Estimating the demand for risk reduction from foodborne pathogens through food irradiation

Die Nachfrage nach risikoärmeren Lebensmitteln durch Lebensmittelbestrahlung

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Abstract

In this study the response of US consumers to irradiation in meat processing is examined. Despite scientific evidence of the effectiveness and safety of irradiation, meat processors and retailers have been slow to market irradiated beef products due to uncertainty about consumer acceptance. The objective of this study was therefore to examine the factors influencing consumer demand for irradiation using data from a contingent valuation (CV) survey with 819 households in eight midwestern US states. The analysis focused on the value of reduced risk from *Escherichia coli O157:H7* and *Salmonella* in ground beef consumption. Respondents were on average willing to pay a price premium of 22 cents/lb. for safer ground beef. Willingness to Pay (WTP) amounts were influenced by protective actions at home and varied partly with the scope of the risk reduction.

Key words

food safety; irradiation; Willingness to Pay (WTP); Contingent Valuation (CV)

Zusammenfassung

In der vorliegenden Arbeit wurde die Zahlungsbereitschaft amerikanischer Verbraucher für bestrahltes Hackfleisch untersucht. Obwohl aus Expertensicht die Lebensmittelbestrahlung als effektiv und sicher eingestuft wird, brachten Fleischverarbeiter sowie der Handel in den USA bestrahltes Rindfleisch nur zögerlich auf den Markt. Dies ist insbesondere auf eine hohe Unsicherheit der Anbieter bezüglich der Verbraucherakzeptanz zurückzuführen. Ziel der Arbeit war es daher, Determinanten der Nachfrage nach bestrahlten Fleischprodukten herauszuarbeiten. Dazu wurde eine Verbraucherbefragung auf Basis der kontingenten Bewertung mit 819 Haushalten in acht US-Staaten durchgeführt. Die Analyse konzentrierte sich auf die Zahlungsbereitschaft der Verbraucher für ein reduziertes Risiko von *Escherichia coli* O157:H7 und *Salmonellen* im Hackfleischkonsum. Befragte waren durchschnittlich bereit, einen Aufpreis von 22 Cents/ Pfund für bestrahltes Hackfleisch zu zahlen. Die Zahlungsbereitschaft war durch private Vorsorgemaßnahmen beeinflusst und variierte zum Teil mit der Höhe der Risikoreduktion.

Schlüsselwörter

Lebensmittelsicherheit; Bestrahlung; Zahlungsbereitschaft; kontingente Bewertung

1. Introduction

Foodborne disease caused by *Escherichia coli* (*E. coli*) O157:H7 and *Salmonella* in red meats, especially ground beef, has been acknowledged for many years to be a serious health problem. US Department of Agriculture (USDA) scientists estimate that there are at least 15 500 annual foodborne cases of *E. coli* infection and at least 656 000 cases of foodborne *Salmonella*. About 58% of *E. coli* cases and eight percent of *Salmonella* cases are due to consumption of ground beef (LIN, 1995). Although the full extent of the social and economic impact of bacterial infections is hard to measure, studies indicate that the cost of illness, death, and business lost is high. For the US, BUZBY et al. (1996) estimated the cost due to *E. coli* infections at $659 million a year; TODD (1989) estimated the cost due to *Salmonella* infections at $4 billion per year.

To address this hazard, major changes related to food safety have been introduced in the US meat industry in recent years. Meat packers and processors are required since 1996 to process in compliance with a HACCP plan. In addition, innovations such as irradiation and steam-pasteurization have been approved by the Food and Drug Administration (FDA) and the USDA to control or reduce foodborne pathogens in meat processing. Despite scientific evidence of the effectiveness and safety of irradiation, processors and retailers have been slow to offer irradiated products. Given the requirement to label irradiated foods, the implementation of this technology depends highly on consumer acceptance and willingness to pay.

The goal of this research is therefore to examine the factors influencing consumer demand for irradiation. The analysis focuses on consumers' willingness to pay for a reduced risk from *E. coli* and *Salmonella* in ground beef consumption. To accomplish our objectives a contingent valuation (CV) study was conducted. A mail survey was sent to 3 000 households in eight states (Colorado, Nebraska, Kansas, Oklahoma, Iowa, Missouri, Arkansas and Wyoming).

A number of previous studies have examined consumer acceptance and WTP for irradiation. This study attempts to address some shortcomings in this literature:

1. *Previous studies use a rather restrictive range of risk reduction strategies – most have focused on a single risk reduction technology and no study has accounted for the possibility of private risk reduction by cooking meat to a high degree of doneness.* Our study compares WTP amounts for irradiation with WTP amounts of an alternative risk reduction technology – steam-pasteurization. In addition, we examine whether respondents' cooking and handling practices (private risk re-

duction) effectively substitute for risk reduction in meat processing achieved with irradiation or steam-pasteurization.

2. *Many CV studies fail tests of internal and external validity - WTP amounts are not sensitive to the scope or magnitude of the good or benefit being offered.* Our study included an external scope test by comparing WTP amounts of independent samples with different risk reduction levels (split-sample).

