Willingness to pay and QALYs: What can we learn about valuing foodborne risk?*

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November 9, 2011

Abstract

This study examines the value of reducing foodborne risk. Research on the valuation of health risk has been dominated by the study of mortality risk. Foodborne risk is, however, in most cases non-fatal and this study therefore focuses on individuals' preferences for reducing morbidity risk related to food consumption. We obtain estimates of the value of a statistical case (VSC) for morbidity risk and the value of a statistical life (VSL) for mortality risk in line with previous findings in the literature. However, we also examine whether WTP is proportional to the expected change in QALYs and estimate a WTP per QALY. We find that WTP is increasing with but not proportional to the change in QALYs. Our monetary estimates are significantly higher than expected and suggest that respondents may have found it difficult to evaluate both a change in risk and health level.

Keywords Contingent valuation, Food safety, QALY, Willingness to pay

*Financial support from VTI and the Centre for Transport Studies, Stockholm, is gratefully acknowledged. The usual disclaimers apply.

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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 US$ 8 and 14 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.

Health related benefits are generally harder to appreciate than costs, however, and policy makers have therefore to a large extent relied on cost-effectiveness and cost-utility analysis (CEA and CUA) to guide health policies. Thus, policies have been evaluated based on the information about their technical efficiency. An example is the use of quality-adjusted life years (QALYs) (Pliskin et al., 1980; Hammitt, 2002) where interventions are evaluated by the cost per expected QALY gained. The use of QALYs, CEA, and CUA separate the decision problem in: (i) compare the cost-effectiveness (CE) of interventions, and (ii) decide on thresholds for CE ratios. That is, the former evaluate the efficiency of the intervention and the latter whether it should be implemented. Hence, it is not necessary to assign monetary values to the interventions' different health outcomes, only the costs, when employing CE as the decision rule. However, since resources are limited, economists in general prefer that allocations be based on benefit-cost analysis (BCA) (Johnson et al., 1997; Pinto-Prades et al., 2009), for which monetary benefit measures are required.

Therefore, there has been a growing interest in examining and estimating monetary preference based values for QALYs (e.g., Gyrd-Hansen, 2003; Pinto-Prades et al., 2009; Mason et al., 2009; Haninger and Hammitt, 2011). Cost-effectiveness analysis evaluating interventions per expected QALY gained is consistent with BCA if QALYs are valid measures of utility and willingness to pay (WTP) per QALY gained is constant in the population (Johannesson, 1995; Hammitt, 2002). Hence, when consistent they will simply provide alternative approaches to present the same information. Moreover, whereas the WTP approach is easy to adopt for mortality risk reductions, since there is little variation in the endpoint, direct estimation of individuals' WTP to reduce morbidity endpoints is infeasible due to the large variation in health states. This has motivated the research on the WTP per QALY where two main approaches have been taken; direct estimation or estimation based on available estimates of the value of a statistical life (VSL). Following the growing interest in monetizing QALYs direct estimation is a more recent line of research and it elicits individuals' WTP for specified interventions where both the duration and the severity may be allowed to vary (Gyrd-Hansen, 2003; Pinto-Prades et al., 2009;

Haninger and Hammitt, 2011). The alternative approach has been to use available estimates of VSL and then to derive a monetary value per QALY gained (French and Mauskopf, 1992; Mason et al., 2009; Tolley et al., 1994). There is a vast amount of VSL estimates and they are also used by policy makers in many countries (Viscusi and Aldy, 2003; Andersson and Treich, 2011) which means that they are easily accessible. QALYs are estimated by combining information about "health-related quality of life" (HRQL) in specific health states with the amount of time spent in that state, and since HRQL is available for many health states, deriving WTP per QALY from VSL estimates is an attractive way to obtain monetary estimates for a wide range of morbidity endpoints. This approach assumes, however, that WTP per QALY is constant, which is why it is important to empirically examine whether this is indeed the case.

In this study we are interested in individual preferences for food safety and in order to obtain monetary estimates of food safety programs aimed at reducing food-related risks two potential methods exist (broadly speaking): the revealed preference (RP) and the stated preference (SP) method. In the RP method consumer decisions on existing markets are used to obtain estimations of willingness to pay (WTP) and its corollaries in risk valuation studies, the value of a statistical case (VSC) and the value of a statistical life (VSL), referring to the marginal WTP for a non-fatal and fatal risk, respectively. The method has primarily been applied to labor markets, where wages for jobs with differing mortality risks have been used to calculate implicit values of risk reductions (Viscusi and Aldy, 2003). 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 hypothetically 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 (Bateman et al., 2002).

The aim of this study is to estimate monetary values for reducing salmonella risk. In addition to the VSC and VSL we also estimate WTP per QALY. Our objective is not only to derive monetary values, but also to examine the empirical relationship between WTP and QALYs, which as explained above is of major policy relevance. For our analysis we prefer the SP approach. One reason is that food safety is an attribute with many features that makes it a candidate for market failure: (i) information about the level of safety is clearly asymmetric in nature, with producers generally having more knowledge (and ability to collect information) than consumers, (ii) 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), and (iii) 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 any 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). The second reason is the flexibility of the SP approach which enables us to design scenarios and extract specific information that we need for our analysis, such as the elicitation of the respondents' subjective health levels in this study.

The remainder of the paper is organized as follows. We start by providing a brief summary of the theoretical framework. Sections 3, 4, and 5 then contain a description of the survey, empirical models used for estimation, and the results. In the final section we discuss and conclude our findings.

2 The theoretical framework

In this study, we are interested in two alternative approaches of valuing reductions in health risks, WTP and QALYs. In the following two sections we briefly describe the two approaches.[1]

2.1 Willingness to pay

The WTP approach is defined in a scenario with uncertain health outcomes; the individual has a certain probability of being sick (s) or healthy (h). The value to an individual of a reduced health risk is estimated by his/her WTP for a reduction in the risk of illness, or alternatively by his/her willingness to accept compensation (WTA) to forgo the risk reduction. The framing of the scenario is usually the state-dependent expected utility model (Rosen, 1988),

$$EU(w,p) = pu_s(w) + (1-p)u_h(w), \tag{1}$$

where p and w denote the baseline probability of being sick and wealth and $u_l(w)$, $l \in \{s,h\}$, the state-dependent utility of wealth. The monetary amount an individual is willing to forgo to reduce the risk level can be derived by totally differentiating Eq. (1) while holding expected utility constant which provides the standard expression,

$$\text{VSC} = \left.\frac{dw}{dp}\right|_{EU \text{ constant}} = \frac{u_h(w) - u_s(w)}{pu_s'(w) + (1-p)u_h'(w)}, \tag{2}$$

where the prime denotes the first derivative. This expression, referred to as the value of a statistical case (VSC), is, thus, the marginal rate of substitution (MRS) between health risk and wealth. When p

[1] See, e.g., Hammitt (2002) for a more comprehensive description.

in Eq. (2) denotes the mortality risk it defines the VSL. Standard assumptions are that: (i) the utility of wealth is non-negative and higher when healthy compared with being sick ($u_h > u_s \geq 0$), (ii) the marginal utility of wealth is positive and higher when healthy ($u'_h > u'_s \geq 0$), and (iii) individuals are weakly risk averse ($u'' \leq 0$). These assumptions are sufficient for the VSC and VSL to be positive and increasing with wealth and baseline risk (Weinstein et al., 1980; Pratt and Zeckhauser, 1996). Moreover, WTP increases with severity and it can be shown that WTP should be nearly proportional to small changes in risk (Hammitt, 2000).

