias to respond in discordance with one´s true preferences, either for strategic reasons or because the scenario is perceived to be unrealistic (Mitchell and Carson, 1989). In relation to valuations of risk reductions, a further problem that often emerges in SP studies is an inadequate sensibility to the risk reduction size (Hammitt and Graham, 1999).

In this study the SP method is used to provide estimates of expected WTP, (E(WTP)), VSC and VSL with according dispersion measures for a reduction of food risk. In section two we provide a summary of the data collection procedure, the survey format and response rates. The next section provides descriptive statistics concerning responses to the non-valuation questions, while section four presents the theory and methods used in the estimations. In section five, results from the actual valuations are presented, including bivariate estimations of E(WTP), VSC and VSL and various tests of dependence and sensitivity with regard to different subgroups of the sample. This analysis is carried out using non-parametric methodologies. In section six, a multivariate sensitivity analysis is provided based on parametric methods, in which the impact of different individual characteristics like income, health, age and gender are further assessed. The final section concludes and provides some policy implications.

2 Survey description

2.1 Data Collection

A first preliminary version of the questionnaire was tested on and assessed by three different local focus groups. Two of these groups consisted of colleagues at SLI and VTI[1] (15 persons in total), while a third group comprised about 15 agricultural students.

After modifications, a pilot version of the questionnaire was distributed by post to 202 randomly selected Swedish citizens, aged 18-74. The pilot included two different versions of the survey; one with valuation questions on both salmonella risk and car risk, and one in which the car risk was excluded. The motive for splitting the sample in this manner was to test whether or not adding more questions would have any severe effect on the response rate. One reminder was sent to non-responders four weeks after the first distribution, including a new copy of the questionnaire. All respondents were also offered a lottery ticket (value SEK 25[2]) if the questionnaire was returned and registered successfully.

After some adjustments the main survey was mailed to 1900 Swedish citizens in Dezember 2006, applying the same selection criteria used in the pilot. The survey was possible to complete in one of two ways. Apart from filling out a paper version included in the envelope and returning it by mail, all respondents were also given the opportunity to use an internet-based version, which was accessed by using the postal number in combination with a special code that was printed on the first page of all questionnaires. Details concerning reminders and lottery tickets in the main survey were identical to those employed in the pilot study.

[1] **SLI** – Swedish Institute for Food and Agricultural Economics; **VTI -** Swedish National Road and Transport Research Institute
[2] Exchange rate $1 = SEK 6.00, http://www.riksbank.se (2007-07-09)

2.2 The Questionnaire

The questionnaire employed in the main survey comprised five subsections.[3] The objective of the first section was manifold. Firstly a number of rather simple questions were provided with the main purpose of getting the respondents ”warmed-up” and ready for the rest of the questionnaire. A second objective was to gain information about the risk perception ability of each respondent. Questions with this purpose included an estimation of the percentage of Swedish citizens that is contaminated by food annually as well as a question where various causes of death (including food-related illness) were to be ranked according to their fatality rates. A final objective of the first section was to appreciate the levels of knowledge and experience of the respondents concerning handling of raw chicken meat.

In the second part of the survey, a training session was provided. The respondents were given a scenario where they had to choose from two types of eggs that differed in their probabilities of causing salmonellosis as well as in the retail prices they commanded. The price of the less safe eggs was lower, implying that there was no clear dominating choice. Accordingly, answers to the training part could not be utilized to exclude respondents that selected a dominated choice, which has been used as an exclusion criterion in some other studies (Krupnick et al., 2002; Alberini et al., 2004). Instead, a respondent was excluded if the general survey comprehension could be disputed, a decision that was made based on two different prerequisites: (i) if the respondent had stated a better health status after getting salmonellosis than before, or (ii) if a respondent had given inconsistent answers to the double-bounded dichotomous choice WTP question (see below paragraphs).

After having chosen between the two egg brands, the respondents were given a feedback, in which their choice was analyzed from a safety-vs-price perspective. A visual aid consisting of 10 000 white squares, in which the different risks were visualised as black squares, was also provided to aid risk communication.[4]

The main valuation questions were introduced in the third subsection of the questionnaire. As an introduction, some basic facts about salmonellosis and

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[3] Since, in the pilot, the response rate was higher in the sample where car safety was included, we decided to keep this part in the main version of the survey.

[4] As indicated in Corso et al (1999), using such visual aids can greatly enhance the communication of risk levels, leading to a higher senistivity to the scope of the good to be valued.

how common it is is were presented. Three different possible states of the illness were described: *mild*, *moderate* and *severe*. These states were described to differ regarding the severity of the symptoms related to them, the number of days they were expected to last and if those infected would need to consult a GP or even to be hospitalized. The different characteristics included in this discussion are summarized in Table 1 below.

Respondents were then asked to quantify the severity of these different states of salmonellosis. The visual analog scale (VAS) used for this quantification ranged from 0 and 100, where 0 corresponded in severity to being dead while 100 would indicate a perfect health. As a reference, the respondents were also asked to value their own current health status on the same scale.

Table 1: The three different variants of salmonellosis and their respective probabilities, symptoms and duration

Variant (% of cases)	Symptoms	Duration	Consultation of GP/ hospitalization
Mild (75 %)	vomiting, diarrhoea, nausea and cramps.	2-3 days	no consultation
Moderate (23 %)	as mild, but more vomitting and cramps per day	3-7 days	consultation of GP but no hospitalization
Severe (2 %)	as moderate but also fever, headache and muscle pains.	15-20 days or more	consultation of GP and hospitalization

As a next step the main valuation scenario was introduced. Two different brands of chicken filet were described – a *normal risk* variant and a *low risk* alternative. The low risk chicken filet was described as being produced using a specific food safety program entitling it to bear a uniquely identifiable label.

The different combinations of morbidity and fatality risks related to the two brands were randomly distributed among the sampled population. In Table 2, the first column indicates baseline morbidity risks (ie risks of getting salmonellosis after consuming the normal risk variant of chicken filet) as well as final morbidity risks (corresponding risks for the low risk variant). Thus, the risk reduction of buying the low risk variant rather than the normal risk one can be calculated by subtracting the two numbers of each cell in this column: 2 in 10 000, 3 in 10 000, 1 in 10 000 and 2 in 10 000, respectively.

The baseline risks of fatal outcomes following consumption were also distributed randomly across the sample. Three different risks were used: 0 in 100 million, 6 in 100 million and 12 in 100 million. The final mortality risk, ie the mortality risk of consuming the low risk chicken, was determined by the morbidity risk reduction indicated in the first column. Thus, given a baseline mortality risk of 6 in 100 million and baseline and final morbidity risks of 4 and 1 in 10 000, respectively, the final mortality risk can be calculated as $6 \times (1/4) = 1.5$ in 100 million. Thus the mortality risk reduction in this case amounts to 6 – 1.5 = 4.5 in 100 million. Both the final mortality risk and the associated risk reduction (in parentheses) are presented in the body of Table 2. Thus, in all, 12 different goods (combinations of mortality and morbidity risk reductions) were used in the sample.

Table 2: The 12 different combinations of morbidity and mortality risk reductions used in the survey

	baseline mortality risk		
morbidity risk reductions	**0 in 100 million**	**6 in 100 million**	**12 in 100 million**
4→2 in 10 000 (2 in 10 000)	**0→ 0 in 100 million** (0 in 100 million)	**6→3 in 100 million** (3 in 100 million)	**12→6 in 100 million** (6 in 100 million)
4→1 in 10 000 (3 in 10 000)	**0→ 0 in 100 million** (0 in 100 million)	**6→1.5 in 100 million** (4.5 in 100 million)	**12→3 in 100 million** (9 in 100 million)
3→2 in 10 000 (1 in 10 000)	**0→ 0 in 100 million** (0 in 100 million)	**6→4 in 100 million** (2 in 100 million)	**12→8 in 100 million** (4 in 100 million)
3→1 in 10 000 (2 in 10 000)	**0→ 0 in 100 million** (0 in 100 million)	**6→2 in 100 million** (4 in 100 million)	**12→4 in 100 million** (8 in 100 million)

Each respondent was only asked to value one of these combination of risks. Apart from being presented as text in a matrix, the initial and final morbidity risks were also visualized graphically in terms of a grid with $100 \times 100 = 10000$ white squares, similar to the one that was used in section 2 described above.

After having been presented with the relevant combination of risks, each respondent was asked if he or she would be willing to pay a certain specified extra premium in order to get the low risk chicken filet rather than the normal risk variant. Respondents were randomly assigned one of five such initial premium (or bid) levels: SEK 2, 10, 20, 40 or 60.[5] Depending on the response to this question, the bid was then lowered (in case the respondent answered no to the initial bid) or increased (if the first answer was negative), and the

[5] The bid range was increased in the main survey as a consequence of the responses in the pilot.

respondent was then asked if he or she would be willing to pay this new bid (or premium) in order to get the low risk chicken. This elicitation method, the double-bounded dichotomous choice method, thus implies that each respondent had to select one out of four different answering schemes: yes-yes (yes to initial bid and yes to increased bid), yes-no, no-yes and no-no.

In case of a yes-yes reply, the questionnaire also included an open follow-up question asking about the maximum premium that would still induce the respondent to buy the low risk variant of the chicken. Similarly, in case of a no-no answer, the respondent was asked to state the minimum premium at which he or she would still prefer the normal risk chicken. These open follow-ups were included mainly in order to be able to distinguish pure zero responses (i e people who were not willing to pay any extra premium for the safer chicken) from those willing to pay a low but non-zero premium.

Finally, those having stated a zero WTP[6], were given a follow-up question in which they were provided with an opportunity to elaborate on their response. This question was posed as an open question and was included in order to enable the exclusion from subsequent analyses of all revealed protesters, i e people having stated a zero WTP for reasons other than a genuine indifference between the two goods.

The fourth part of the survey included a similar valuation question as in part three, but with mortality risk reductions from car safety devices rather than from food safety. The data from this part will not be included in this study.[7] The final subsection of the survey included a few socio-economic questions related to the respondent´s gender, age, family situation, education and income.

2.3 Response Rates

In Table 3 the response rates from the pilot and the main survey are presented. All in all a response rate of nearly 50 percent was obtained in both the pilot and the main versions of the survey. Almost 10 percent of all returned questionnaires were blank. Since only three of those respondents who returned blank surveys made any comments, it is difficult to draw any

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[6] To qualify for this question, a respondent must thus have given a no-no response to the ordinary valuation questions in combination with a premium of zero in the follow-up question asking for the minimum premium at which the normal risk chicken would be preferred.