The paper is structured as follows. Chapter 2 describes the irradiation technology. The research on consumers' acceptance of and WTP for irradiation is reviewed in chapter 3. In chapter 4 the contingent valuation (CV) approach is discussed as a method to estimate consumers WTP for improvements in food safety and the hypothetical scenario we used is introduced. Chapter 5 describes the design of the survey and outlines the resulting data. The estimation results are presented and discussed in chapter 6. In the final section, major conclusions are summarized and recommendations for future research are given.

2. Food irradiation

The food irradiation process exposes products to ionizing radiation to reduce disease-causing bacteria. At approved dosage levels, the process has been shown to reduce 99.9% or more of the *E. coli* and *Salmonella* population in ground beef (AN-HUNG-FU, 1994; ITO, 1998). Irradiation has, if any, little effect on the taste and appearance of ground beef and hamburgers (WHEELER et al., 1999). In 1997, the FDA approved irradiation for red meat, and in 1999, USDA followed allowing irradiation of raw meat and raw meat products (BUZBY and MORRISON, 1999). Current USDA rules require that irradiated meat and meat products be labeled with the *Radura* symbol (figure 1) and with a statement indicating that the product was treated by irradiation (Buzby and Morrison, 1999).

Figure 1. Radura symbol

The requirement to label irradiated foods has been viewed in the meat industry as an impediment to consumer acceptance. The 2002 US Farm Bill provides for a re-examination of the requirement and raises the possibility that irradiated foods could be labeled as "cold-pasteurized" or "electronically pasteurized" (USDA, 2003). It is argued that food irradiation as currently done often involves exposure to an electron beam rather than radioactive isotopes. The irradiation industry hopes to reduce consumer concerns about irradiation with a more euphemistic labeling. One of the goals of this study is therefore to examine the difference in acceptance for products labeled as "irradiated" or "pasteurized".

In the US, the marketing of irradiated beef began in May 2000. Huisken Meat Company was the first meat processor distributing irradiated ground beef in the Minneapolis-St. Paul area. Since then other meat processors, retailers and supermarkets have begun to offer irradiated ground beef. The three major beef packers (*IBP*, *Excel*, and *Swift*) have either used irradiation for some ground beef products or have announced plans to use the technology. On the restaurant side, *Dairy Queen* was the first company to introduce irradiated hamburger patties in February 2002. *Champps Americana Restaurants* and *Embers Restaurants* followed in fall 2002. With accelerating pace in late 2002 and early 2003, several large retailer and supermarket chains such as *Hy-Vee Supermarkets*, *Pathmark Supermarkets*, *Giant Foods*, and *Publix* began to sell fresh irradiated ground beef in selected markets. As of February 2003, about 210 restaurants and about 2 700 stores from 18 retail-chains offered irradiated meat products (MINNESOTA BEEF COUNCIL, 2003). However, in January 2004, one of the primary suppliers of irradiated foods, *Surebeam Corp.*, declared bankruptcy, leaving many restaurants and supermarkets without supplies of irradiated ground beef.

In contrast to the increasing recognition of food irradiation in the US, the application of this food safety technology in Europe is rather restricted. In the EU, irradiated foods and food ingredients are regulated by two directives. The *Framework Directive 1999/2/EC* covers general and technical aspects for carrying out the process, labeling of irradiated foods and conditions for authorizing food irradiation. In addition, the *Implementing Directive 1999/3/EC* established a list of food and food ingredients which may be treated with ionizing radiation. So far, this list contains only a single food category, namely dried aromatic herbs, spices and vegetable seasonings (EUROPEAN COMMISSION, 2004).

3. Consumer acceptance and willingness to pay

Regarding food irradiation, it is important to know whether consumers are willing to purchase irradiated products, and whether they are also willing to *pay a premium* for them, since there is an additional cost associated with using irradiation. The USDA estimates that irradiated ground beef will cost 13 to 20 cents more per pound than non-irradiated ground beef because of additional handling and packaging, the cost of irradiation itself, and post-irradiation testing for pathogens (MINNESOTA BEEF COUNCIL, 2003).

A number of studies examined consumer acceptance of irradiated products finding a high level of variability in the results (SAPP et al., 1995; SHOGREN et al., 1999; LUSK et al., 1999; FRENZEN et al., 2001; HASHIM et al., 2001). Regarding meat products, the acceptability rate ranged from 50% (FRENZEN et al., 2001) to 70% (SCHROETER et al., 2001). Variations in acceptance rate are to be expected due to differences in sampling frames, methodology, the information given to the consumer and the particular food for which acceptability is examined (LUSK et al., 1999).

WTP studies also show a high level of variability in the results. FRENZEN et al. (2000) found that only 23% of consumers were willing to pay more for irradiated ground beef. However, results from a laboratory experiment by GIAMALVA et al. (1997) showed that 68% of participants are willing to pay some positive amount for an irradiated meat sandwich. Participants were on average willing to pay 71 cents for the right to exchange a standard for an irradia-

ted sandwich. A CV study by FINGERHUT et al. (2001) confirmed a high rate of WTP showing that 60% of the respondents would pay a positive price premium for irradiated beef, with an average WTP of 36 cents/lb. Similar to acceptance rates, WTP rates and amounts depend on the sampling frame, the methodology and the information given to the consumers.

A conclusion that emerges from the literature is that WTP estimates are sensitive to the characteristics of the study population. Several variables are discussed that might systematically influence WTP.