Equation (2) defines the marginal WTP. In many empirical applications the estimated WTP is non-marginal, for instance when respondents in an SP study are asked to state their WTP. For a small (but finite) risk reduction, Δp, VSC and VSL are therefore estimated as the ratio between WTP and Δp,

$$\text{VSC} = \frac{\text{WTP}}{\Delta p}. \tag{3}$$

2.2 QALYs

The QALY framework provides a method to value health interventions. It does not estimate a monetary value, instead the number of QALYs for a specific health profile is given by a quality weighted life span of M periods according to,

$$\text{QALYs} = \sum_{i=1}^{M} q_i T_i, \tag{4}$$

where q_i and T_i refers to the weight and the duration of period i, respectively. The weight q_i is the HRQL representing the quality of health in period i and can be estimated with techniques such as standard gamble or time-tradeoffs (Bleichrodt and Johannesson, 1997) or classification systems such as health utilities index (Feeny et al., 2002) and the EQ-5D (EuroQol Group, 1990). It is usually scaled to be between zero and one with perfect (or excellent) health and a health state equivalent to death equal to one and zero, respectively.[2] It is evident from Eq. (4) that QALYs increase with q_i and T_i and the value of an health intervention is given by the difference in QALYs between the health profiles, i.e. with and without intervention.

Whereas few constraints are placed on WTP, for QALYs to be consistent with individuals' preferences for health several conditions must be satisfied, including, mutual utility independence of health and longevity, constant proportional tradeoff of longevity and health, risk neutrality for longevity, and preferences for tradeoffs between health and longevity independent of income (Pliskin et al., 1980; Hammitt, 2002).

[2]The HRQL can also be below zero if it is assumed that some health states are worse than death.

3 Contingent valuation survey

3.1 Data collection and questionnaire design

The survey was distributed to 1898 randomly selected Swedish citizens. Prior to the main survey, the questionnaire was tested in focus groups and in a pilot. When receiving the questionnaire the respondents where informed that they also had the opportunity to complete the questionnaire on the web. A total of 920 questionnaire were returned after two reminders. Taking into account that 34 survey could not be delivered, because recipients had moved or the address was incorrect, our final response rate was 49.4 percent. Of the 920 returned questionnaires 46 had been filled out on the web. The postal and the web version of the survey were identical but due to differences in design features between the two formats we decided to only use the answers from the postal version to mitigate survey heterogeneity. Moreover, all respondents were offered a lottery ticket (value SEK 25) if the questionnaire was returned and registered successfully. This reward had the effect that 103 empty questionnaires were returned, but these are not included in the response rate reported above.

The questionnaire employed in the main survey comprised five subsections. The objectives of the first section were 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 accuracy of each respondent's risk perception. 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 investigate 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 aim of this exercise was to make the respondents familiar with the hypothetical WTP scenario. After having chosen between the two egg brands, the respondents were given 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 visualized as black squares, was also provided to aid risk communication.[3]

The third and fourth sections contained two WTP scenarios. The WTP scenario of interest to this study, i.e. the one on food safety, was presented in section three of the questionnaire and is described in detail in the following section. Section four of the questionnaire contained questions on respondents'

[3]As indicated in Corso et al. (2001), using such visual aids can greatly enhance the communication of risk levels, leading to a higher sensitivity to the scope of the good to be valued.

preferences for car safety. The findings on WTP for car safety are analyzed in Andersson et al. (2008) and in this paper we report only the results on food safety. Finally, the fifth section contained follow-up questions on respondents' demographics and socio-economics.

3.2 Risk scenario, perceived health, and willingness to pay

As an introduction to the main valuation questions, some basic facts about salmonellosis and how common it is were presented. Three different possible states of the illness were described: mild, moderate and severe. Respondents were informed about the probability of the different states, the severity of the symptoms, 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.

[Table 1 about here.]

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 perfect health. As a reference, the respondents were also asked to value their own current health status on the same scale. We decided to use the VAS, rather than alternative measures, because of its simplicity is well suite for a postal questionnaire.

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 (i.e. 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.

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, i.e. 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 about here.]

Each respondent was asked to value only 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 10 000 white squares, similar to the one that was used in the training section as 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. 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 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 (DB) dichotomous choice method (Hanemann et al., 1991), 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. Using only the respondents' answer to the initial bid is equivalent to only asking the initial question and is referred to as the single-bounded (SB) format.

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-ended 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[4], 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. In the end we decided to include all respondents stating a zero WTP in the analysis, including the 15 that could be considered protesters. It is not clear how to deal with protesters and the motivation for including them, is that they would "say no" if the projects was real (Carson and Hanemann, 2005).

[4]To qualify for this question, a respondent must 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.

4 Empirical models

The following three sections describe the empirical analysis. We first describe how the health variable was calculated. We thereafter describe the non-parametric and then the parametric specifications.

4.1 Health related quality of life

All respondents were presented with the same information regarding probability, the severity, and duration of the different health states related to getting salmonellosis. Hence, it is not possible to examine whether respondents' WTP is proportional to the severity and duration of being sick from salmonellosis. Instead we examine whether WTP is proportional to the change in the probability of getting salmonellosis and the expected change in QALYs.

Based on the respondents' answers on how they perceived different health states, i.e. their current health level and the three specified health levels when sick (mild, moderate, and severe), we can estimate the respondents' expected QALY loss conditional of becoming ill (ΔQALY). Hence, our estimates of ΔQALY are conditional of being ill and the variation between respondents is a result of differences in the perceived health loss if ill (which depends on the respondents' current health and perceived severity of the three health states if ill as assessed using the VAS scale). The total expected health loss conditional of being ill is therefore calculated as follows,

$$\Delta\text{QALY}_i = \sum_{j=1}^{3} (H_i - S_{ij})\, q_j \, \frac{\text{days}_j}{\text{year}} + r_i H_i L_i, \tag{5}$$

where H_i is the perceived current health level with the subscript referring to an individual i, S_{ij} are individual i's perceived health levels for the three different health states, i.e. $j = \{\text{mild, moderate, severe}\}$, and q_j is the probability of health state j when sick from salmonellosis. The last term, i.e. $r_i H_j L_i$, denotes the expected change in QALYs due to premature death with r_i being the conditional mortality risk and L_i the life expectancy, the latter being based on the age and gender of the respondent.