[7] In Andersson et al (2008), this data is used to study time framing issues in contingent valuation studies.

conclusions about underlying reasons for this non-negligable rate, although the promise to send respondents a lottery ticket might have provided one incentive.

As discussed above, the option to respond via an internet-based survey was offered to all respondents of the main survey. Only 46 chose to utilize this option, however, equivalent to only about 3 percent of the entire main version sample.

Table 3: Response rates from the pilot and the main survey

Qustionnaire version	Sent out questionnaires	Returned questionnaires *	Response rates (%) **
Pilot	202	97(8)	48.0 (44.1)
Main	1898	920*** (40)	48.5 (46.4)
Total	2100	1017 (48)	48.4 (46.1)

** Numbers in brackets are returned empty questionnaires*
*** Numbers in brackets are response rates excluding empty questionnaires*
**** 863 questionnaires were returned by post and 46 by the Internet*

3 Descriptive statistics

3.1 Statistics for the different survey formats

In the formal data analysis, only respondents to the main survey are included in order to minimize risks of survey heterogeneity.[8] In this subsection, however, we briefly summarize and compare some of the key characteristics of all the three questionnaire formats: pilot study, main postal survey and main web survey.

Most of the statistics in Table 4 come very close to the corresponding objective data for the general population. The most obvious deviation regards gender, with almost 60 percent of respondents (all survey types) being female as compared to about 50 percent in the general population. In the web based survey, however, men dominate markedly, probably highlighting the fact that men use the internet more frequently than women.[9] Also, respondents to the web based survey have larger incomes in general, which can be explained by the high proportion of men as well as the fact that internet users tend to have

[8] Not including respondents from the survey only had minor qualitative effects on the results.
[9] According to the World Internet Institute (WII) men spend 33 percent more time on the Internet than women in Sweden (2005), web address: http://www.wii.se (2008-07-10).

a higher education than non-users or less frequent users.[10] The number of household members in the population is not immediately comparable to the survey data, partly because the population data is not up-to-date (1990) and partly because it includes the entire population, while the sample only comprises ages 18-74.

Table 4: Descriptive Statistics for the three survey formats

	all survey types	main	web based	pilot	population
gender (0=male, 1=female)	0.58	0.59	0.38	0.64	0.50
age	47	47	41	47	44.7
income *	25 659	24 982	30 255	-	22 639
highest education					
elementary school	0.19	0.20	0.14	0.16	0.17
secondary school	0.43	0.44	0.36	0.37	0.48
university	0.37	0.35	0.49	0.47	0.35
household members	2.8	2.8	2.7	2.6	2.1*
marital status					
married	0.56	0.57	0.53	0.53	0.35
single	0.19	0.19	0.27	0.20	0.2
cohabitee/ other	0.25	0.25	0.20	0.27	0.45

** Based on the latest population sensus (FoB 90) where this information was included (1990). The number includes the entire population (see text).*

Finally, income per consumption unit is somewhat higher than the population mean, which could possibly be explained by the exclusion of respondents outside the interval 18-74 years. Particularly households with respondents older than 74 years in general have lower incomes than average households.

3.2 Statistics for the main survey

Excluding responses from the pilot study and the web based survey, Table 5 tabulates descriptive statistics for some of the more material questions of the main survey.

[10] Pearson´s correlation coefficient for the relation between education and internet access is 0,32 according to the World Internet Institute web address: http://www.wii.se (2008-07-10).

Table 5: Main survey responses to some of the questions

Question	male	female	all
Q2: If we randomly select a group of 100 Swedish citizens, how many of these do you think will suffer from food contamination during one year?	13	18	16
Q3: How common do you think death due to food contamination is compared to other causes of death in Sweden?			
- Correct ranking of all death causes	0.25	0.23	0.24
- Correct ranking of food contamination	0.56	0.52	0.58
Q19: State your own current health status (0-100)	89	89	89
Q19: Value different salmonellosis conditions (0-100) *			
Mild variant	72	71	71
Moderate variant	52	52	52
Severe variant	32	31	32
Q22: Was scenario realistic?			
yes	0.52	0.50	0.51
no	0.24	0.18	0.21
don't know	0.24	0.32	0.29
Q23: Was the training example helpful?			
yes	0.59	0.58	0.59
no	0.17	0.12	0.14
don't know	0.24	0.30	0.28

**) The original responses had to be recalculated, since respondents were asked to state how much their current health status would deteriorate by the respective states of salmonellosis.*

Female respondents in particular seem to overstate the risk for annual food-related IID (18 per 100 citizens), with the true frequency being in the range 8-11 cases per 100 citizens (SLV 1994; SoS 2001). This divergence might well be a consequence of the fact that people who believe in a larger risk are also more concerned about the issue and, as a consequence, more inclined to reply.

Question Q3 was included to determine risk perception abilities. About 25 percent of the respondents correctly ranked the risk of dying from five different causes[11] (including food contamination), while more than 50 percent accurately ranked food contamination as the least deadly of the diseases.

The mean VAS estimates of own current health status (Q19) are almost identical to results in several other studies (Koltowska-Häggström et al.,2007; Andersson, 2007; Brooks et al. 1991). Additionally, respondents were also asked to rank the three different variants of salmonellosis (mild, moderate and severe) on the VAS. These estimated values are somewhat more difficult to compare with other results, since the definitions of symptoms and illness

[11] These were cardio-vascular diseases, lung cancer, car accidents, AIDS/HIV and food contamination

duration may vary considerably between studies. In Mauskopf and French (1990), whose definitions of the illness states are similar to ours, mild, moderate and severe salmonellosis were estimated to 77, 60 and 31, respectively, on the VAS scale as compared to 72, 52 and 32 in this study.

Finally, a majority of the respondents also found the scenario to be realistic and the training example to be helpful, with no big divergence between male and female respondents.

3.3 Self-perceived knowledge of food safety

In one of the survey questions, respondents were asked to state their self-perceived knowledge about issues related to food safety. Typically, more respondents appreciated their own knowledge to be above average (33 percent) rather than below average (12 percent). Table 6 cross-tabulates the stated knowledge by the responses to some other related survey questions. Some interesting aspects may be noted here.

Firstly, those asserting an extensive knowledge of food safety scored higher in Q3 when ranking different death causes. This holds true both for the percentage ranking all causes correctly (28 percent compared to 18 percent for those having stated a lower than average knowledge) and for ranking food safety as a death cause correctly (57 percent vs 47 percent). Thus, self-perceived knowledge seems to be able to predict risk perception ability to some degree.

Appreciating one´s knowledge as extensive also seems to imply placing an appreciably higher value on food safety as compared to the price of food (see Q5) than the sample as a whole. This may seem somewhat counter-intuitive, considering the fact that respondents with a self-certified limited knowledge overstate the risk of foodborne IID (Q2) to a larger degree than others do, and thus should, *ceteris paribus*, place a higher value on food safety relative to the price (Q5). However, this seeming contradiction may be explained, at least partly, by the fact that those having stated a limited knowledge also have a smaller mean income per consumption unit, and should therefore value a low price relatively higher as compared to other food attributes than the other two groups do. It is also possible that some responses to Q2 act as declarations of general concern about the issue rather than any genuinely higher acquaintance in the topic, a hypothesis that could account for responses to both Q2 and Q5.

Respondents stating a higher degree of knowledge also estimate their own risk of contracting food-borne IID as lower than the rest of the sample (Q14). Assuming the degree of self-certified knowledge to be correct, this would be a natural conclusion, since many preventive measures to avoid food-borne illnesses are rather straightforward to implement (like hygiene) once you know about them.

Table 6: Tabulation of responses to some of the survey question by self-certified knowledge of food safety

Q4: Self-certified knowledge of food safety	**limited** (12 %)	**average** (55 %)	**extensive** (33 %)
Q2: (See previous table for a description)	18	15	16
Q3: (See previous table for a description)			
- Correct ranking of all death causes	0.18	0.22	0.28
- Correct ranking of food contamination	0.47	0.57	0.57
Q5: How important is food safety compared to the price when you go shopping? (scale 1-7: 1=food most important, 7=food safety most important)	4.6	5.4	6.0
Q14: Is your risk of getting IID from chicken smaller than the average risk?	0.22	0.24	0.38

3.4 Protesters

It is very common in contingent valuation studies to have a subgroup of respondents who do not reply to the valuation questions in a truthful manner. In other words, in these cases, the underlying preferences for the good to be valued will differ from the actual responses submitted in the survey. There are various reasons for providing such protest bids, including disagreement with the payment vehicle and the scenario, ethical concerns or a belief that the good should be provided by alternative means. Including protest respondents in the analysis may well introduce biases in the results, the direction of which cannot be appreciated in advance (Jorgensen, 1999; Mäler and Vincent, 2005).

In order to identify potential protest bidders, there was an open follow-up question in the survey for respondents who had explicitly stated a zero WTP for the safer chicken. The reasons provided as responses to this open question can be broadly classified into the four subgroups presented in Table 7: too small risks, unrealistic scenario, payment mechanism and other reasons. Subgroups 2 and 3 in the table indicate protest responses in accordance with the above specification, while responses in the two remaining groups *may* indicate sincere bidding responses. Conservatively, in the remaining bivariate analysis, we will therefore exclude respondents from subgroups 2 and 3 only.

Table 7: Motivations for providing zero responses

Subgroup	Motivation	Frequency (%)	Excluded
1	The risks are too small to motivate any price differences	15 (43 %)	no
2	The scenario is not realistic	12 (34 %)	yes
3	Chicken filet should be safe, and you should not have to pay any premium for having a safer food	4 (11 %)	yes
4	Other/none	4 (11 %)	no
	Total	35 (100%)	

Table 8: descriptive statistics for zero WTP respondents

Motivation	Zero WTP respondents	Entire sample (main survey)
Age	47	47
Gender (0=male, 1=female)	0.4	0.59
Income*	10 246	10 768
No of household members	2.7	2.8
Highest education:		
-elementary school	0.21	0.20
- secondary school	0.42	0.44
- university	0.36	0.35
Q2: Estimated frequency of foodborne IID annually	9.9	15.8
Q3: Correct ranking of death causes	0.26	0.24
Q3: Correct ranking of food related mortality	0.57	0.56
Q19: Own current health status	92	94
Q19: Valuation on VAS of salmonella mild variant	71	64
Q19: Valuation on VAS of salmonella moderate variant	54	46
Q19: Valuation on VAS of salmonella severe variant	35	29

** income per consumption unit (based on indices developed by Statistics Sweden)*

To eliminate a part of a sample in this way is not generally unproblematic, however, since those excluded may deviate substantially from the rest of the sample, in which case the resulting estimated WTP measures could be biased in either direction (Jorgensen, 1999). For this reason it is necessary to relate relevant aspects of the excluded respondents to those of the main sample. In Table 8 some key descriptive statistics for the excluded subsample are provided. Apart from gender and the estimated frequency of acquiring IID, most aspects appear to accord, indicating that the exclusion should not cause any major detrimental effects on the estimations.