In this context it might be necessary to account for differences in demand associated with the vulnerability of some segments of the population to foodborne illness. In particular, benefits from technologies to reduce foodborne pathogens like *E. coli* O157:H7 and *Salmonella* are greater for children, older persons, and persons in compromised health (CDC, 2003). Thus, consumers with *children* in the household might allocate greater expenditures to reduce children's risk. VISCUSI et al. (1987) indeed reported that valuations of reduced nonfatal risks from hazardous home insecticides are about 2.3 times greater for avoided risk to children compared to adults. There is no evidence, however, that consumers with children are willing to pay more for *irradiated* products (GIAMALVA et al., 1997; SHOGREN et al., 1999). Similarly, it is conceivable that *elderly* persons have a higher WTP, but again, studies show no clear empirical evidence for this assumption (FOX, 2002).

Another source of variation in WTP is *income*. Theory suggests that individuals with less income may choose to give up more safety for a given amount of money relative to others, reflecting their higher marginal utility of money (BOCKSTAEL, 1999). Income is therefore expected to be positively correlated with WTP. Empirically, GIAMALVA et al. (1997) and SHOGREN et al. (1999) reported a positive relationship between income and WTP for irradiated meat, although the income parameter was not significant in either case. In addition, there is empirical evidence that *men* are more willing to accept, but less willing to pay for irradiated products (FRENZEN et al., 2001; MALONE, 1990; SAPP et al., 1995; SHOGREN et al., 1999).

Meat-processors can choose among a wide variety of risk reduction technologies such as irradiation and steam-pasteurization. So far not many studies have examined the effects of different risk reduction technologies. FINGERHUT et al. (2001) investigated consumers' WTP for beef treated with steam and hot water pasteurization, in comparison with beef treated with irradiation, and beef that had not been treated with any technology at all. More than 87% of respondents reported that they preferred ground beef treated with some technology to ground beef not treated at all. Between the risk reduction technologies, consumers had a preference toward the more effective technologies. Thus, more than 60% indicated that they preferred beef treated with irradiation rather than beef treated with steam or hot water pasteurization. FINGERHUT et al. (2001) concluded that the stronger consumer preference towards the more effective technology irradiation suggests that consumers value marginal reductions in already low risk levels.

4. Contingent valuation

4.1 Contingent valuation as a method to value non-market goods

The value of enhanced food safety resulting from irradiation could be obtained from aggregate market demand data or alternatively by directly eliciting from consumers their willingness to pay (WTP). Since irradiated foods were, as of 2003, only sold in selected markets, we estimated the value of irradiated ground beef directly by using a contingent valuation (CV) approach.

A number of studies have questioned the validity of stated WTP values (DIAMOND and HAUSMAN, 1994; NEILL et al., 1994; CUMMINGS et al., 1995). Potential biases, like hypothetical, strategic, starting point, non-response, and sampling frame biases, are widely discussed in the literature (ANDERSON and BISHOP, 1986; CUMMINGS et al., 1986; MITCHELL and CARSON, 1989). The major weakness of CV surveys is their reliance on *hypothetical* scenarios implying that respondents will answer *hypothetical* questions in the same way they would answer an identical question asking for a real economic commitment. BRADEN et al. (1991) discuss the fact that respondents tend to inflate stated WTP amounts in hypothetical market settings. DIAMOND and HAUSMAN (1994) point to respondents' lack of experience in trading or valuing abstract commodities like food safety as another potential source for *hypothetical bias*. An often-discussed CV anomaly in this context is the *embedding effect* (KAHNEMAN and KNETSCH, 1992; DIAMOND and HAUSMAN, 1994). It describes the tendency of WTP responses to be highly similar across different surveys, even where theory suggests that the responses be very different. A review by HAMMIT and GRAHAM (1999) showed that WTP is often not sensitive to the magnitude of risk reduction.

One explanation for this result points to a lack of peoples' perception for small numerical differences in magnitude (KAHNEMAN and TVERSKY, 1973; BARON, 1997). Another reason could be that people make decisions based on their own beliefs and do not pay attention to risk information provided in the scenario (VISCUSI, 1989). In this case, stated WTP should be proportional to their risk perception rather than to the risk reduction stated to respondents in the scenario. A study by GIAMALVA et al. (1997), for example, suggests that consumers' perception of the risks associated with foodborne disease may be more important in consumers' decision-making process than the actual risk. Other studies suggest that consumers' level of concern and worry is an important determinant of WTP (HENSON, 1996; HAMMIT, 1990). It is also possible that respondents do not value risk changes in compliance with the predictions of utility theory. Respondents might focus more on general concerns about food safety than on differences in the level of risk; any improvements toward complete safety are acceptable and the level of improvement does not matter. Several studies suggest that the baseline level of risk will influence WTP (WEINSTEIN et al., 1980; PRATT and ZECKHAUSER, 1996). Thus, respondents may hold a subjective threshold level of the baseline risk below which the different magnitudes of risk reduction are irrelevant. Moreover, respondents simply might not pay close attention to the evaluation task (LIN and MILON, 1995).