Our analysis of the data from the survey showed that respondents had difficulties evaluating the change in QALYs due to the mortality risk change and we therefore include in the regressions two separate variables for morbidity and mortality. Given the values from the survey on probability and duration the expected health loss related to the morbidity risk is calculated as,

$$\Delta\text{QALY}_{morb,i} = (H_i - S_{i,\text{mild}})0.75\frac{3}{365} + (H_i - S_{i,\text{mod}})0.23\frac{7}{365} + (H_i - S_{i,\text{sev}})0.02\frac{20}{365}, \tag{6}$$

whereas the equivalent for mortality risk is,

$$\Delta\text{QALY}_{mort,i} = r_i H_i L_i. \tag{7}$$

4.2 Non-parametric estimation

Non-parametric estimation offers an advantage over parametric estimation since it does not rely on distributional assumptions made by the analyst. In this study we use Turnbull's lower bound (TB) estimator of WTP (Turnbull, 1976).[5] It is a conservative estimator of WTP and of VSL that counteracts the tendency of respondents in SP studies to overstate their WTP (Blumenschein et al., 2008), usually referred to as hypothetical bias. A drawback of using the TB is that it will not necessarily generate a mean WTP that is proportional to the size of the risk reduction, even if the true WTP is proportional. Hence, when using TB we cannot use proportionality of WTP to risk reduction as a validity test.

Let b_j and $F(b_j)$ denote the bid and the the proportion of no answers to the offered bid. The TB mean WTP is estimated by

$$E_{TB}[WTP] = \sum_{j=0}^{J} b_j \left(F(b_{j+1}) - F(b_j)\right), \tag{8}$$

where it is assumed that $F(0) = 0$ and $F(\infty) = 1$, i.e. no respondent has a negative or infinitive WTP, and that $F(b_j)$ is weakly monotonically increasing. When $F(b_j)$ is non-monotonic, the pooled adjusted violators algorithm (PAVA) needs to be used prior to estimation of Eq. (8) (Turnbull, 1976; Ayer et al., 1955). Equation (8) can be used for interval data when bid ranges are non-overlapping as in the SB elicitation format. The bid levels in our DB format result in bid ranges that are overlapping, however. We therefore have to use Turnbull's self consistency algorithm (TSCA). In this case the TSCA divides the bids into non-overlapping "basic intervals" and allocates observations to each interval through an iteration process until the survival function converges (Bateman et al., 2002, pp. 232-237).[6]

In order to test how excluding different risk reduction levels, based on various exclusion criteria, may affect the VSC and VSL values calculated from these TB estimations of E(WTP), Monte Carlo simulation methods were used. In these simulations, which were based on 100 000 iterations each, both the number of respondents in each subsample included as well as the mean and variance of each E(WTP) estimation were accounted for. In this way weighted means and dispersion measures for different combinations of risk reduction levels were possible to estimate.

4.3 Parametric estimation

The main purpose of the parametric estimation is to examine how different covariates influence WTP, not to examine the underlying structural model. Since the coefficient estimates of the bid-function approach show the marginal impact on WTP of different covariates (Cameron and James, 1987; Cameron, 1988;

[5]The Turnbull lower bound estimator is also known as the Kaplan-Meier estimator (Carson and Hanemann, 2005).

[6]We used a conversion criterium equal to 0.005.

Patterson and Duffield, 1991; Cameron, 1991; Bateman et al., 2002), our parametric models are based on the bid-function approach (instead of the utility-function approach Hanemann (1984)).

We assume a multiplicative model. Taking logs results in the econometric model estimated,

$$\ln(WTP_i) = \alpha + \beta_1 \ln(\Delta p_{morb,i}) + \beta_2(\Delta \text{QALY}_{morb,i}) + \beta_3(\Delta \text{QALY}_{mort,i}) + \sum_{k=4}^{K} \beta_k f_{k-1}(x_i) + \varepsilon_i, \quad (9)$$

where $f(x)$ defines dummy variables and the natural logarithm of continuous variables. Proportionality between WTP and a change in risk and QALYs implies $\beta_1 = \beta_2 = \beta_3 = 1$.[7] Preliminary analysis showed that a normal distribution fits our logged data best, and we therefore estimate a log-normal model (Alberini, 1995).

5 Results

This section is divided into three main sections. We first present results from the survey based on descriptive statistics. Thereafter, we show our results from the non-parametric analysis and finally the results from the parametric analysis. We also enforced an exclusion rule based on survey comprehension. This stated that 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 conditional on getting salmonellosis than without, or (ii) if a respondent had given inconsistent answers to the double-bounded dichotomous choice WTP question (see paragraphs below).[8] In the first part of the survey respondents were asked whether and if so how often they eat chicken. If they stated that they did not eat chicken they were asked to "value a food with similar characteristics as chicken". We found that about 5 % never eat chicken. We considered dropping these respondents from the sample, but our analysis showed that including them had only minor effects on the quantitative results and no effect on the qualitative results. We therefore decided to include them in the final analysis.

5.1 Descriptive statistics

5.1.1 Demographics, socio-economics, and perceived risk and health

The description of the respondents and the general Swedish population is shown in Table 3. Most of the statistics come very close to the corresponding values for the general population. The most obvious

[7] WTP will then be strictly proportional to Δp and ΔQALY since

$$\begin{aligned} WTP_i &= \exp(\alpha)(\Delta p_{morb,i})^{\beta_1}(\Delta \text{QALY}_{morb,i})^{\beta_2}(\Delta \text{QALY}_{mort,i})^{\beta_3} e^{\varepsilon_i}, \\ \ln(WTP_i) &= \alpha + \beta_1 \ln(\Delta p_{morb,i}) + \beta_2 \ln(\Delta \text{QALY}_{morb,i}) + \beta_3 \ln(\Delta \text{QALY}_{mort,i}) + \varepsilon_i. \end{aligned}$$

[8] An alternative would have been to use answers from the training part to detect probability comprehension in line with Krupnick et al. (2002) and Alberini et al. (2004). However, in our example 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.

deviation regards gender, with 58 % of respondents being female as compared to about 50 % in the general population. The income level 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. Finally, the household size is larger in our sample compared with the general population. Even if the population is not immediately comparable to the survey data, because the population data is not up-to-date (1990) and our sample is restricted to the age interval 18-74, the difference in household size between our sample and the general population could be a result of non-single households having more interest in food safety.

[Table 3 about here.]