4 Theory and methods

4.1 Economic theory and WTP for health risk reductions

The following economic model for valuing health risk reductions has been used to value food safety risk reductions in eg. Hayes et al. (1995). In the model, expected utility is represented by a von-Neumann-Morgenstern state-dependent utility function $U(W,H)$ with W and H denoting wealth and health state, respectively. The individual may be either healthy ($H=1$) or ill ($H=0$), and assuming that being healthy is always better than being ill and that $U'>0$ and $U''\leq 0$ regardless of health state, the utility function can be formalized as

$$E(U) = pU_S(W) + (1-p)U_H(W) \tag{1}$$

with $U_S(W) = U_H(W,0)$, $U_H(W) = U_H(W,1)$ and p denoting the baseline risk for food-related illness.

The marginal WTP for a risk reduction is now obtained by taking the total differential of (1) while holding expected utility constant, which yields (Jones-Lee, 1974):

$$\left.\frac{dW}{dp}\right|_{\overline{E(U)}} = \frac{U_H(W) - U_S(W)}{(1-p)U'_H(W) + pU'_S(W)} > 0 \tag{2}$$

where $U_H(W) - U_S(W)$ is the difference in utility between the healthy and the sick states, while $(1-p)U'_H(W) + pU'_S(W)$ defines expected marginal utility of income. Thus, equation (2) defines the marginal rate of substitution (MRS) between risk and wealth, and is the theoretical basis for calculating E(WTP), VSC and VSL for infinitely small risk reductions.

4.2 Elicitation methods

Stated preference techniques involve inquiring each respondent in a sample population about his or her maximum WTP to implement a proposed change that will increase welfare. The WTP values obtained by such an inquiry can be regarded as a random variable, C, whose distribution can be described by a cumulative distribution function F, defined generally by:

$$F(C) = \Pr(C \leq c) \tag{3}$$

where c is simply some value in the domain of the function F. By analyzing the data, a researcher can obtain an estimate of F, from which it is possible to calculate measures of central tendency like the mean and median.

Different elicitation formats now call for alternative ways of estimating F. Using open-ended elicitation questions, in which respondents are asked to directly reveal their true WTP for the proposed welfare increase, makes this estimation procedure exceptionally straightforward. An empirical estimation of the cdf is obtained by calculating, for each level of c, the proportion of the sample with a stated WTP higher or equal to c. In the limit, such an empirical distribution will become equal to the true distribution, F, which renders the open-ended method an attractive alternative from this perspective.

One problem is, however, that the open-ended method relies on respondents' abilities to accurately appreciate their WTP for goods that they may never have come across or even considered. Empirically, this has often proved an erroneous assumption. For this and other reasons, including an inclination for strategic responses (Whitehead, 2006), the open-ended question format has lost manifestly in popularity in recent years.

In its place, dichotomous choice questions have become the method of choice for many researchers. Instead of having to explicitly value the altered level of the non-market good, respondents are now asked to either accept or refuse to pay a specified money amount, the *bid level*. One advantage of such an approach is that it resembles to a greater extent the real market decisions made on a day-by-day basis by most people. However, the information gained from discrete choices does not directly reveal a repondent's WTP, but rather indicates an interval within which this value lies. Thus, in general, the dichotomous choice method becomes somewhat less efficient in terms of the number of respondents required to obtain a certain degree of statistical significance.

In effect, a dichotomous choice analysis commences with a specification of a number of different bid levels presumed to span the WTP range of the non-market good change. Formally, let M be the number of bid amounts, and denote each bid level B_m so that

$$0 = B_0 < B_1 < B_2 < ... < B_M < B_{M+1} = \infty \tag{4}$$

If only one acceptance/refusal question is asked at any bid level B_k, the researcher gets information that the respondent's WTP is either below that bid (in case of a refusal) or above/equal to it (in case of an acceptance). This is called the *single-bounded* approach in the literature (Hanemann et al, 1991).

Alternatively, the initial bid can be combined with a second follow-up bid, which is made contingent upon the response to the initial bid question. More specifically, the second bid is raised in case of an acceptance to the first bid, and decreased otherwise. Respondents are thus asked to accept or refuse two consecutive bid level amounts, resulting in a more confined range of potential WTP values for each respondent. Theoretically, this *double-bounded* approach gains in statistical efficiency in comparison to the single-bounded method due to the increased precision (Hanemann et al, 1991). However, there are indications that responses to the two valuation questions might not always emerge from the same distributions, in which case the different responses should not be combined in a single estimation procedure (Cameron and Quiggin, 1994).

4.3 Estimation procedures

Using either elicitation method, an estimate of F may be obtained by using either *parametric* or *non-parametric* techniques. The parametric approach implies hypothesizing which underlying distribution has generated the WTP-responses obtained in the survey. This rather common technique can be carried out either implicitly, by deriving WTP estimates from underlying assumptions on indirect utility (the utility difference approach) or explicitly by stating a distribution for F directly (expenditure difference approach, bid function approach) (Hanemann, 1984; Cameron, 1988). In most cases the two methods can be used interchangeably (Hanemann and Kanninen, 2001).

Characterizing the procedure using the utility difference approach, consider an individual who gets satisfaction from some non-market good q, and income y. His utility is given by the general indirect utility function $v(q, y, \varepsilon)$, where ε is a stochastic component not visible to the researcher observing the individual´s behaviour. This random component is supposed to incorporate unobservable characteristics of an individual as well as variation in preferences and measurement errors.

Now imagine the individual is facing a program that will change the level of the non-market good q from q_0 to q_1, its status quo level. Assuming additive separability of stochastic and non-stochastic components, the probability that he will be in favour of the change given by the program is given by:

$$\Pr("YES") = \Pr(v(q_0, y) + \varepsilon_0 \leq v(q_1, y - A) + \varepsilon_1) \quad (5)$$

where A corresponds to the bid level. Rearranging (5) yields:

$$\Pr("YES") = \Pr(\Delta v \geq \eta) \quad (6)$$

where $\Delta v = v(q_0, y) - v(q_1, y - A)$ and $\eta = (\varepsilon_0 - \varepsilon_1)$. It is common to assume that η follows either a Probit or a Logit distribution, although other distributions like Weibull, Gamma, Exponential and Log-log are also possible. Combined with an assumption regarding the functional form of the indirect utility function estimates of F can now be obtained by simple maximum likelihood techniques for either elicitation technique discussed above. In this paper, the parametric methodology is employed in the multivariate estimations where both bids and different socioeconomics are being used as independent variables.

Obviously, the propriety of using parametric assumptions to estimate F is contingent on whether this parametrization corresponds to the functional form of the true but unknown underlying data-generating distribution. It has been shown that the mean in particular can be relatively sensitive to variations in these parametric assumptions, especially when dealing with less well-behaved datasets (see Haab and McConnell, 2002). Therefore, when the main objective is to obtain statistics of central tendency and variation, it can be fruitful to utilize a least restrictive approach to estimating WTP and thus minimizing the risks for misspecification (Haab and McConnell, 2002)). Non-parametric estimation techniques, which are entirely empirically based, provide the analyst with precisely such a framework. This study will employ non-parametric maximum likelihood estimators introduced by eg. Ayer et. al (1955) and Turnbull (1976) as the primary basis for estimating mean WTP. This method will be discussed briefly below.

When using only the first round of yes/no responses (the single bounded approach) the estimation procedure is extremely straightforward. The full sample is first split into M different subsamples according to the range of bid levels presented to the respondents. The joint log-likelihood function can now be reduced to

$$\ln L = \sum_{m=1}^{M} \left[N_m \ln(F_m) + Y_m \ln(1 - F_m) \right] \tag{7}$$

where N_m and Y_m are the number of no and yes responses to bid level j. Maximizing this function with respect to F_m for all m yields a system of first order conditions

$$\frac{\partial \ln L(F)}{\partial F_m} = \frac{N_m}{F_m} - \frac{Y_m}{(1 - F_m)} = 0 \quad \textit{for} \;\; m = 1,.., M \tag{8}$$

Solving for F_m results in the first order conditions $F_m = N_m / T_m$ where T_m is the total number of respondents offered with bid level m. Thus, the maximum likelihood point estimates of F_m are intuitively obtained by calculating the fraction of no responses by the total number of responses at each bid level.

However, the above procedure does not guarantee that the proportion of no-responses increase monotonically with the bid level, a feature that we would expect from basic economic theory. Accordingly, we need to include in the maximization problem the condition ($F_m \leq F_{m+1} \; \forall m$), and then estimate the set of F_m's simultaneously. The Kuhn-Tucker solution to the maximization problem where non-monotonicity exists between two bid level amounts is obtained by

$$f_m^* = \frac{N_m + N_{m+1}}{N_m + N_{m+1} + Y_m + Y_{m+1}} \tag{9}$$

where f_m^* is the Turnbull PAVA estimator. PAVA is an acronym for *Pooled Adjacent Violators Algorithm*, and implies pooling, in accordance with the above formula, all consecutive bid levels that do not adhere to the monotonicity criterion.

When applying the double-bounded approach, in which two rounds of yes/no-responses are used, the estimation procedure becomes somewhat more complicated. Responses from the double bounded method indicate whether the WTP of a respondent belongs to one of four possible intervals: below the lowest bid amount (no/no response), above the highest bid amount (yes/yes response), between the lowest bid amount and the initial bid amount (yes/no response) or between the initial bid amount and the higher bid amount (yes/no response). The difference between this approach and the single-bounded approach is that any of the intervals for a particular bid level may overlap with one or more interval(s) for some other bid level(s). Since we need non-overlapping intervals in the estimation procedure, we have to partition each WTP-response into the different smaller intervals that it spans.