4.2 Tests of external and internal validity

To measure for the embedding effect and for the success of a CV survey, KRUPNICK et al. (2002) recommend internal and external scope tests. An internal scope test is passed when a respondent's WTP increases with the size of the risk reduction *within* the sample. External scope tests use a *split-sample*, where different groups of respondents are asked to value risk changes of different magnitudes (ARROW et al., 1993). The scope test is passed when WTP differs with the scale of the risk reduction between these independent samples[1] (NEILL et al., 1994). In addition, if respondents maximize expected utility or, more generally, if their utility-function is linear in probabilities, WTP for small risk changes increase in proportion to the size of the risk change.

In this study we used four different risk reduction levels with different groups of respondents: i) reduction from 10 illnesses per 10 000 consumers to 1 illness (10→1), ii) from 10→3, iii) from 3→0, and iv) from 3→1. This design facilitates several comparisons. First, we can compare WTP amounts between versions with common baseline risk, i.e. between the 10→1 and 10→3 cases, as well as between the 3→0 and 3→1 risk reductions. Given the common baseline[2] and the greater level of reduction we might expect to find greater WTP for the 10→1 case than for 10→3, respectively greater WTP for the 3→0 case than for 3→1. Second, we can compare WTP between the 10→1 case and the 3→1. Given both the greater reduction in the 10→1 case and its higher baseline, we would expect to find higher WTP.

Another interesting comparison can be made using the 10→1, 10→3, and 3→1 reductions.[3] In particular the 10→1 reduction can be achieved in a single step, or alternatively in two steps: first 10→3, followed by 3→1. Since the end result is the same regardless of the path, we might expect the combined WTP for the two step path to equal that of the single step path. However, if we were to find similar WTP for all three reductions, such that the value placed on the two step path were approximately double that for the single step path, that could be interpreted to support the existence of an embedding effect (DIAMOND and HAUSMAN, 1994).

4.3 Hypothetical szenario

To limit potential biases, the challenge of successful CV research is to communicate the market setting in a way that the respondent completely understands and accepts the specified conditions (MITCHELL and CARSON, 1989). Our CV instrument created a hypothetical market scenario for respondents in which they could choose between standard ground beef "A" and ground beef "B" (irradiated or steam-pasteurised) in their local supermarket. The survey provided information about the differences in the processing of ground beef "A" and "B" as well as differences regarding the risk of illness from consuming ground beef "A" and "B over a 10-year period. Following KRUPNICK et al. (2002) we used a 10-year risk reduction period, since it is assumed that respondents are more willing to accept risk changes or baseline risks over longer periods. To enhance the communication of the risk of illness, we further used grids containing 10 000 squares where black squares represented the chance of getting ill.

Respondents were then asked whether they would purchase ground beef "A" or ground beef "B", if both cost the same. This question was followed by *double-bounded dichotomous-choice* (DC) questions to obtain more information about respondents WTP. In the literature it is argued that DC questions are easier for respondents to answer than open-ended questions, since DC questions more closely resemble an actual market transaction (BOYLE and BISHOP, 1988; ARROW et al., 1993).

Double-bounded means that respondents are asked to engage in two rounds of bidding, in which the second DC question depends on the response to the first question. HANEMANN et al. (1991) showed that the statistically efficiency of the DC method can be improved substantially by asking a second DC question. Thus, our initial DC question asked the respondent to choose between "A" and "B" with product "B" priced at a certain premium. The follow-up DC question repeated the choice at a lower/ higher premium for ground beef "B", depending on whether the respondent chose "A"/"B" at the initial premium. The wording in the initial as well as in the follow-up question was: "*If you could choose between the standard product (A) at $1.69 per pound, or the irradiated product (B) at $"PRICE" per pound every time you purchase ground beef, which one would you buy?"* The premium for the safer ground beef "B" varied between 5 cent/lb. and 40 cent/lb. based on earlier focus group findings and the additional cost of irradiation (SCHROETER et al., 2001).

5. Survey design and data[4]

The survey was sent to 3000 households in eight different states (CO, NE, KA, OK, IA, MO, AR and WY) in August 2002. In addition, a follow-up mailing was sent to 900 non-respondents. The overall response rate was 28% with 819 surveys returned. Households were selected by purchasing a random sample list of households from a commercial survey-sampling company.

In addition to respondents' WTP the survey elicited information about respondents' ground beef and hamburger *consumption habits* as well as their *food safety perceptions*. Respondents were asked how often they consumed and how they typically prepared hamburgers (degree of doneness). To determine the extent to which respondents cooked hamburgers above their preferred level of doneness for safety reasons, we asked them how they would prepare hamburgers that were "*guaranteed not to be contaminated with any*

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[1] The scope test involves testing whether median WTP for a sample with higher risk reduction is significantly greater than the corresponding WTP for a sample with lower risk reduction. Therefore the null hypothesis is $WTP_{HighRisk} = WTP_{LowRisk}$. Theory suggests the alternative is $WTP_{HighRisk} > WTP_{LowRisk}$.

[2] JONES-LEE (1974) found that the marginal value of a decrease in risk increases with the initial level of risk. Thus, reductions of similar magnitudes from different baselines could lead to different valuations, and reductions of differing magnitudes from differing baselines might lead to very similar valuations.

[3] We are grateful to an anonymous reviewer for suggesting this comparison.