Table 4 tabulates descriptive statistics for some of the more material questions of the main survey. Respondents overstate in question 2 the risk for annual food-related illness; 16 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. Moreover, females in particular overstate the risk with the gender difference being statistical significant. 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[9] (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 Swedish 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 duration may vary considerably between studies. In Mauskopf and French (1991), 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.

[Table 4 about here.]

5.1.2 Self-certified 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 considered their own knowledge to be above

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

average (33 %) rather than below average (12 %). Table 5 cross-tabulates the stated knowledge by the responses to some other related survey questions. Some interesting aspects may be noted.

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 % compared to 18 % for those having stated a lower than average knowledge) and for ranking food safety as a death cause correctly (57 % vs 47 %). Thus, self-perceived knowledge seems to be able to predict risk perception ability to some degree.

Judging 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-perceived limited knowledge overstate the risk of foodborne illness to a larger degree than others do, and thus should, ceteris paribus, place a higher value on food safety relative to the price. 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 perceived risk of food contamination 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 the question on risk perception and how important food safety is compared to the price when shopping.

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-assessed 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 5 about here.]

5.2 WTP distribution and non-parametric analysis

In this section we provide estimates and distributions of mean WTP, VSC and VSL based on choices made by respondents in the main survey. Point estimates are based on the TB non-parametric measures discussed above, while the distributions are assessed using Monte Carlo simulation procedures.

5.2.1 Distribution of responses

The number of actual respondents in each of the 60 groups[10] as well as the proportion rejecting the proposed bid (in the first round of yes/no responses) are summarized in Table 6. Notably, in some

[10]There were 60 combinations of mortality risks, morbidity risks and bid amounts.

combinations of morbidity risk and mortality risk reduction, the percentage of the sample rejecting the proposed bid does not increase monotonically with the bid level as would be predicted by economic theory. As was discussed, 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.

[Table 6 about here.]

Apart from this procedural modification, we also want to analyze 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 yes/no responses are independent. Interestingly, rejecting the null hypothesis seems to be negatively correlated with the mortality risk reduction size, with rejections at the 5 % level for the lowest risk levels (1 and 6 in 100 million), but with three non-rejections at the higher levels (12 in 100 million), respectively. 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.[11]

5.2.2 Estimation of mean WTP

Turnbull non-parametric estimations of mean WTP for each of the 12 different combinations of mortality risk and morbidity risk in the survey are summarized in Table 10 in the appendix. A graphical presentation provides a better understanding of the main results and we therefore report them here as Figures 1 and 2. The figures (and the table) include estimations for both the SB and the DB formats as described above.

Normally, there would be at least two hypotheses one would expect these WTP values to comply with regarding the morbidity risk, 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 and Graham, 1999), so that WTP should change nearly proportionately with the risk reduction size

[11] Estimations of VSC and VSL for alternative risk reduction combinations available upon request from the authors.

(strong scope sensitivity). However, the TB estimators will not necessarily adhere to this criterion even theoretically, which implies that we will focus entirely on the weak scope sensitivity requirement here.

Moreover, since the WTP question, in addition to the morbidity risk, also covered a mortality risk, there are two additionally requirements on WTP that generally 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 increasing the morbidity risk reduction would lead to an increase in WTP. 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 mean WTP.

The findings from the survey reveal mixed results. Focusing on the SB format shown in Figure 1, with one exception we find that mean WTP is increasing with mortality risk.[12] Regarding sensitivity to scope for the morbidity risk, we find only for those respondents where mortality risks are absent (that is, where we have a 0 in 100 million base mortality risk) a mean WTP that is increasing monotonically with the size of the morbidity risk reduction. For those groups with a positive mortality risk we find U-shaped relationships.

[Figure 1 about here.]

The findings from the DB format reveal a similar result for those respondents being presented with a 0 mortality risk, i.e. a monotonically increasing WTP with the size of the morbidity risk reduction. When respondents were also presented with a mortality risk, mean WTP either followed a U-shape or was even declining. Moreover, the DB format produce results that suggest mean WTP is not increasing with the mortality risk, instead results are mixed. These results suggest, as in the previous section, that the inclusion of the mortality risk makes it increasingly difficult to respond to the WTP question resulting in answers not in line with the theoretical predictions.

[Figure 2 about here.]

5.2.3 Value of a statistical case and life

Since we have finite risk reductions, the VSC is estimated according to Eq. (3) by dividing the mean WTP by the morbidity risk reduction facing the various subsamples. 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 presented with a zero mortality baseline risk. Moreover, the VSL is calculated according to Eq. (3) by using the mortality risk reductions for Δp. To minimize confounding effects

[12] Mean WTP is equal when the change in the morbidity risk is 2 in 10 000 and the mortality risk is either 0 or 6 in 100 million.

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 WTP values can be interpreted as the WTP for reducing mortality risk only.

Our preferred estimates of VSC and VSL are shown in Table 7. The estimated VSC point values for a case of salmonellosis are SEK 112 451 and SEK 150 339 for the SB format and the DB format, respectively. For each elicitation method, two different VSL estimates were possible to calculate according to the above criteria.[13] To obtain a unit measure for VSL, 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 13.6 million using the SB method, and SEK 32.3 million using the DB method. Of these values, the SB estimates provide the preferred values, because of the scope insensitivity of the DB format discussed earlier.

[Table 7 about here.]

The distribution for the two formats of the VSC is also visualized in Figure 3. Monte Carlo simulations using weighted averages of all the different VSC values (i.e. for all possible risk reduction levels) were conducted, also 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 121 045 and 182 966 using the SB and DB format, respectively. Thus including all estimations increases the VSC values by 8 to 22 %, depending on the format considered.

[Figure 3 about here.]

The distributions for the SB and DB formats based on the Monte Carlo simulation for VSL are presented in Figure 4. As indicated in Figure 4, neither of the estimates are statistically significant. The reason for the magnitude of the variation lies in the design of the questionnaire where four different mean WTP values (each with its own variance) had to be used for each VSL estimation.

[Figure 4 about here.]

Calculations of the 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 CVM study to calculate a VSC of salmonellosis following chicken consumption

[13]Considering that we only use morbidity risk reductions of 2 in 10 000 in accordance with previous considerations.

of US$ 19 500 in 2006 price level, which is within the range obtained in this study (US$ 15 300 and 20 400 using the SB and DB format).[14] 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 US$ 8 300 and 16 100 for a statistical case, while households with children were prepared to pay slightly more, between US$ 10 800 and 16 400 (in 2004 price level). Their values are in general somewhat lower than the values in this study, but differences regarding severity (e.g., the chance of needing to see a doctor) and duration of illness may account for most of this difference.