We denote, for each respondent i, the lower and higher bounds of each specific WTP interval by B_{L_i} and B_{H_i}, respectively. Also, define an interval j as $\lfloor B_{j-1}, B_j)$ and an indicator variable

$$d_{ij} = \begin{cases} 1 \;\; if \;\; B_{L_i} \le B_{j-1}, B_j \le B_{H_i} \\ 0 \;\; otherwise \end{cases} \tag{10}$$

The interval defined by j is called a *basic interval*, and does not necessarily correspond to a unique WTP interval. For example, a yes response to both bid amounts always results in the single WTP interval $\lfloor B_{H_i}, \infty \rfloor$ but may span several basic intervals depending on the bid design. The indicator variable d creates the necessary relation between a WTP interval and its corresponding basic interval(s).

From these specifications, the problem may be formalized by the following Non-Parametric Maximum Likelihood (NPML) function:

$$\begin{aligned} &\underset{F}{Max} \ln L = \sum_{i=1}^{N} \ln \left(\sum_{j=1}^{J} d_{ij} \left[F(B_j) - F(B_{j-1}) \right] \right) \\ &s.t. \;\; 0 = F_0 \le F_1 \le \ldots \le F_j = 1 \end{aligned} \tag{11}$$

The solution to this problem can be shown to be strictly concave, implying there is a unique solution to the NPML problem (Turnbull, 1976).

In Turnbull (1976) an algorithm to obtain a solution to the above problem was introduced, the *Turnbull Self-Consistency algorithm(SC)*. Since no closed form solution to the maximization exists, the SC algorithm (as well as other proposed solutions to the NPML) relies on iterative numerical procedures. Firstly, start values of F that adhere to the monotonicity condition has to be guessed and used to calculate the fraction of each WTP interval that should be attributed to each of the basic intervals it spans. Secondly, from these calculations new parameter estimates of F are obtained, which then replace the first guesses made. Then new parameter estimates are obtained which are used to calculate new fractions and so on. The iterations proceed in this way until the changes in the parameter estimates all converge and fall below some pre-determined level.

5 Results

In this section we provide estimates and distributions of E(WTP), VSC and VSL based on choices made by respondents in the main survey. Point estimates are based on the Turnbull Lower Bound non-parametric measures discussed in the previous section, while the distributions are assessed using Monte Carlo simulation procedures. We also investigate how the choice estimates are affected by responses to some other survey questions.

The number of actual respondents in each of the 60 groups[12] as well as the proportion voting against the proposed bid (in the first round of yes/no responses) are summarized in Table 9.[13] Notably, in some combinations of morbidity risk and mortality risk reduction, the percentage of the sample voting against the proposed bid does not increase monotonically with the bid level as would be predicted by economic theory. As was discussed in the previous section, the remedy for this violation is to pool adjacent non-compliant bid levels and to recalculate choice measures and dispersion parameters based on the new sample distribution.

Apart from this procedural modification, we also want to analyse whether the relation between proposed bid and response is in accordance with what we would expect from economic theory. For this purpose a chi-squared test ($\chi^2_{(4)}$) of this interdependence was performed for each of the twelve risk reduction combinations. The null hypothesis for this test is that the bid level and the

[12] There were 60 combinations of mortality risks, morbidity risks and bid amounts.
[13] For responses to the second round of responses, see Appendix A

yes/no responses are independent, and thus a p-value below 0,01 indicates that with 99 % certainty the two variables are not independent, and the null hypothesis can be rejected.

Table 9: Number of respondents replying, percentage responding "no" and chi2 statistics for different combinations of morbidity risk reductions, mortality risk reductions and bid amounts

Mortality baseline risk 0 in 100 million

	4→2		4→1		3-->2		3→1		4→2 & 3→1	
Bid	Number	%No	Number	%No	Number	%No	Number	%No	Number	%No
2	12	0.000	15	0.000	11	0.000	9	0.000	21	0.000
10	13	0.154	15	0.133	14	0.286	15	0.400	28	0.286
20	14	0.214	9	0.333	12	0.333	6	0.333	20	0.250
40	11	0.727	16	0.563	17	0.824	16	0.688	27	0.704
60	16	0.813	13	0.538	10	0.800	8	0.500	24	0.708
Total	66	-	68	-	64	-	54	-	120	-
chi2(4)	26.26		17.97		25.47		11.59		37.00	
p-value	<0.01		<0.01		<0,01		0.02		<0.01	

Mortality baseline risk 6 in 100 million

	4→2		4→1		3-->2		3→1		4→2 & 3→1	
Bid	Number	%No	Number	%No	Number	%No	Number	%No	Number	%No
2	7	0.000	12	0.167	11	0.091	8	0.000	15	0.000
10	16	0.250	15	0.267	15	0.200	14	0.214	30	0.233
20	12	0.417	12	0.417	13	0.308	8	0.125	20	0.300
40	13	0.692	16	0.500	11	0.273	15	0.600	28	0.643
60	14	0.571	8	0.875	7	0.714	6	0.667	28	0.600
Total	62	-	63	-	57		51		113	
chi2(4)	12.25		13.82		12.7		14.26		24.78	
p-value	0.02		<0.01		0.01		<0.01		<0.01	

Mortality baseline risk 12 in 100 million

	4→2		4→1		3-->2		3→1		4→2 & 3→1	
Bid	Number	%No	Number	%No	Number	%No	Number	%No	Number	%No
2	13	0.231	11	0.091	14	0.071	12	0.083	25	0.160
10	12	0.333	17	0.235	10	0.500	17	0.059	29	0.172
20	12	0.500	12	0.167	9	0.444	10	0.600	22	0.545
40	13	0.615	11	0.455	10	0.500	14	0.714	27	0.667
60	7	0.857	14	0.429	9	0.556	10	0.700	17	0.765
Total	57	-	65	-	52	-	63	-	120	-
chi2(4)	9.23		7.33		8.69		27.03		30.36	
p-value	0.06		0.12		0.07		<0.01		<0.01	

Interestingly, rejecting the null hypothesis seems to be negatively correlated with the mortality risk reduction size, with only one non-rejection for the lowest level (1 in 100 million), but with two and three non-rejections at the higher levels (6 and 12 in 100 million), respectively.[14] Thus it seems that introducing mortality risk in the decision process makes it increasingly difficult for respondents to discriminate between the different bid levels.

Merging the two morbidity risk reduction combinations of 3 to 1 in 10 000 and 4 to 2 in 10 000 (which both result in a risk reduction of 2 in 10 000) produces the strongest rejection of the null hypothesis (rejection at the 1 percent level for all mortality baseline risks). To get more reliable results, we will therefore use the 2 in 10 000 risk reduction when constructing primary policy values for VSC and VSL later in this section. Estimations for alternative risk reduction combinations will be reported in Appendix B and Appendix C for VSC and VSL, respectively.

5.1 Estimation of E(WTP)

Turnbull non-parametric estimations of E(WTP) and variance for each of the 12 different combinations of mortality risk and morbidity risk in the survey are summarized in Table 10 below. The table includes estimations for both the single-bounded and the double-bounded formats.

Normally, there would be at least two hypotheses one would expect these E(WTP) values to comply with, based on theoretical considerations. Firstly, *ceteris paribus*, one would expect WTP to be a positive function of the risk reduction (*weak scope sensitivity*). Secondly, for sufficiently small risk reductions, WTP should be possible to approximate by a linear function (Hammitt et al 1999), so that WTP should change nearly proportionately with the risk reduction size (*strong scope sensitivity*). However, the Turnbull lower bound estimators will not necessarily adhere to this criterion even theoretically, which implies that we will focus entirely on the weak scope sensitivity requirement here.

Since, for most respondents, we have two disparate risk reductions (morbidity and mortality), there are also two different requirements on E(WTP) that have to be met if the weak scope sensitivity criterion is to be satisfied. Firstly, we would expect that holding the mortality risk reduction constant and

[14] Rejections at the 1 % level

increasing the morbidity risk reduction would lead to an increase in E(WTP). As we can se in Figure 1, the survey data support this supposition, with E(WTP) increasing monotonically with the size of the morbidity risk reduction for both the single-bounded and the double-bounded formats.[15]

Table 10: Estimations of E(WTP) using Turnbull Lower Bound for the double-bounded and the single-bounded formats.

mortality		morbidity		Double bounded method			Single bounded method		
high	low	high	low	E(WTP)	5%	95%	E(WTP)	5%	95%
0	0	4	2	30.9	27.5	34.3	25.8	18.8	32.9
0	0	4	1	42.4	33.2	51.7	24.3	19.4	29.2
0	0	3	2	29.1	21.8	36.3	18.1	13.7	22.5
0	0	3	1	29.2	22.1	35.9	18.2	12.2	24.2
*	*	4;3	2;1	30.1	25.4	34.8	22.6	17.0	28.1
6	3	4	2	31.9	24.0	39.8	21.2	16.3	26.1
6	1.5	4	1	29.6	23.8	35.3	25.9	18.4	33.4
6	4	3	2	34.2	27.0	41.4	24.2	13.1	35.3
6	2	3	1	32.3	25.7	38.9	27.2	16.5	37.9
*	*	4;3	2;1	32.3	27.0	37.7	22.6	18.8	26.5
12	6	4	2	21.9	16.8	27.1	17.0	6.2	27.8
12	3	4	1	39.1	32.3	45.9	34.1	24.5	43.7
12	8	3	2	34.8	21.0	48.6	28.6	17.5	39.7
12	4	3	1	33.1	24.7	41.6	13.8	7.6	19.9
*	*	4;3	2;1	32.4	26.0	38.9	24.2	17.8	30.6

** Different mortality risk reductions depending on which of the two morbidity risk reductions considered.*

Secondly, and similarly, the weak sensitivity criterion suggests that holding the morbidity risk reduction constant while increasing the mortality risk reduction should generate a higher E(WTP). In this case, the two elicitation formats seem to produce somewhat more diverse results.[16] Using the single bounded approach, the monotonicity outcome of morbidity risk reductions above is replicated for each morbidity risk level, as visualized in Figure 2.