[4] The survey instrument is available from the authors upon request.

disease-causing bacteria". Two questions were used to investigate respondents' food safety practices in the home – whether they ever forgot to wash hands after handling raw meat, and whether they ever forgot to refrigerate leftovers following a meal.

Following a brief description of food-poisoning symptoms, we asked respondents whether they or any member of their close family had experienced food-poisoning. We then asked how worried they were about getting a food-related illness. Following the WTP questions, the final part of the survey instrument elicited demographic information about children, gender, age, education level, employment status and household income.

Different versions of the questionnaire were used to explore, (a) whether the risk-reduction technology mattered, (b) whether reminding respondents about the effectiveness of proper cooking to eliminate pathogens would have a significant effect on WTP, and (c) how WTP varied with the risk reduction level. Table 1 summarizes the 24 alternative versions of the survey instrument. Our primary focus was on irradiation as the risk reduction technology. However, in versions with risk reduction from 10→3 we had two sub-samples – one in which risk was reduced using irradiation and the other using steam-pasteurization. Similarly, in versions in which the risk reduction was 10→1, we included an additional version that included a reminder about the effectiveness of proper cooking – what we will term a 'cheap-talk' sentence. For each of those six scenarios we had four sets of bids or price levels for the 'treated' product for a total of 24 distinct versions.

Table 1. Versions of the questionnaire

Survey versions	Initial payment question	Follow-up question (if "no")	Follow-up question (if "yes")	Technology	Cheap-Talk	Risk reduction (Cases Per 10,000)
A.1	1.79	1.74	1.89	Irradiated	No	10 → 1
A.2	1.89	1.79	1.99			
A.3	1.99	1.89	2.09			
A.4	2.09	1.99	2.19			
B.1	1.79	1.74	1.89	Irradiated	Yes	10 → 1
B.2	1.89	1.79	1.99			
B.3	1.99	1.89	2.09			
B.4	2.09	1.99	2.19			
C.1	1.79	1.74	1.89	Steam-pasteurized	No	10 → 3
C.2	1.89	1.79	1.99			
C.3	1.99	1.89	2.09			
C.4	2.09	1.99	2.19			
D.1	1.79	1.74	1.89	Irradiated	No	10 → 3
D.2	1.89	1.79	1.99			
D.3	1.99	1.89	2.09			
D.4	2.09	1.99	2.19			
E.1	1.79	1.74	1.89	Irradiated	No	3 → 0
E.2	1.89	1.79	1.99			
E.3	1.99	1.89	2.09			
E.4	2.09	1.99	2.19			
F.1	1.79	1.74	1.89	Irradiated	No	3 → 1
F.2	1.89	1.79	1.99			
F.3	1.99	1.89	2.09			
F.4	2.09	1.99	2.19			

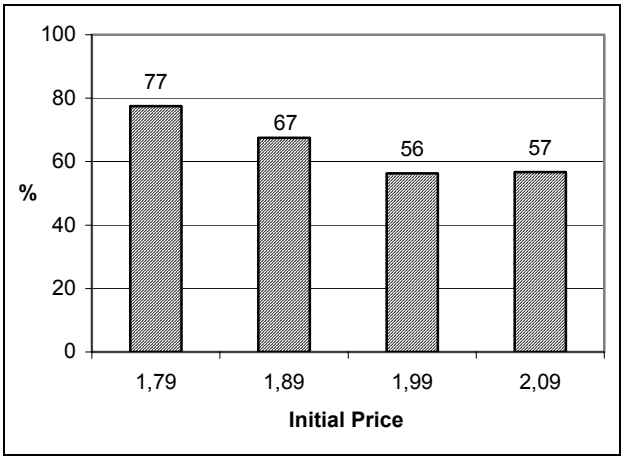
Source: authors' compilation

Table 2 presents the coding and definition of independent variables as well as sample statistics. In terms of consumption, respondents indicated they consumed ground beef about 6 times per month at home and about 5 times per month away from home. These responses appear to match well with national averages. Most respondents prepared hamburgers well-done (55%) or medium well-done (26%). Given a guarantee of "bacteria-free burgers", 17% of respondents indicated that they would prepare hamburgers to a lower degree of doneness.[5] About 53% indicated some carelessness in the handling of meat. In addition, 44% reported that they or a close family member had experienced food poisoning in the past. When asked how worried they were about getting foodborne illness, most respondents stated that they were seldom worried (43%) or moderately worried (35%).

In terms of demographic data, our sample was somewhat wealthier and older than the study population. Due to the low response rate, we also caution about possible non-response errors.

Regarding the WTP data, economic theory suggests that the proportion of "yes" ("no") responses is a decreasing (increasing) function of the bid amount and an increasing (decreasing) function of the risk-reduction level. Figure 2 shows that the proportion of "yes" and "no" responses is in fact sensitive to the bid amount. However, no specific pattern was found when responses were plotted against risk-reduction levels.

Figure 2. Proportion of respondents who preferred treated product at the initial price



Source: authors' computations

[5] However, we have some concerns about this variable, because 52 respondents probably misunderstood the question – indicating that they would prepare meat guaranteed to be bacteria free to a higher degree of doneness.