In the only other VSL study of poultry-borne salmonellosis found in the literature, VSL was estimated to US$ 10.8-22.6 million (Henson, 1996).[15] These estimates are higher than those obtained in the present study which amount to US$ 1.85 and 4.39 million using the SB and DB methods, respectively. They are, however, in line with values from the Swedish transport sector where the current official policy value is US$ 2.86 million (SIKA, 2008) and where values in the range of US$ 1.81–7.34 million have been found in other studies (Persson et al., 2001; Andersson, 2005; Hultkrantz et al., 2006; Johannesson et al., 1996).

5.2.4 WTP per QALY

Following the approach above we also estimate our WTP per QALY based on the TB estimates. To estimate the WTP per QALY we use information about mean WTP (E[WTP]), the change in morbidity risk (Δp_{morb}), and change in QALYs from being sick or dead (ΔQALY_{morb} and ΔQALY_{mort}), and the equation is as follows,

$$\text{WTP}_{\text{QALY}} = \frac{\text{E[WTP]}}{\Delta p_{\text{morb}} \times (\Delta\text{QALY}_{morb} + \Delta\text{QALY}_{mort})}. \tag{10}$$

Thus, the change in mortality risk is given by the survey design and in line with our analysis above we restrict our analysis to a change equal to 2 in 10 000, whereas the two other variables are given by the survey results.

Three estimates based on the SB format are shown in Table 8; all with the same morbidity risk reduction and with a 0, 6, or 12 in 100 million mortality risk. The results reveal a significant drop between the scenario with no mortality risk and the two scenarios with a mortality risk. The WTP per QALY for these two scenarios are about 30 % and 40 % of the scenario with no mortality risk. The reason for this significant effect is because, whereas the inclusion of the mortality risk increase the change in QALY from consuming the safer chicken, the mean WTP is fairly constant between the scenarios.

[14] Average exchange rates 2006, £ 1 = US$ 1.840 and SEK 1 = US$ 0.136 (http://www.riksbank.se, 2011-10-27) and UK consumer price index (CPI) for 1993-2006, 1.246 (stats.oecd.org, 2011-10-27).

[15] Converted to US$ and 2006 price level, see footnote 14.

[Table 8 about here.]

The levels of the WTP per QALY found in this study (US$ 1.1–3.5 million) are considerably higher than the values for policy evaluation used by health authorities in the UK and USA, which are in the ranges £ 20 000–30 000 and US$50 000–100 000 (Shiroiwa et al., 2010). They are also higher than other studies trying to estimate the WTP per QALY. For instance Gyrd-Hansen (2003) and Pinto-Prades et al. (2009) who used approaches where respondents were directly asked about their WTP for a health gain found higher end estimates of US$ 16 200 and US$ 98 600.[16] Haninger and Hammitt (2011) used a similar analysis as ours and due to a non-proportional WTP they found estimates in the range US$156 000–5 587 000 in 2004 price level. Combing the morbidity with a mortality risk seem to have created difficulties answering the WTP question in our study, and our estimate of US$ 3.5 million is therefore the most relevant one for a comparison. The estimators in our study and Haninger and Hammitt (2011) differ, non-parametric lower bound in ours and parametric medians in theirs, but both studies find that the ex ante approach can produce quite high estimates of WTP per QALYs compared to both policy values and ex post approaches.

5.3 Parametric 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 and based on the results above we focus on the SB format.[17] Table 9 shows the regression results for three models; *Model 1* includes only variables for the reduction in the probability of illness and changes in QALYs, *Model 2* adds demographic and socio-economic variables, and *Model 3* in addition to those also adds variables defining behavior and perception related to food safety.

[Table 9 about here.]

In *Model 1* we find the expected results that WTP is positively related to the size of the change in the morbidity risk ($\ln(\Delta p_{morb})$) and the non-mortal QALY change ($\ln(\Delta \text{QALY}_{\text{morb}})$). We do not find any statistical relationship between WTP and the change in QALYs related to the mortality risk ($\ln(\Delta \text{QALY}_{\text{mort}})$). This contradicts our theoretical expectations but is in line with our expectations based on the non-parametric analysis which revealed difficulties for respondents when the mortality risk was

[16] Average exchange rates 2006, DKK 1 = US$ 0.168 and €1 = US$ 1.255 (http://www.riksbank.se, 2011-10-27) and the Danish CPI for 2001-2006, 1.097 (stats.oecd.org, 2011-10-27). Pinto-Prades et al. (2009) examined the proportionality of the WTP to the change in QALY, and order effects. Since they found both order effects and that WTP was not proportional to duration, change in QALY, and the risk reduction, they have a large variation in their reported values. (No information on which year values refer to in Pinto-Prades et al. (2009).)

[17] Regression results for the DB format available upon request from the authors.

included in the scenario. Preliminary analysis including one variable representing the change in QALY for both morbidity and mortality risk resulted in a positive but statistically insignificant coefficient estimate. We therefore decided to split the variable into two separate ones to examine why the result was not in line with our expectations. Regarding proportionality we find that $\ln(\Delta p_{morb})$ and $\ln \Delta \text{QALY}_{\text{morb}}$ are not close to one, and thus, WTP is not proportional to either. We cannot, however, reject the hypothesis that $\ln(\Delta p_{morb})$ is equal to one, i.e. we cannot reject that WTP is indeed proportional to the change in mortality risk in *Model 1*.

Including the demographic and socio-economic variables in *Model 2* have only minor effects on the coefficient estimates for $\ln(\Delta p_{morb})$ and $\ln \Delta \text{QALY}_{\text{morb}}$. The former no longer is statistically significant, though. Among the variables describing individual characteristics we find that WTP is positively correlated with being a female, age, and household size. 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; Haninger and Hammitt, 2011; Buzby et al., 1995). The general predicted effect from age is largely indeterminate (Hammitt, 2005). Our results suggest that older respondents are willing to pay more to reduce their salmonella risk. The result on household size is somewhat stronger than in other studies (Hammitt and Haninger, 2007; Haninger and Hammitt, 2011; Buzby et al., 1995). 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 one self (Andersson and Lindberg, 2009; Hammitt and Haninger, 2007, 2010).

Income is expected to have a positive impact on WTP for two reasons. Firstly, the potential utility loss is greater the wealthier the individual. Secondly, spending a specific amount causes less utility loss due to diminishing marginal utility (Andersson and Treich, 2011). We get a positive but insignificant coefficient estimate. 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, 2011). Moreover, we find no evidence that WTP is influenced by the respondents' education level. If any we expected a negative relationship. 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).

Adding the variables defining behavior and perception related to food safety in *Model 3* does not change any of the results from *Model 2* apart from that $\ln(Age)$ becomes statistically insignificant. Among those new variables included we find that eating chicken (a dummy variable coded to 1 if respondent eats chicken) is negative and significant, 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 who did not eat chicken, did so partly because of its well-known association with foodrelated illnesses. Those respondents would thus assign a higher value on avoiding food-related illnesses than average consumers, which would account for the negative sign found.