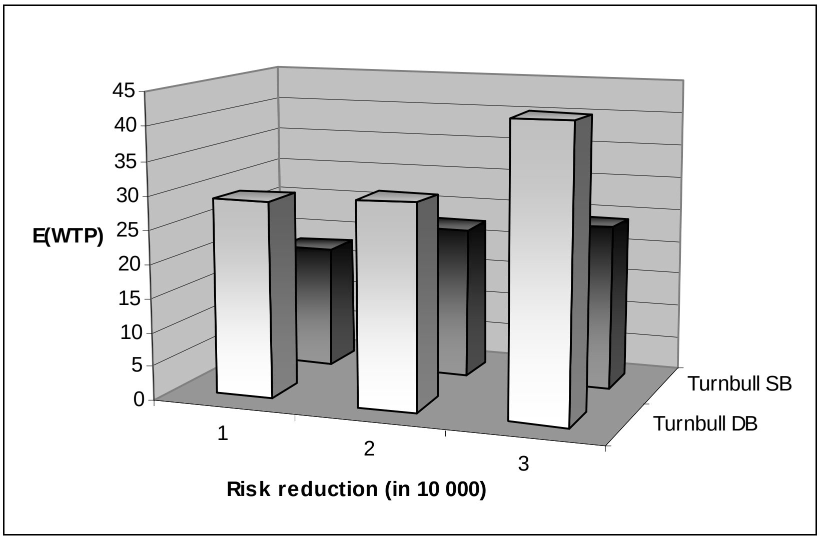
However, the double bounded format outcome deviates from this general result since E(WTP) does not increase monotonically for morbidity risk reduction levels 2 in 10 000 and 3 in 10 000 (see Figure 3). VSL values obtained

[15] In order to exclude any influence from the mortality risk reductions, weak sensitivity for morbidity risk reductions is analyzed only in the case where mortality risks are absent (that is, where we have a 0 in 100 million base mortality risk).

[16] Note that in Figure 2 and Figure 3, mortality baseline risk is used rather than mortality risk reduction on the x-axis. This is due to the construction of mortality baseline and final risks in the survey. As described in Section 2 the mortality baseline risk was distributed randomly across the sample, while the final risk was determined by the morbidity risk reduction level presented in each survey. Thus, for each level of morbidity risk reduction in Figure 2 and Figure 3, an increase in the mortality baseline risk can be directly translated into a corresponding increase in the mortality risk reduction level.

by using the double bounded format should thus, in this case, be utilized with with an enhanced discretion.[17]

Figure 1: E(WTP) values for Turnbull estimator using the single bounded (SB) and double bounded (DB) formats (for mortality risk 0 in 100 million, see footnote 15).



5.2 Sensitivity of E(WTP) to the exclusion of some categories

In this section we study the effects of excluding seven different categories of respondents, based on responses to some of the questions in the survey. A summary of the different categories analyzed, as well as their relative sample sizes and their effects on E(WTP) are presented in Table 11. For convenience, and since inclusion of more risk reduction levels does not alter the outcome qualitatively, only E(WTP) values for a morbidity risk reduction of 2 in 10 000 have been included in this analysis.

[17] Note here that we do not have any cases where morbidity risks are absent. Thus weak sensitivity to scale in the case of mortality risk reduction is contingent upon the weak sensitivity to scale for morbidity risk reductions demonstrated in the previous section.

Figure 2: Estimated E(WTP) for different mortality risk reduction levels holding the morbidity risk reduction constant: the SB method

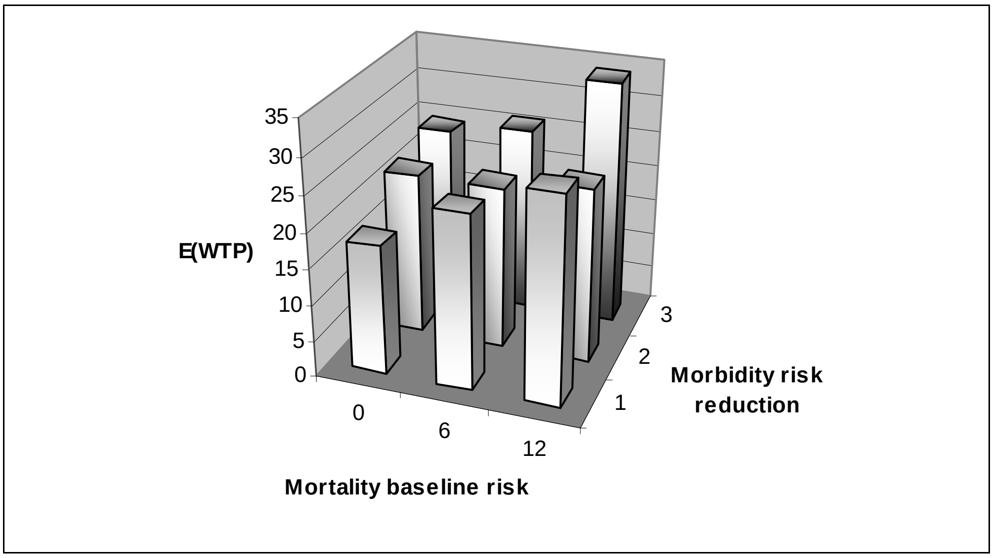
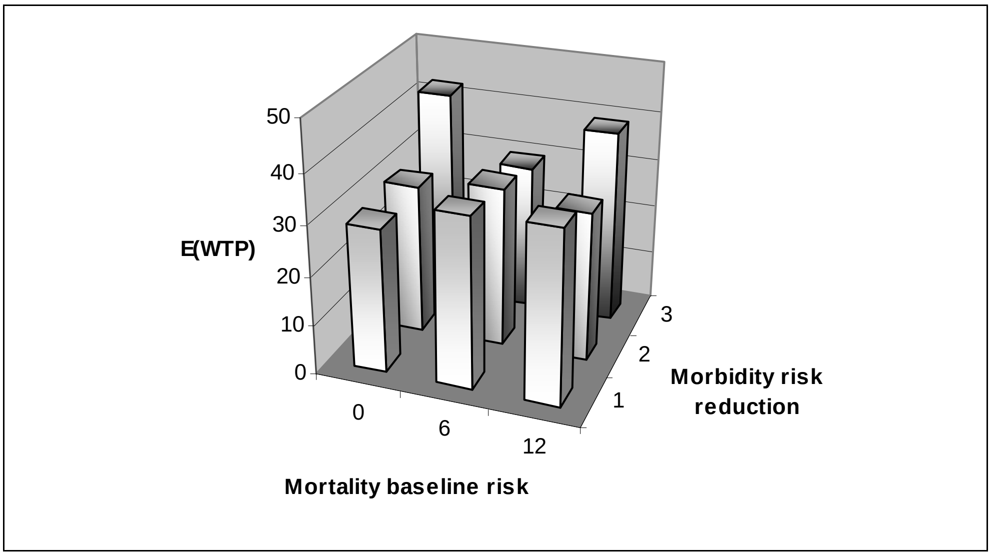


Figure 3: Estimated E(WTP) for different mortality risk reduction levels holding the morbidity risk reduction constant: the DB method



The first exclusion criterion concerns respondents who have indicated they are not absolutely certain about their yes/no response to the valuation question. This group constitutes almost half of the total sample size, and by excluding it the Turnbull lower bound estimates of the sample mean fall by SEK 1.4 and SEK 2.9 for mortality baseline risks 6 and 12 in 100 million. However, for the subsample presented with a 12 in 100 million mortality baseline risk, the estimate instead increased by 3.0. The overall effect of not being absolutely certain thus seems to be indefinite regarding the valuation of food safety. The same irregular pattern is also noted for the category stating they do nothing of the cooking in the households.

Table 11: Sensitivity test results for exclusion of certain categories of respondents using morbidity risk reduction level 2 in 10 000 and Turnbull single bounded method.

		Mortality baseline risk (in 100 million)		
		0	6	12
Exclusion criteria	**% Excl**	Change in E(WTP)	Change in E(WTP)	Change in E(WTP)
Uncertain yes/no response	49.5	-1.40	-2.90	+3.00
Infrequent chicken consumption	6.3	-4.10	-1.60	-2.90
Health <50	8.3	-1.60	-0.60	-2.40(*)
Health=100	24.6	-2.10	-1.10	-1.00
Poor risk perception	3.6	-1.50	-0.80	-1.10
Do not cook food	6.3	-1.00	+0.50	-1.30
Scenario found unrealistic or don´t know	47.9	-0.60	-3.50(*)	-0.20(*)

(*) Pooled adjacent multipliers algorithm (PAVA) applied

The second category excluded are those who stated they do not eat chicken or eat chicken only very infrequently. Despite the rather small sample size of about 6 percent of the total sample, the effect on E(WTP) is quite manifest with changes between SEK -1.60 and SEK -4.10. Thus, respondents who eat chicken infrequently seem to place a higher value on food safety. At first sight this result may not appear completely intuitive, since less consumption would mean these respondents are less likely to get into contact with chicken and its associated probability of generating food-borne illnesses. However, and as indicated in some of the survey comments, it is possible that at least some of these respondents have chosen not to eat chicken due to its documented association with intestinal diseases like campylobacteriosis or salmonellosis.

Excluding those who stated a poor current health status (below 50 on the VAS) and those stating a perfect health (100 on the VAS) seem to have a similar effect upon E(WTP). Constituting 8 percent and 25 percent of the total sample, respectively, both these categories seem to value a risk reduction higher than the main sample. In the literature, there is no clear consensus on what sign to expect in either of these cases (Hammitt, 2005).

Almost half of the sample presented with a 2 in 10 000 morbidity risk reduction declared they did not find the scenario realistic or were uncertain. Despite the appreciable size of this category, excluding these respondents does not seem to have any dramatic effect on the Turnbull lower bound estimates. Sometimes finding the scenario unrealistic may lead to protest zero WTP responses (Jorgensen, 1999), but in this case E(WTP) is actually higher in the category who found the scenario unrealistic. Thus, with our sample, zero responses do not seem to have any association with how the scenario was perceived.

The final category investigated consists of respondents who were found to have risk perception abilities/ risk understanding below average.[18] The result indicates that in general, this category seems to value food risk reductions higher than average. Considering how few respondents actually belong to this category (18 persons), the reduction of the sample mean by between SEK 0.80 and SEK 1.50 probably makes this category the most deviant of all categories in this sensitivity analysis.