Table 2. Definitions of variables and sample statistics

Description of the variable	Variable name	Mean	Standard deviation
Consumption – behavior			
Hamburger consumption (frequency per month)			
At home	HOME	6.21	5.05
Away from home	AWAY	4.57	4.51
Hamburger preparation (0=Rare,… 4=Well done)	DONENESS	3.27	0.92
Preference for a lower degree of doneness, if the risk of contaminated hamburgers would be zero (1=Yes)	PREFRARE	0.17	0.38
Forget to wash hands before and after handling raw meat or to refrigerate immediately left-overs after a meal (1=Yes)	CARELESS	0.53	0.50
Experience – risk perception			
Self or family member ever had food poisoning (1=Yes)	FOODPOI	0.44	0.39
Worried about foodborne illness (0=not at all,… 4=very)	WORRIED	1.54	0.90
Demographics			
Children living in the household (1=Yes)	KIDS	0.36	0.48
Gender (1=male)	MALE	0.39	0.49
Age (years)	AGE	49.85	13.68
Education (1=some high school,… 5 =post graduate)	EDUCATION	3.36	1.09
Employment (1=homemaker)	EMP-HOME	0.08	0.28
Employment (1=retired)	EMP-RET	0,19	0,39
Household Income (1=<$20k,… 7=>$100k)	INCOME	4.43	1.88

Source: authors' computations

6. Empirical results

6.1 Acceptance rate

If products were offered at the same price, 77% of respondents would choose the irradiated rather than the standard product. The acceptance rate was higher for steam-pasteurized product with 93% of respondents preferring steam-pasteurized over standard product. These results reflect the fact that some consumers have reservations about the food irradiation process. And while we did not attempt to investigate the reasons for rejecting irradiation, the results would appear to confirm the opinion of many in the irradiation industry that a product labeled as "pasteurized" would enjoy higher consumer acceptance than one labeled as "irradiated".

6.2 Median WTP

Median WTP was computed by fitting to the sample a double-bounded dichotomous choice model that included only the intercept and price parameter (HANEMANN et al., 1991). Median WTP for treated ground beef, estimated using all 718 usable responses, was estimated to be 1.91$/lb. With the price of standard product at 1.69$/lb., respondents were thus willing to pay a median premium of 22 cent/lb., or approximately 13% of the base value of the product. Among respondents who indicated that they preferred the treated product when treated and untreated product were equally priced (N=571), the median premium was 34 cent/lb. (20% of value). These results suggest that consumers' WTP would exceed the additional costs of the steam pasteurization or irradiation treatments (13 to 20 cent/lb.).

6.3 Determinants of WTP

Results of the double-bounded dichotomous choice model are presented in table 3. We included in the model only those individuals who accepted (respondents who would rather choose the irradiated than the standard product, if offered at the same price) the treated product. The sample size was reduced from 571 by incomplete responses to 520. The goodness of fit, as indicated by the McFadden R^2, equals 0.136.[6]

Demographics

As previously discussed, economic theory suggests that consumers with children and elderly people would allocate greater expenditures to reduce risk. The positive sign of the *KIDS* coefficient is therefore plausible, though the effect is not significant (p-value 0.218). Elderly people, as indicated by the variable *RETIRED*, tend to have a significantly higher WTP. The variable *AGE* was found to be correlated with the variable *RETIRED* and was therefore excluded from the estimation.

In agreement with former findings, the negative coefficient for *MALE* respondents implies that men have lower WTP for food safety. However, the estimated parameter is not significant (p-value 0.221). Furthermore, there is no evidence that homemakers have a different WTP given the insignificant coefficients on *EMP-HOME*. The coefficient on *INC* is also insignificant, although the positive sign on *INC* is in accord with the theoretical expectation that higher-income respondents can afford higher quality products. The variable *EDU* was excluded from the estimation due to correlation with the *INC* variable.

Experience and risk perception

Respondents might base WTP on prior experiences and perceived risk of food poisoning rather than on the actual risk information provided in the scenario. According to table 3, experience with food poisoning tends to reduce WTP as indicated by the negative *FOODPOIS* coefficient, though the estimated parameter is not significant (p-value 0.214). This negative sign is somewhat unexpected. HENSON (1996) reported similar results and discussed two factors that might explain this phenomenon. First, consumers might believe that having suffered from food poisoning

6 $R^2_{McFadden} = 1 - \frac{\ln L(M_{Full})}{\ln L(M_{Intercept})}$, where $\ln L(M_{Full})$ is the value of the log likelihood function at the estimated parameters and $\ln L(M_{Intercept})$ is its value when all parameters except the intercept are set equal to zero.

Table 3. Regression results, individuals who preferred the treated product (N=520)

Independent variable	Coefficient	T-Statistic	P-Value
Intercept	8.523***	8.855	0.000
Offer price	5.025***	12.361	0.000
Consumption – behavior			
HOME	-0.064***	-2.877	0.004
AWAY	0.027	1.164	0.244
DONENESS	0.302***	3.070	0.002
CARELESS	-0.248	-1.399	0.162
Experience – risk perception			
FOODPOIS	-0.227	-1.242	0.214
WORRIED	0.432***	4.174	0.000
Demographics			
KIDS	0.194	1.232	0.218
RETIRED	0.537**	2.243	0.025
EMP-HOME	0.536	1.334	0.182
MALE	-0.236	-1.223	0.221
INC	0.071	1.401	0.161
Survey versions[a)]			
B: Risk 10 → 1 + TALK	-0.363	-1.190	0.234
C: Risk 10 → 3 (Steam)	-0.351	-1.584	0.134
D: Risk 10 → 3	0.386	1.255	0.209
E: Risk 3 → 0	0.468	1.478	0.139
F: Risk 3 → 1	-0.178	-0.600	0.548
Log likelihood: -590.748			
McFadden R^2: 0.136			

*** Statistically significant at the 0.01-level.
** Statistically significant at the 0.05-level.
* Statistically significant at the 0.1-level.

a) The omitted baseline (Version A) offered risk reduction from 10 → 1.