Concern about food-related illnesses when shopping and ranking safety higher than price both have the expected positive signs, and are both significant. Reading descriptions on food labels indicates a more general awareness of and interest in nutrition and healthiness related to food than the concern variable. This variable turns out to be statistically insignificant. Finally, on the basis of similar reasoning as eduction level we expected respondents with a better risk knowledge to be willing to pay less for the safer chicken. Indeed, respondents that ranked different causes of death accurately, and thus gave evidence of an enhanced awareness of the subject area and related probabilities, were less inclined to pay for food safety.

6 Discussion

This is the first Swedish SP study where the WTP for food safety has been estimated. We have used the results from a Swedish CVM survey to estimate the mean 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 analysis of the relationship between WTP, the size of the risk reduction, and QALYs.

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. Our estimated mean WTP and "mortality premium" translates to preferred estimates of VSC and VSL equal to SEK 112 451 and SEK 13.6 million, respectively. Our VSC is in line with results from a UK study (Henson, 1996) but slightly higher than estimates obtained in US studies (Hammitt and Haninger, 2007; Haninger and Hammitt, 2011). Differences in the valuation scenarios (duration/severity of different illness states) as well as country-specific factors can probably account for these differences, though. The obtained VSL in our study is in line with other estimates and with the policy values in use for transport in Sweden. It is important to remember that the WTP for a mortality risk reduction was not statistically significant. However, due to the fact that no policy value exists in Sweden today for preferences related to food safety, and that our values are in line with other estimates and policy values, we believe that the VSL obtained in this study is a good indicator of Swedish consumers' preferences for food safety related to salmonellosis.

We found weak evidence of scale sensitivity. The non-parametric analysis suggests a monotonic

relationship between WTP and the magnitude of the morbidity risk reduction when the mortality risk is equal to zero, but non-monotonic when respondents are also presented with a positive mortality risk. In the parametric analysis we find a positive relationship where the size of the coefficient estimate is in line with previous findings in the literature, i.e. positive but non-proportional. Our estimate is fairly stable between our three regressions, but only statistically significant in one of them. In the same regression it is also not statistically significantly different from one, i.e. it is in line with our theoretical predictions. However, overall our results only show a weak relationship. One explanation could be a too low variation in the risk levels, which translates into a too low variation in the differences in risk changes between the scenarios. When the survey was developed one objective was to create a realistic scenario. Choosing risk levels close the actual ones at the time of the survey may have increased realism, but may have increased the difficulty for respondents to distinguish the difference between them.

An important contribution of this paper is the analysis of the WTP per QALY. We found a strong relationship between WTP and the size of the QALY change related to a non-fatal outcome. We could, however, reject that it was proportional. This result is in line with previous findings (Pinto-Prades et al., 2009; Haninger and Hammitt, 2011). We did not find any statistically significant relationship between WTP and a change in QALYs related to mortality risk. This is contrary to our expectations and could be a result of the very small mortality risk presented to the respondents, per 100 million, or that the cognitive task of evaluating both a morbidity and mortality risk was too cumbersome for the respondents. Regarding the monetary estimates of a WTP per QALY we find significantly higher values than those used by policy makers and estimates from some recent studies (Shiroiwa et al., 2010; Gyrd-Hansen, 2003; Pinto-Prades et al., 2009), but within the range of estimates from a recent study using a similar survey design as ours (Haninger and Hammitt, 2011).

Our high estimates of a WTP per QALY may suggest problems related to our framing of the risk scenario to elicit individuals' preferences for gains in QALYs. In our study we chose an ex ante scenario, i.e. the respondents faced a certain risk of illness with an uncertain outcome of the severity of the illness. This is a relevant scenario for many health risks including food safety. Haninger and Hammitt (2011) also used an ex ante approach and found similar qualitative results. Thus, eliciting the WTP per QALY based on an ante scenario may be difficult, since respondents will have to evaluate the combination of the risk of getting sick and the outcome of the sickness.

In addition to the estimates of VSC and VSL that can be used for policy evaluations the main contribution of this study is methodological. The aim of the study was to estimate the VSC, VSL, and WTP per QALY based on answers from a CVM study. Our results suggest that we may have had too much confidence in how much respondents can cope with in an SP study. We know from previous

research that individuals find it hard to evaluate small probabilities. In this study respondents were asked to evaluate one risk reduction and the distribution of different health states if getting salmonellosis, and in addition some subsamples were presented with a mortality risk. As described above we only found a WTP increasing with the size of the risk reduction among those respondents who were not presented with the mortality risk, which suggests that the evaluation of two risk changes may have been to challenging to the respondents.

Appendix: Mean non-parametric WTP

[Table 10 about here.]

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Figure 1: Mean WTP based on Turnbull lower bound estimator: Single bounded format

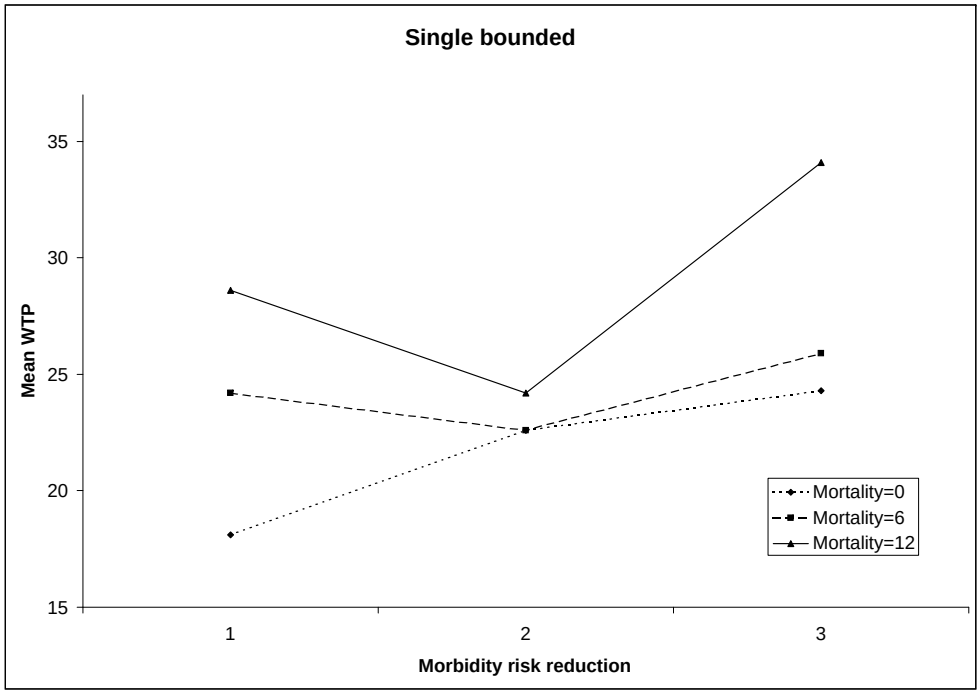

Figure 2: Mean WTP based on Turnbull lower bound estimator: Double bounded format