5.3 Value of a statistical case (VSC)

Since we do not have infinitely small risk reductions, Equation (3) cannot be used directly to calculate VSC. For finite risk reductions, VSC is instead approximated by dividing E(WTP) by the morbidity risk reduction facing the various subsamples:

$$VSL = \frac{E(WTP)}{\Delta p} \qquad (5)$$

Note that in order to minimize the risk for respondents confounding the two different types of risk reductions, calculations were only performed for subsamples that were encountered with a zero mortality baseline risk.

As can be seen in Table 12, the estimated VSC point values for a case of salmonellosis[19] are SEK 150 374 and SEK 112 778 for the DB format and the SB

[18] To qualify, respondents had to simultaneously comply with the following two criteria. Firstly, they would have to state that more than 20 percent of all people in Sweden are contracted with food-borne illnesses annually (true number 8-11). And , secondly, in the question where different death causes were to be ranked in terms of their relative frequencies, respondents must have stated food-related illness as a more frequent cause than at least two of the other alternatives.

[19] Excluding any risk for mortality, since only the case of a 0 in 100 million mortality risk reduction is considered.

format, respectively. The distribution for the two formats is also visualized in Figure 4.

Table 12: Value of a Statistical Case (VSC) using the preferred risk reduction level

Baseline risk	low risk	Risk reduction	E(WTP)	Implied VSC	5 %	95 %
Double bounded						
4	2	2 in 10 000	30,9	154 500	123 037	185 950
3	1	2 in 10 000	29,0	144 995	110 570	179 420
4 and 3	2 and 1	2 in 10 000	30,1	150 374	126 904	173 843
Single bounded						
4	2	2 in 10 000	25,8	129 155	94 005	164 305
3	1	2 in 10 000	18,2	91 012	60 794	121 230
4 and 3	2 and 1	2 in 10 000	22,6	112 778	85 233	140 323

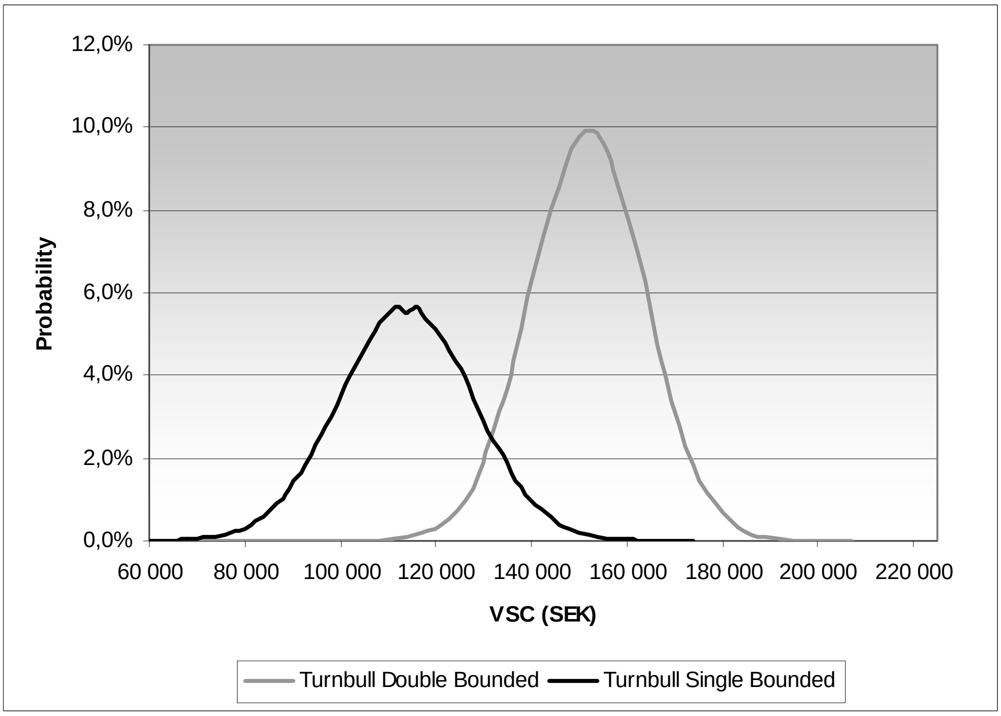
Monte Carlo simulations using weighted averages of all the different VSC values[20] were also made, taking into account both the number of respondents in each subsample, and the mean and variance of each estimation. The results indicate a mean VSC of SEK 182 966 (167 915 - 197 896) using the double bounded format, and a mean of 121 045 (110 297 - 131 814) using the single bounded format (values in parenthesis constitute a 90 percent confidence interval). Thus including all estimations increases the VSC values by 8 to 33 percent, depending on the format considered.

Calculations of VSC for salmonellosis (or other similar diseases) are scarce in the literature, and none has been previously carried out in Sweden. Internationally, two relevant studies have been found; Henson (1996) used a CV study to calculate a VSC of salmonellosis following chicken consumption of $8 501.[21] Considering inflation rates, this is still a considerably lower value than the ones obtained in this study. Hammitt and Haninger (2007) used a stated preference study to calculate VSC of ”foodborne illness” with symptoms largely matching those used in this study. They found that households without children were willing to pay, on an average, between $8 300 and $16 100 for a statistical case, while households with children were prepared to pay slightly more, between $10 800 and $16 400. This is also somewhat lower than the values in this study ($18 000 using SB and $25 000

[20] VSC values for other risk reduction combinations are provided in Appendix B.
[21] Using an average conversion rate for 1996 (GBP/USD) of 1.561 (The Swedish Riksbank, http://www.riksbanken.se, 2008-09-10)

using DB),[22] but differences regarding GP admittance and duration of illness may account for most of this difference.

Figure 4: Estimated Value of a Statistical Case (VSC) Using the Turnbull Lower Bound Single Bounded and Double Bounded Methods



5.4 Value of a Statistical Life (VSL)

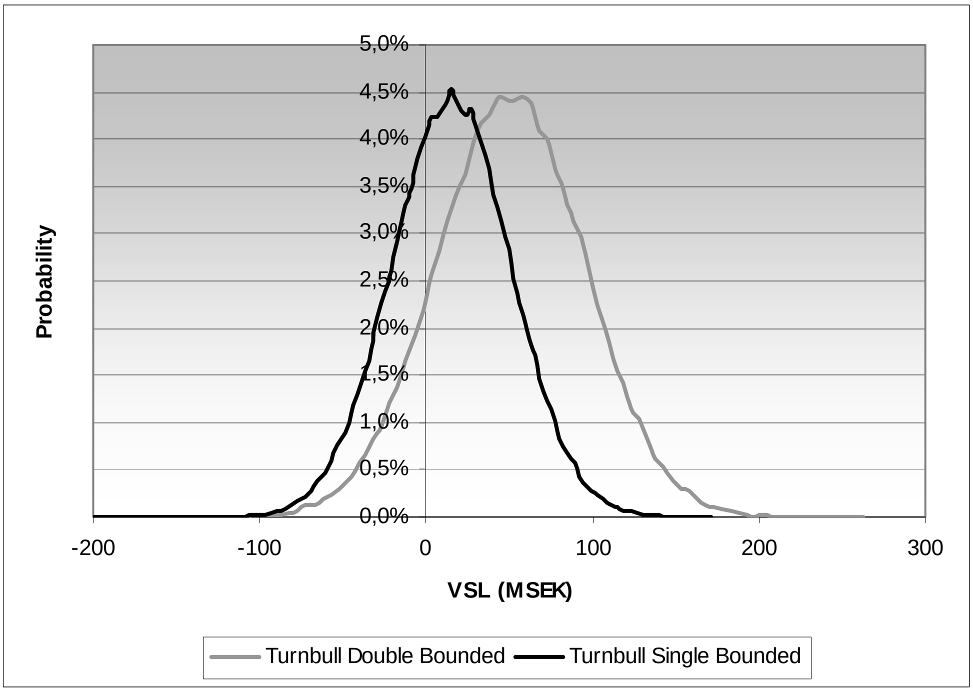
The Value of a statistical life (VSL) is calculated according to (5), using the mortality risk reductions to calculate Δp. To simplify the elicitation procedure, only pairwise comparisons of subsamples with the same morbidity risk reductions are used. Further, calculations were based only on subsample pairs with one of the samples having a mortality risk of 0 in 100 million. Thus, a difference between two such E(WTP) values can be interpreted as E(WTP) for reducing mortality risk only.

For each elicitation method, two different VSL estimates were possible to calculate according to the above criteria.[23][24] To obtain a more reliable unit measure for VSL (i e a measure that incorporates all relevant VSL estimations),

[22] Exchange rate $1 = SEK 6.00, http://www.riksbank.se (2007-07-09)
[23] Considering that we only use morbidity risk reductions of 2 in 10 000 in accordance with previous considerations
[24] In Appendix C, VSL calculations for other risk reduction levels are provided

Monte Carlo simulations were made for both the SB and the DB formats. We ran 100 000 Monte Carlo estimations of weighted averages of the VSL values for each format, taking both means and variances of the different estimates into account. The mean VSL from these simulations amounts to SEK 13.3 million using the single bounded method, and SEK 48.8 million using the double bounded method. Of these values, the SB estimation provides the preferred value, because of the scale insensitivity of the DB format discussed earlier. As indicated in Figure 5 below, however, neither of the estimations are statistically significant. The reason for the magnitude of the variation lies in the design of the questionnaire where four different E(WTP) values (each with its own variance) had to be used for each VSL estimation.

Figure 5: Estimated Value of a Statistical Life (VSL) Using the Turnbull Lower Bound Single Bounded and Double Bounded Methods: Results from 100 000 Monte Carlo Simulations



We also ran Monte Carlo simulations using weighted averages of all the VSL values obtained (see Appendix C), regardless of the performance regarding chi2 tests and scale sensitivity. In these calculations, the VSL using the SB format dropped to SEK 5 million, while VSL using the DB format increased to

SEK 66 million.[25] As above, however, neither of these estimations were statistically significant.

In the only other VSL study of poultry-borne salmonellosis found in the literature, VSL was estimated to $7.3–15.5 million (Henson, 1996).[26] These estimates are somewhat higher than those obtained in the present study which, converted to USD, amount to $2.2 million and $8.1 million using the SB and DB methods, respectively. The official VSL value in Sweden, as used in the transport sector, is currently $3.5 million, but VSL values in the range of $2-9 million have been previously calculated for this sector (Persson et al., 2001; Andersson, 2005; Hultkrantz et al., 2006; Johannesson et al., 1996; Andersson et al, 2008). Thus both our mean estimations are within the range of these Swedish VSL estimates.