Source: authors' computations

in the relatively recent past reduces the chance that they will suffer food poisoning in the future. Second, those respondents who had recently experienced a mild food poisoning might have given less weight to the probability of suffering severe food poisoning. As a further possible reason, BOECKER (2003) suggests that the effect of a food-poisoning experience interacts with gender. While such an experience intensifies females' risk perception, it has no or the opposite effect on males. We checked for this possible interaction effect in our data, but we could not confirm that *FOODPOIS* was interrelated with *GENDER*.

The variable *WORRIED* also provides information about perception of food related risks. *WORRIED* has a significant positive effect on WTP, implying that higher concerns about getting a food-related illness increases WTP.

Technology

In Survey Version C, the risk-reducing technology was steam-pasteurization as opposed to irradiation in all the other versions. In table 3, the estimated coefficient for the dummy variable representing Survey Version C is negative and close to being statistically significant. This suggests that respondents have lower willingness to pay when steam is the risk-reducing technology. However, the baseline survey version featured a higher level of risk reduction (10→1) than that in Version C (10→3), making interpretation of that coefficient problematic.

To isolate the effect of changing the risk-reducing technology we estimated a separate WTP model using only the responses from versions C and D which featured similar risk reductions but different technologies. In that model, the estimated coefficient for the dummy variable representing Version C was significant (p-value 0.090) with a value of -0.546 indicating that among respondents preferring the treated product, WTP is higher for irradiation than for steam-pasteurization.

However, this higher WTP for irradiation is compensated by the fact that rejection of the treated product (i.e., when treated and untreated were offered at equal prices) was significantly higher when the treatment was irradiation.

Private risk reduction

One group of respondents (Version B) received a reminder about risk reduction possibilities at home – somewhat analogous to a reminder about their budget constraint, i.e., 'cheap-talk'. The estimated coefficient on the Version B variable in table 3 suggests that this reminder had a negative impact on WTP but the effect is not significant. Again, to better isolate this effect, we estimated a separate model using responses from versions A and B which featured the same level of risk reduction (10→1), with and without the reminder statement. In this model, the estimated coefficient on Version B was negative and statistically significant indicating that the reminder about risk reduction possibilities at home– i.e., the availability of a substitute – reduced WTP. Estimated median WTP for the sub-sample receiving the reminder was \$1.953/lb. compared to \$2.074 for respondents not receiving the reminder. A Wald test indicated that the difference in median WTP between the two sub-samples was significant (wald-statistic 11.087; p-value 0.001).

This result suggests that WTP is significantly lower when respondents are aware of the possibility of risk reduction at home. This association may indicate that trade-offs exist between risk reduction by meat processors and risk reduction at home in the sense that respondents are willing to pay less for higher safety in meat processing when they can reduce their risk at home and feel safe about the ground beef served in their own kitchen.

In this context we would also like to discuss results related to respondents' consumption habits. The estimates in table 3 indicate that WTP for the treated product is negatively related to respondents' at home consumption of hamburgers, and positively related to away from home consumption. This suggests that respondents with different consumption patterns place different values on improved safety in meat processing. Thus, those who tend to consume more at home might be more familiar with private risk reduction and may be less willing to pay for safety in meat processing. Those who tend to consume more away from home might be less "devoted" to cooking and meal preparation, so that they consider their private risk reduction possibilities as more limited. This interpretation supports the hypothesis that consumers view private and collective risk reduction strategies as substitutes.

Another variable directly connected to risk reduction at home is how respondents prepare their hamburger – i.e., level of *DONENESS*. In table 3, the coefficient on *DONENESS* is positive and significant, indicating that respondents who prepare hamburger to a higher degree of doneness would tend to pay more for treated ground beef. However, the variable *DONENESS* may be difficult to interpret, because manifold influences like taste and habit, in addition to awareness of private risk reduction may determine the chosen degree of doneness. The positive relationship between *DONENESS* and WTP in our model may reflect respondents who prepare hamburgers well-done - because of food safety reasons -, but who actually prefer the taste of medium hamburgers. Unfortunately, we could not use the variable *PREFRARE* to test for this possible relationship due to data validity concerns (see footnote #5). Further research is needed to examine the relationship between home preparation and WTP for safety enhancements such as irradiation.

The negative coefficient on the *CARELESS* variable indicates that respondents with more careless behavior are less willing to pay for treated ground beef. While not statistically significant, the negative sign could be interpreted as evidence against our hypothesis that trade-offs exist between private and collective safety.