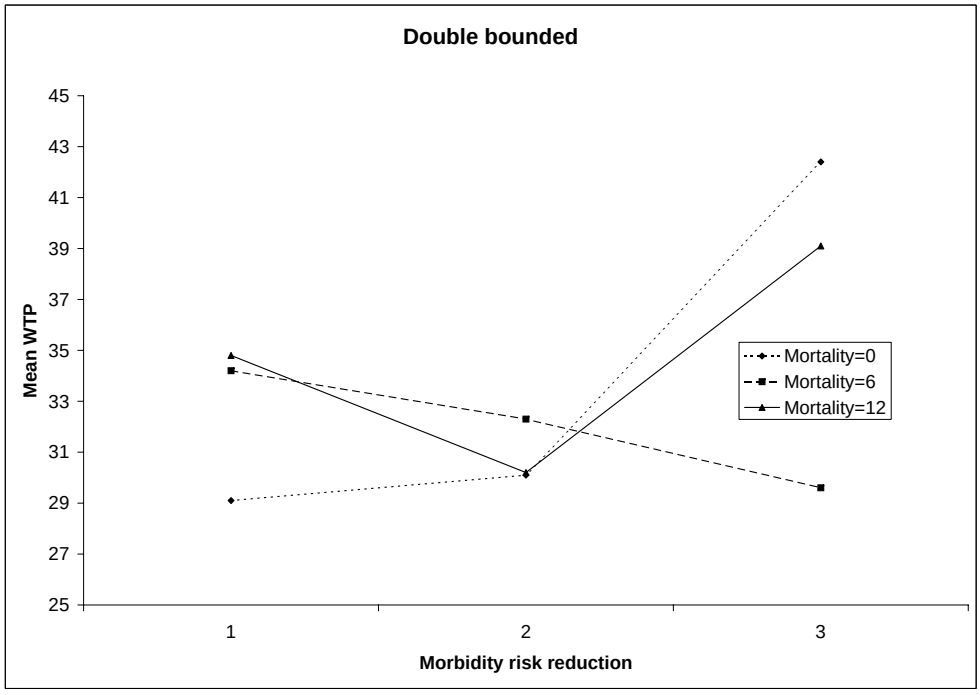

Figure 3: Value of a statistical case (VSC): Monte Carlo simulation based on Turnbull estimator

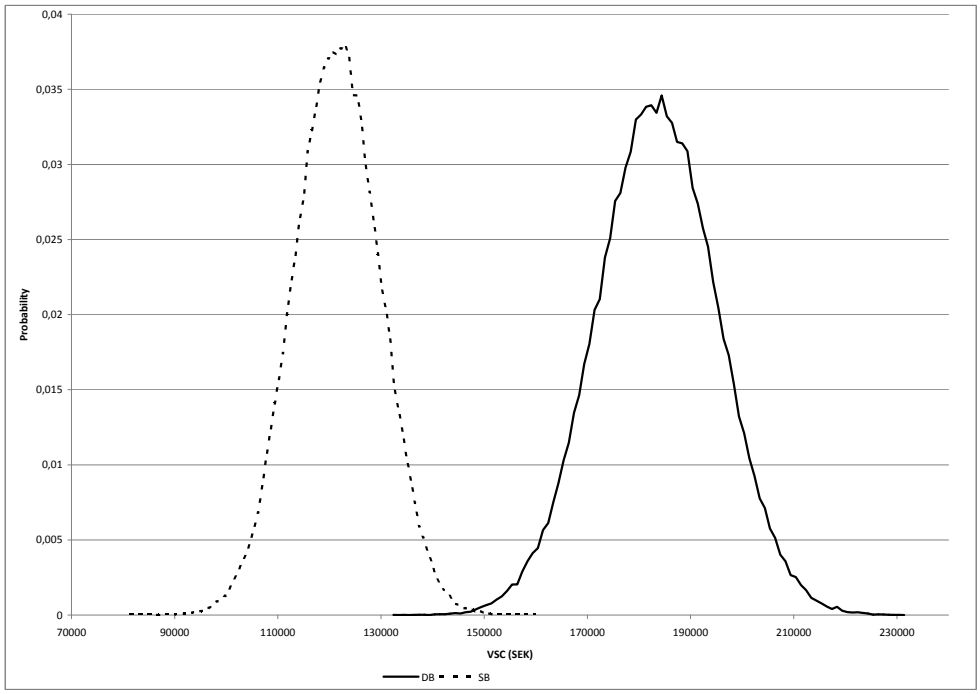

Figure 4: Value of a statistical life (VSL): Monte Carlo simulation based on Turnbull estimator

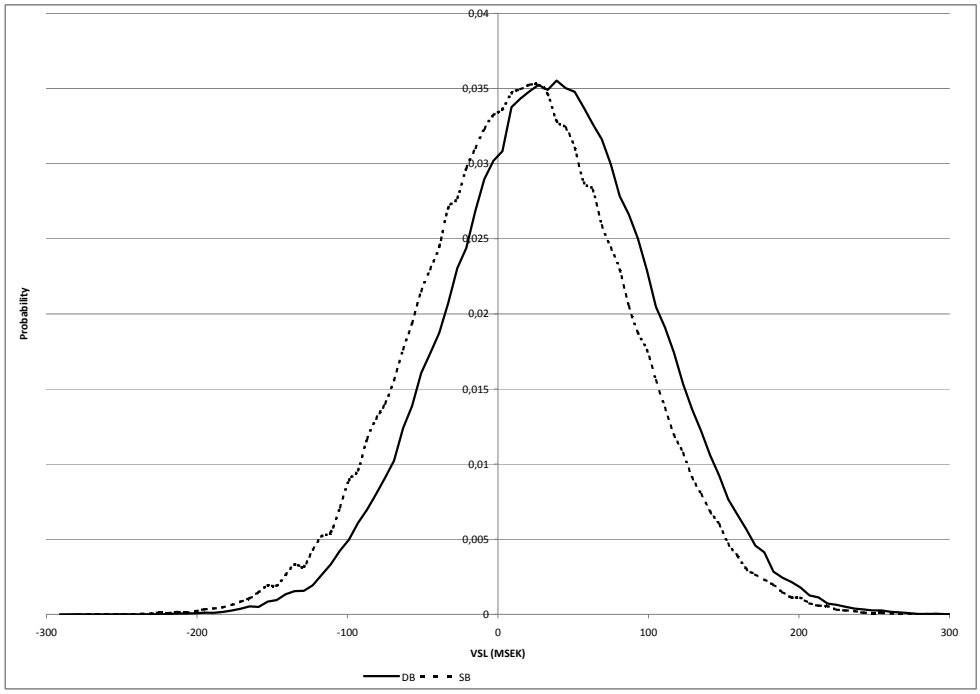

Table 1: The three different variants of salmonellosis and their respective probabilities, symptoms and duration