Table 14: Mean, median and variance of estimated VSL values using the Turnbull Lower Bound single bounded and double

Method	Mean VSL	Median VSL	σ
Single bounded	13 325 892	13 325 098	35 940 756
Double bounded	48 327 179	48 388 435	44 495 860

6 Sensitivity analysis

In this section, effects from various socioeconomic and other variables are studied. The regression models used are based on the bid-function approach as discussed in the methods section. In short, the bid function approach allows the researcher to obtain the marginal effects of the WTP value itself, in contrast to the utility difference approach, where estimated independent variables measure marginal effects on utility changes (Cameron, 1988; Patterson and Duffield, 1991; Bateman et al., 2002).

[26] Using an average conversion rate for 1996 (GBP/USD) of 1.561 (The Swedish Riksbank, http://www.riksbanken.se, 2008-09-10)

In the analysis we estimate the following multiplicative bid function with logs:

$$\ln(WTP_i) = \alpha + \beta_i \ln(\Delta p_i) + \sum_{k=2}^{K} \beta_k f_{k-1}(x_i) + \varepsilon_i \qquad (12)$$

with $f(x)$ defining dummy variables and the natural log of continuous variables. Based on preliminary estimations, a log-normal model was chosen as a best-fit to model the above WTP distribution.

By definition, log-normal models do not allow for WTP values of zero, which is in contrast to the specifications used in the questionnaire (where this alternative was explicitly available). Thus equation (12) was also estimated using a *mixture model* which allows for a spike (a positive mass) at zero (An and Ayala, 1996; Werner, 1999).[27]

As a follow-up to the WTP question, respondents were given the opportunity to state whether they found the valuation scenario realistic or not. We used this information to test for the robustness of the model, by excluding, from some of the regressions, respondents that did not find the scenario realistic.

In Table 16 we present the regression results for the mixture model as well as for the conventional model. For the mixture model (which is our preferred approach in conjunction with the above discussion) the results are further separated according to the inclusion or exclusion of the third rejection criterion just related to (realistic/unrealistic scenario).

Morbidity risk ($\ln(\Delta p_{morb})$) has the predicted positive sign, but is insignificant in all but one of the regressions. Similar results were obtained when exchanging $\ln(\Delta p_{morb})$ for dummies for the various risk reduction levels. Thus the parametric approach seems to impair scale sensitivity as compared to the non-parametric technique, where weak sensitivity to scale was satisfied for morbidity risk changes (see Section 5.2).

[27] In our case the number of zero responses was known prior to running the regressions. For this reason, and by using an indicator variable that discriminates between zeros and non-zeros in the sample, the log-likelihood function could be easily manipulated to incorporate a spike. See An and Ayala (1996) for details.

Table 16: Regression results

	Mixture model				***Conventional model***	
	All respondents		Unrealistic excluded[a]		All respondents	
Variable	**SB**	DB	SB	DB	SB	DB
$\ln(\Delta p_{morb})$	0.314*	0.128	0.257	0.051	0.276	0.102
	(0.189)	(0.111)	(0.204)	(0.127)	(0.213)	(0.124)
Δp_{mort} [h]	0.105	0.035	0.092	0.067	0.159	0.058
	(0.160)	(0.095)	(0.170)	(0.536)	(0.180)	(0.105)
$\ln(QALY)$ [b]	0.245*	0.148*	0.168	0.101	0.325**	0.173*
	(0.135)	(0.080)	(0.145)	(0.093)	(0.156)	(0.090)
$\ln(Income)$ [c]	0.119	0.054	0.094	0.111	0.130	0.051
	(0.148)	(0.089)	(0.159)	(0.102)	(0.170)	(0.100)
Female	0.207	0.045	0.221	0.093	0.370*	0.154
(0=M. 1=F)	(0.183)	(0.109)	(0.192)	(0.122)	(0.205)	(0.120)
$\ln(Age)$	0.238	-0.003	0.068	-0.114	0.398	0.096
	(0.238)	(0.142)	(0.252)	(0.157)	(0.261)	(0.530)
Secondary	-0.224	-0.196	-0.456*	-0.282*	-0.075	-0.077
school highest	(0.239)	(0.142)	(0.260)	(0.162)	(0.263)	(0.154)
University	-0.335	-0.161	-0.346	-0.180	-0.234	-0.06
highest	(0.248)	(0.149)	(0.271)	(0.172)	(0.271)	(0.162)
Household size	0.174***	0.079**	0.193***	0.093**	0.159**	0.060
	(0.067)	(0.039)	(0.070)	(0.043)	(0.074)	(0.043)
Eats chicken	-0.159	-0.170**	-0.174	-0.220**	-0.241*	-0.217**
	(0.128)	(0.076)	(0.138)	(0.086)	(0.146)	(0.085)
Concern[d]	0.375	0.237*	0.483*	0.280*	0.445*	0.272*
	(0.233)	(0.140)	(0.247)	(0.154)	(0.257)	(0.152)
Price vs	0.375***	0.293***	0.341***	0.298***	0.462***	0.345***
Safety[e]	(0.071)	(0.041)	(0.077)	(0.047)	(0.080)	(0.046)
Correct	-0.452***	-0.092	-0.469**	-0.120	-0.432**	-0.039
ranking[f]	(0.177)	(0.106)	(0.191)	(0.122)	(0.202)	(0.119)
Reads	0.001	-0.087	-0.032	-0.134*	-0.150	-0.210***
descriptions	(0.111)	(0.066)	(0.116)	(0.073)	(0.125)	(0.074)
Main cook in	0.141	0.138	0.214	0.137	0.151	0.145
household	(0.180)	(0.106)	(0.191)	(0.120)	(0.202)	(0.118)
ln(Frequency)[g]	-0.026	-0.013	-0.137*	-0.078*	0.014	0.020
	(0.070)	(0.041)	(0.076)	(0.047)	(0.079)	(0.046)
Intercept	-0.559	1.667*	0.784	1.847*	-1.476	1.176
	(1.687)	(0.987)	(1.810)	(1.117)	(1.899)	(1.094)
σ	1.156	0.863	1.069	0.855	1.380	0.992
N	591	591	462	462	591	591
Pseudo-R^2	0.289	0.256	0.325	0.282	0.310	0.253

Significance levels: * (10%) ** (5%) *** (1%) (Standard errors in parentheses)
a: Excluding respondents stating that they did not find the valuation scenario realistic
b: Implicit calculation of QALY:s lost due to salmonellosis, based on estimations of the severity of the different states provided by each respondent.
c: Income per consumption unit
d: Concerned about illnesses like salmonellosis when shopping
e: Coded on a scale from 1 (price much more important) to 7 (safety much more important)
f. Dummy coded as 1 if respondent ranked the probabilities of different causes of death correctly
g. Stated probability of getting food contamination annually
h. Dummy coded as 1 if Δp_{mort} >0, and as 0 otherwise

The mortality risk variable was coded as a dummy, indicating whether the risk reduction was equal to zero or positive. Again we find the predicted positive sign throughout, but estimations are insignificantly different from zero in all regressions. Neither using a continuous variable, nor using dummy variables for the different risk reduction levels, altered this outcome qualitatively.

For the DB case, this outcome was expected considering the negative outcome of the weak scale sensitivity analysis carried out in Section 5.2, where E(WTP) did not increase monotonically by the mortality risk reduction size. For the SB case, however, the use of parametric methods seems to have had a similar unfavourable effect on scale sensitivity as for the morbidity risks. Although weak scale sensitivity is often found in the empirical literature when using parametric methods, insignificance is not uncommon either (Hammitt and Graham, 1999).

The variable $\ln(QALY)$ is an estimation of the Quality Adjusted Life Years (QALY) lost due to an episode of salmonellosis, based on self-reported evaluation of the different states of salmonellosis on a VAS scale made by all respondents. The variable has the predicted positive sign, and is significant in most regressions, indicating that perceived illness severity is positively correlated with the WTP for any particular risk reduction.

Income per consumption unit should have a positive impact on WTP for two reasons. Firstly, the potential wealth loss from dying is greater the wealthier the individual. Secondly, spending a specific amount causes less utility loss due to diminishing marginal utility (Andersson and Treich, 2008). All regressions produce positive signs, but are insignificantly different from zero. Different setups, including grouping income levels in different combinations, does not change this outcome. Insignificant relationships between WTP and income has been found in other studies of food safety as well (Buzby et al., 1995; van der Pol et al., 2003), and may reflect the low costs often involved when reducing the food risk (Haninger and Hammitt, 2007)

We found only a very weak and negative link between wtp and education (and only in the case of secondary school being the highest educational level). A negative relationship may indicate that individuals with a higher educational level may have better information about food contamination and would thus be less concerned about the risk of suffering from such illness (Henson, 1996).

This interpretation is reinforced by the fact that respondents that ranked different causes of death accurately[28], and thus gave evidence of an enhanced awareness of the subject area and related probabilities, also were less inclined to pay for food risk reduction. In this case, the results were also strongly significant in all SB regressions (but not in those involving DB).

The general predicted effect from age is indeterminate (Hammitt, 2005). In line with this we did not find any significant relation in any regression. Female respondents have been found to be willing to pay somewhat more for food safety than men in some studies, but again the empirical evidence is inconclusive. (Hammitt and Haninger, 2007; Buzby et al, 1993; Krupnick, 2007). We get positive signs in all regressions (which would indicate a premium for female respondents), but significance in only one case.

Household size seems to be a very strong predictor of WTP in our sample, with positive signs and significance in five out of six regressions. This result is somewhat stronger than in other studies (Hammitt and Haninger, 2007; Buzby, 1993). The relation may be explained by the fact that household size works as a close proxy for the number of children in the household, and that WTP for protecting one's children has been shown to be higher than for oneself (Hammitt and Haninger, 2007).

Concern about food-related illnesses when shopping as well as ranking safety higher than price both have the expected positive signs, and are both significant in almost all regressions. Reading descriptions on food labels indicates a more general awareness of and interest in nutrition and healthiness related to food than the concern variable, which is morespecifically directed towards food safety. In line with this, reading descriptions shows a rather inconclusive relation with WTP for food safety in our sample, with only two regressions being significant.