Magnitude of risk reduction

The coefficients on survey versions in table 3 indicate the effect on WTP of changing the level of risk reduction. The coefficient on Version D indicates the effect of changing the level of risk reduction from 10→1 (in the baseline Version A) to 10→3. Given the smaller amount of risk reduction, we expected a negative coefficient. As estimated however, the coefficient is actually positive, but statistically insignificant. As before, to better isolate this effect, we conducted a separate regression using only the observations from Versions A and D, both of which had irradiation as the technology, and neither featured the reminder about risk reduction at home. Again, we found a positive but insignificant effect. Similarly, using Version A (10→1) and Version F (3→1) we found a negative but statistically insignificant effect associated with the much smaller level of risk reduction in Version F.

In another regression we used responses from Versions E and F in which risk reduction changes from 3→0 to 3→1. The impact of this change is not directly observable in table 3. The estimated coefficient on the dummy variable for Version F had the expected negative sign and was statistically significant (p-value 0.052), indicating higher WTP for the elimination of the risk in Version E.

Next we calculated median WTP for the different risk reduction levels. For this purpose, we split the data into the corresponding four risk reduction groups, and fit to each sub-sample a model that included only the intercept and the price parameter. Table 4 indicates that median WTP for risk reduction 10→1 was 2.074$/lb., somewhat higher than for risk reduction 10→3 (2.062$/lb.). However, a Wald test could not confirm that median WTP was statistically different between the two samples (wald-statistic 0.391; p-value 0.532). Median WTP for risk reduction 3→0 (2.099$/lb.) was higher than for risk reduction 3→1 (1.987$lb.). A Wald test indicated that those WTP values were statistically different from each other (wald-statistic 8.380; p-value 0.004).

Finally, we tested for the embedding effect by comparing WTP amounts for the one-step risk reduction 10→1, with the sum for the two-step risk reduction from 10→3 and from 3→1. Since the overall risk reduction is identical, WTP should theoretically be the same (sensitivity to the magnitude of the risk reduction). However, the results show that WTP for the two-step reduction is almost twice as much as for the one-step reduction.

Overall, our results suggest that WTP values are not particularly sensitive to variation in the level of risk reduction. Respondents do however appear to add a special value for the cancellation of the last unit of risk in Version E. ZECKHAUSER and VISCUSI (1990) pointed out that consumers value the elimination of the last unit of risk more than the penultimate unit.

Table 4. Median WTP regarding the risk reduction levels

Survey versions		Median WTP ($/lb.)
A: Risk 10 → 1	(N=98)	2.074
D: Risk 10 → 3	(N=91)	2.062
E: Risk 3 → 0	(N=82)	2.099
F: Risk 3 → 1	(N=99)	1.987

Source: authors' computations

7. Summary and conclusions

We conducted a CV study by sending a consumer survey to 3,000 households in eight different states (CO, NE, KA, OK, IA, MO, AR and WY). The overall response rate on the survey was 28% (819 returned).

Our goal was to examine the value respondents would place for a reduced risk from *E. Coli* and *Salmonella* in ground beef. In this context, the study explored (a) median WTP for risk reduction; (b) whether "who" is at risk (elderly or children) influences preferences; (c) whether alternative technologies (irradiation and steam-pasteurization) influence preferences; (d) whether protective actions at home (care in cooking and handling) influence WTP; and (e) whether preferences for risk reduction vary with the severity of the risk.

Several interesting findings emerged from our study. The WTP analysis showed that respondents were on average willing to pay a price premium of 22 cent/lb. for treated ground beef. Stated WTP amounts would therefore exceed the additional cost associated with using irradiation.

We found some evidence that WTP is related to "who" is at risk. While households with children did not have higher WTP values, retired persons did. In addition, we can conclude that the risk reduction technology has an effect. Steam-pasteurization has a higher acceptance rate, but for consumers who prefer the treated product, the more effective irradiation technology has higher value.

WTP was significantly lower for respondents who were made aware of the possibility of risk reduction at home. Furthermore, respondents with higher levels of at-home consumption tended to place lower value on product treat-

ment – possibly because they are more familiar with the option of risk reduction via cooking. This suggests that consumers treat risk reduction at home and risk reduction in meat processing as substitutes – however we did find one result to contradict this conclusion. Respondents who admitted carelessness in handling raw meat had lower WTP than those who were more careful. Thus, the more careful respondents might be viewed as treating both risk reduction strategies as complements.

We found that the result of an external scope test – checking the sensitivity of WTP to the magnitude of the risk reduction – was ambiguous. WTP was insensitive to scope between a 10→1 (10 illnesses per 10 000 consumers to 1 illness per 10 000 consumers) and a 10→3 risk reduction. However, WTP was significantly related to the scope or magnitude of the risk reduction between a 3→0 and a 3→1 risk reduction. We assume that respondents add a special value to cancellation the last unit of risk.

For further research it may be worthwhile to attempt to confirm some of our results in non-hypothetical settings or to compare them with actual market data. In particular, the insensitivity of WTP to the scope of the risk reduction in this study may reflect a narrow range of risk reduction possibilities but alternatively it may be a consequence of the hypothetical nature of the exercise. If laboratory valuation exercises could be shown to demonstrate more sensitivity to scope in this type of valuation, it would certainly enhance their appeal in situations where embedding is a problem. Non-hypothetical valuation tasks might also be able to shed more light on the question of whether private and public risk reduction strategies are viewed as substitutes or complements.

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