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

Table 2: Different combinations of morbidity and mortality risk reductions used in the survey

Morbidity risk reductions	Baseline mortality risk		
	0 in 100 million	6 in 100 million	12 in 100 million
4→2 in 10000 (2 in 10000)	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 10000 (3 in 10000)	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 10000 (1 in 10000)	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 10000 (2 in 10000)	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)

Table 3: Descriptive Statistics of respondents

Variable	**Mean**	**(Std. Dev.)**[a]	**Population**
Gender (0=Male, 1=Female)	0.58	(–)	0.5
Age of respondent	47.28	(15.65)	44.7
Income	24 982	(13 152)	22 639
Highest education level			
Elementary school	0.2	(–)	0.17
Secondary school	0.44	(–)	0.48
University	0.35	(–)	0.35
Household size	2.8	(2.97)	2.1
Marital status			
Married	0.57	(–)	0.35
Single	0.19	(–)	0.2
Cohabitee/ other	0.25	(–)	0.45

a: For dummies, std.dev.$(x) = \sqrt{\bar{x}(1-\bar{x})}$.

Table 4: Risk perception, knowledge, and subjective health assessment

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)[a]			
Mild variant	72	71	71
Moderate variant	52	52	52
Severe variant	32	31	32

a: 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.

Table 5: Tabulation self-certified knowledge of food safety

Q4: Self-certified knowledge of food safety	limited (12 %)	average (55 %)	extensive (33 %)
Q2: (See previous table)	18	15	16
Q3: (See previous table)			
- 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 = price most important, 7 = 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

Table 6: Distribution of responses to first bid for the different combinations of bids, morbidity and mortality risk

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	9.00	0.333	12.00	0.333	6	0.333	20	0.250
40	11	0.727	16.00	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	-
$\chi^2_{(4)}$	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	7.000	0.714	6	0.667	28	0.600
Total	62	-	63	-	57		51		113	
$\chi^2_{(4)}$	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	-
$\chi^2_{(4)}$	9.23		7.33		8.69		27.03		30.36	
p-value	0.06		0.12		0.07		<0.01		<0.01	

Table 7: Value of a Statistical Case (VSC) and Life (VSL)

	E(WTP)	VSC/VSL	2.5%	97.5%
		Morbidity risk[a]		
Single bounded	23	112 451	88 650	136 246
Double bounded	30	150 339	127 152	173 657
		Mortality risk[b]		
Single bounded	0.73	13 628 436	-120 590 917	148 703 089
Double bounded	1.72	32 265 964	-99 303 558	163 693 430

In SEK 2006 price level. Based on TB estimator and estimated only for a 2 in 10 000 change in morbidity risk.
a: Estimated only with zero mortality risk.
b: Monte Carlo simulation. E(WTP) refers to "mortality premium".

Table 8: WTP per QALY

Morbidity risk reduction	Mortality risk baseline	Mean WTP	ΔQALY		WTP per QALY (SEK million)
			Morbidity	Mortality	
2	0	22.6	0.0044	0	26.00
2	6	22.6	0.0044	0.0061	10.76
2	12	24.2	0.0041	0.0110	8.00

Mean WTP from Table 10.
WTP per QALY estimated with Eq. (10).

Table 9: Regression results single-bounded

Variable	Model 1	Model 2	Model 3
Baseline risk$_{\text{morb}}$	-0.784	-0.450	-0.345
	(0.817)	(0.869)	(0.829)
ln(Δp_{morb})	0.547*	0.469	0.370
	(0.297)	(0.312)	(0.297)
ln(ΔQALY$_{\text{morb}}$)	0.430***	0.497***	0.337**
	(0.158)	(0.181)	(0.168)
ln(ΔQALY$_{\text{mort}}$)	-0.011	0.021	0.033
	(0.040)	(0.042)	(0.040)
ln(Income)[a]		0.226	0.094
		(0.168)	(0.167)
Female (0=M, 1=F)		0.512***	0.384**
		(0.179)	(0.175)
ln(Age)		0.689***	0.376
		(0.250)	(0.247)
University highest		-0.159	-0.157
		(0.185)	(0.181)
Household size		0.162**	0.132*
		(0.072)	(0.071)
ln(Health status)		-0.173	-0.124
		(0.584)	(0.568)
Eats chicken			-0.301**
			(0.135)
Concern[b]			0.454*
			(0.253)
Price vs. Safety[c]			0.472***
			(0.079)
Correct ranking[d]			-0.400**
			(0.199)
Reads description			-0.120
			(0.123)
ln(Frequency)[g]			0.022
			(0.077)
Intercept	6.280***	1.989	1.459
	(1.315)	(3.567)	(3.504)
N	671	618	601
Pseudo-R^2	0.11	0.21	0.30

Significance levels: * 10 %, ** 5 %, *** 1 %
a: Income per consumption unit
b: Concerned about illnesses like salmonellosis when shopping
c: Coded on a scale from 1 (price much more important) to 7 (safety much more important)
d: Dummy coded as 1 if respondent ranked the probabilities of different causes of death correctly
e: Stated probability of getting food contamination annually

Table 10: Estimations of E(WTP) using TB estimator for the DB and SB formats

Mortality		Morbidity		Single bounded			Double bound		
High	Low	High	Low	E(WTP)	0.025	0.975	E(WTP)	0.025	0.975
0	0	4	2	25.8	18.8	32.9	30.9	15.4	46.4
0	0	4	1	24.3	19.4	29.2	42.4	33.2	51.7
0	0	3	2	18.1	13.7	22.5	29.1	21.8	36.3
0	0	3	1	18.2	12.2	24.2	29.0	22.1	35.9
*	*	4;3	2;1	22.6	17.0	28.1	30.1	25.4	34.8
6	3	4	2	21.2	16.3	26.1	31.9	24.0	39.8
6	1.5	4	1	25.9	18.4	33.4	29.6	23.8	35.3
6	4	3	2	24.2	13.1	35.3	34.2	27.0	41.4
6	2	3	1	27.2	16.5	37.9	32.3	25.7	38.9
*	*	4;3	2;1	22.6	19.0	26.2	32.3	27.0	37.7
12	6	4	2	17.0	6.2	27.8	21.9	16.8	27.1
12	3	4	1	34.1	24.5	43.7	39.1	32.3	45.9
12	8	3	2	28.6	17.5	39.7	34.8	21.0	48.6
12	4	3	1	13.8	7.6	19.9	33.1	24.7	41.6
*	*	4;3	2;1	24.3	18.4	30.2	30.2	24.2	36.2

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