Finally, eating chicken (a dummy variable coded to 1 if the respondent eats chicken at all) was negative and significant in four regressions, suggesting that those who do not eat chicken (and who were asked to ”value a food with similar characteristics as chicken”) have a higher WTP than those who do eat chicken. A plausible explanation might be that at least some of the respondents

[28] The different causes of death were, in order of appearance, AIDS/HIV, lung cancer, food contamination, car accidents and cardio-vascular diseases.

who did not eat chicken, did so partly because of its well-known association with food-related illnesses. Those respondents would thus assign a higher value on avoiding food-related illnesses than average consumers, which could account for the negative sign found. Other reasons for a negative relationship between consumption frequency and WTP has also been noted in the literature (Henson, 1996).

Summary

This is the first Swedish stated preference study where willingness to pay for food safety has been estimated. We have used the results from a Swedish CV survey to estimate E(WTP), VSC and VSL for a reduction of the risk of getting salmonellosis as a consequence of chicken consumption. Apart from providing policy values, we have also made an extensive sensitivity analysis to find the most important predictors of the size of WTP.

We find that, depending on the risk reduction presented, people are willing to pay a premium of between SEK 14-42 for a chicken product that reduces the risk of getting salmonellosis by between 1 and 3 in 10 000. This translates to (preferred) VSC estimates of SEK 112 000 – 150 000 and a VSL estimate of 13,3 million. The criteria used to obtain preferred values have included the exclusion of both protest responses and irrational valuation responses, as well as requisites to comply with well-founded economic criteria (like scale sensitivity and correlation between bid amount and yes/no responses).

The VSC estimates are somewhat higher than the very few other estimates found in the literature, but very probably differences in the valuation scenarios (GP admittance, duration/severity of different illness states) as well as country-specific factors can account for these differences. The VSL estimate has a very high variation and is not statistically significant, which is due to the construction of the survey, but the mean and median values fall well within the range of values found elsewhere in the literature. Here is an evident need for future studies to isolate mortality risk changes to a larger degree in order to obtain more stable VSL estimations from the food safety area.

We find that scale sensitivity seems to depend, at least partly, on the elicitation method used. Using the non-parametric Turnbull lower bound format, we find that weak sensitivity to scale is satisfied for morbidity risk reduction, and for those mortality risk reductions that were estimated using the single bounded format. The parametric sensitivity analysis, however, shows a very weak relationship with both morbidity risk reduction and mortality risk reduction.

We also find no effects of age, income or gender on WTP. While the effects of age as well as gender are inconclusive in the literature, income and WTP should have a positive and significant sign. However, insignificance is found in other studies on food safety as well, and may be explained by the often relatively small amounts required to pay for the risk reductions.

Interestingly, risk perception abilities that are either above or below average seem to have a strong negative effect on WTP. Other strong predictors include perceived QALY:s lost (positive effect), household size (positive effect) and general concern about food-related illnesses (positive effect). Finally, an extreme current health status (either very good or very bad) seems to have a negative effect on WTP. However, conflicting effects make the predictions from theory regarding own health indeterminate.

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Appendix

Appendix A: Responses to the double-bounded questions in the survey

	Bid number		Basic interval		morbidity baseline risk/ **morbidity final risk**/ mortality baseline risk											
Bid	**1:st**	**2:nd**	**Low**	**Hi**	4**2**0	4**1**0	3**2**0	3**1**0	4**2**6	4**1**6	3**2**6	3**1**6	4**2**12	4**1**12	3**2**12	3**1**12
2	no	no	0	1	0	0	0	0	0	2	0	0	2	1	0	1
2	no	yes	1	2	0	0	0	0	0	0	1	0	0	0	1	0
2	yes	no	2	4	0	1	0	1	1	1	0	0	1	1	0	2
2	yes	yes	4	inf	12	14	11	8	6	10	10	8	9	9	13	9
10	no	no	0	5	0	1	1	3	1	3	1	0	2	0	1	1
10	no	yes	5	10	2	1	3	3	3	1	2	3	2	4	4	0
10	yes	no	10	20	2	2	6	3	3	1	3	1	5	3	2	4
10	yes	yes	20	inf	9	11	4	6	9	10	9	10	3	10	3	12
20	no	no	0	10	0	2	3	1	3	3	3	0	2	0	3	2
20	no	yes	10	20	3	1	1	1	2	2	1	1	4	2	1	4
20	yes	no	20	40	6	5	6	2	6	4	6	5	3	6	2	2
20	yes	yes	40	inf	5	1	2	2	1	3	3	2	3	4	3	2
40	no	no	0	20	3	5	4	4	4	2	2	3	4	2	3	8
40	no	yes	20	40	5	5	10	7	5	6	1	6	4	3	2	2
40	yes	no	40	80	3	3	2	4	3	7	6	5	5	6	4	2
40	yes	yes	80	inf	0	4	1	1	1	1	2	1	0	1	1	2
60	no	no	0	30	10	5	2	4	6	3	3	4	4	2	4	4
60	no	yes	30	60	3	2	6	0	2	4	2	0	2	4	1	3
60	yes	no	60	120	2	3	0	4	4	1	2	2	1	7	2	2
60	yes	yes	120	inf	1	3	2	0	2	0	0	0	0	1	2	1

Appendix B: Estimated VSC values for all morbidity risk reduction levels

Turnbull lower bound, DB results

mortality		morbidity											
high	**low**	**high**	**low**	**delta**	**in**	**E(WTP)**	**5%**	**95%**	**variance**	**VSC**	**5%**	**95%**	**obs**
0	0	4	2	2	10 000	30,9	24,6	37,2	10,3	154 494	123 037	185 950	69
0	0	4	1	3	10 000	43,1	33,8	52,4	22,7	143 596	112 501	174 692	69
0	0	3	2	1	10 000	29,1	21,8	36,3	13,7	290 723	218 262	363 184	64
0	0	3	1	2	10 000	29,0	22,1	35,9	12,3	144 995	110 570	179 420	54
0	0	4 ;3	2 ;1	2	10 000	30,1	25,4	34,8	5,7	150 374	126 904	173 843	123
6	3	4	2	2	10 000	31,9	24,0	39,8	16,2	159 564	120 082	199 046	62
6	1,5	4	1	3	10 000	29,5	23,7	35,2	8,6	98 215	79 025	117 406	66
6	4	3	2	1	10 000	31,3	24,0	38,6	13,8	313 069	240 167	385 972	59
6	2	3	1	2	10 000	32,3	25,7	38,9	11,4	161 344	128 295	194 394	51
6	3;2	4;3	2;1	2	10 000	32,3	27,0	37,7	7,5	161 741	134 938	188 544	113
12	6	4	2	2	10 000	24,8	18,1	31,5	11,7	123 892	90 311	157 473	57
12	3	4	1	3	10 000	39,0	32,0	46,0	12,6	130 004	106 808	153 200	70
12	8	3	2	1	10 000	34,8	21,0	48,6	49,4	348 271	210 481	486 061	53
12	4	3	1	2	10 000	33,1	24,7	41,6	18,6	165 720	123 474	207 966	66
12	6;4	4;3	2;1	2	10 000	32,4	26,0	38,9	10,7	162 182	130 070	194 294	123

Turnbull lower bound, SB results

mortality		morbidity											
high	**low**	**high**	**low**	**delta**	**in**	**E(WTP)**	**5%**	**95%**	**variance**	**VSC**	**5%**	**95%**	**obs**
0	0	4	2	2	10 000	25,8	18,8	32,9	12,9	129 155	94 005	164 305	69
0	0	4	1	3	10 000	24,6	19,6	29,5	6,4	81 885	65 391	98 379	69
0	0	3	2	1	10 000	18,1	13,7	22,5	5,0	180 847	136 931	224 762	64
0	0	3	1	2	10 000	18,2	12,2	24,2	9,5	91 012	60 794	121 230	54
0	0	4;3	2;1	2	10 000	22,6	17,0	28,1	7,9	112 778	85 233	140 323	123
6	3	4	2	2	10 000	21,2	16,3	26,1	6,2	106 204	81 743	130 665	62
6	1,5	4	1	3	10 000	25,9	18,4	33,4	14,6	86 222	61 237	111 207	66
6	4	3	2	1	10 000	26,7	13,1	40,3	48,2	267 301	131 196	403 406	59
6	2	3	1	2	10 000	27,2	16,5	37,9	29,6	136 061	82 700	189 421	51
6	3;2	4;3	2;1	2	10 000	22,6	18,8	26,5	3,8	113 167	94 063	132 270	113
12	6	4	2	2	10 000	17,0	6,2	27,8	30,2	84 930	31 063	138 798	57
12	3	4	1	3	10 000	25,0	19,0	30,9	9,3	83 210	63 326	103 094	70
12	8	3	2	1	10 000	30,0	18,5	41,4	34,3	299 566	184 721	414 410	53
12	4	3	1	2	10 000	14,9	8,3	21,5	11,2	74 477	41 639	107 315	66
12	6;4	4;3	2;1	2	10 000	24,2	17,8	30,6	10,7	121 093	89 097	153 090	123

Appendix C: Value of a Statistical Life (VSL) for different morbidity and mortality risk reductions

Baseline mortalityrisk	Low mortality risk	Risk reduction	DB E(WTP)	DB Implied VSL (SEK)	SB E(WTP)	DB Implied VSL (SEK)
0	0	0 in 100 million	30,9	-	25,8	-
0	0	0 in 100 million	42,4	-	24,3	-
0	0	0 in 100 million	29,1	-	18,1	-
0	0	0 in 100 million	29,0	-	18,2	-
6	3	3 in 100 million	31,9	33,8 million	21,2	neg
6	1,5	4,5 in 100 million	29,6	neg	25,9	36,1 million
6	4	2 in 100 million	34,2	255,0 million	24,2	305,3 million
6	2	4 in 100 million	32,3	81,7 million	27,2	225,2 million
12	6	6 in 100 million	21,9	neg	17,0	neg
12	3	9 in 100 million	39,1	neg	34,1	109,3 million
12	8	4 in 100 million	34,8	143,9 million	28,6	262,7 million
12	4	8 in 100 million	33,1		13,8	neg

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AgriFood Economics Centre utför kvalificerade samhällsekonomiska analyser inom livsmedels-, jordbruks- och fiskeområdet samt landsbygdsutveckling. Verksamheten är ett samarbete mellan Sveriges Lantbruksuniversitet och Lunds Universitet och syftar till att ge regering och riksdag vetenskapligt underbyggda underlag för strategiska och långsiktiga beslut.

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