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The Benefits of Avoiding Cancer (or Dying from Cancer): Evidence from a Four-country Study

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Summary

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Keywords: Cancer Risk, Value of a Statistical Life, Value of a Statistical Case of Cancer, Mortality Risk Reduction, Stated Preferences

JEL Classification: I18, J17, K32, Q51

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The Benefits of Avoiding Cancer (or Dying from Cancer): Evidence from a Four-country Study

By

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Abstract. We use stated-preference methods to estimate the cancer Value per Statistical Life (VSL) and Value per Statistical Case (VSCC) from a representative sample of 45-60-year olds in four countries in Europe. We ask respondents to report information about their willingness to pay for health risk reductions that are different from those used in earlier valuation work because they are comprised of two probabilities—that of getting cancer, and that of dying from it (conditional on getting it in the first place). The product of these two probabilities is the unconditional cancer mortality risk. Our hypothetical risk reductions also include two qualitative attributes—quality-of-life impacts and pain. The results show that respondents did appear to have an intuitive grasp of compound probabilities, and took into account each component of the unconditional cancer mortality risk when answering the valuation questions. We estimate the cancer VSL to be between € 1.9 and 5.7 million, depending on whether the (unconditional) mortality risk was reduced by lowering the chance of getting cancer, increasing the chance of surviving cancer, or both. The VSCC is estimated to be up to € 0.550 million euro, and its magnitude depends on the initial (conditional) cancer mortality and on the improvement in survival. We interpret these as "pure" mortality and cancer risk values, stripped of morbidity, pain or quality-of-life effects. The survey responses show that impacts on daily activities and pain have little or no effect on the WTP to reduce the adverse health risks.

Keywords: Cancer risk; Value of a Statistical Life; Value of a Statistical Case of Cancer; mortality risk reduction; stated preferences.

JEL Classification: I18 (Government Policy, Regulation, Public Health); J17 (Value of Life, Forgone Income); K32 (Environmental, Health, and Safety Law); Q51 (Valuation of Environmental Effects)

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1. Introduction

Benefit-cost analyses of environmental health and safety regulations that reduce mortality risks have relied extensively on a key metric known as the Value per Statistical Life (VSL) or Value of a Prevented Fatality (VPF),[2] which is a summary measure of the willingness to pay for a small reduction in the risk of dying. Government agencies' policy analyses have frequently applied the VSL, even when estimates of it come from other contexts (such as workplace accidents, in the case of the US Environmental Protection Agency, or transportation accidents, in the case of the UK Health Executive or Department of Environmental, Food and Rural Affairs).

The appropriateness of such transfers is often discussed in academic and policy circles (Cropper et al., 2011). Some observers point out that the accidental nature of workplace and transportation risks is in sharp contrast with most environmental exposure risks, where the onset of disease leading to death is likely to occur many years after exposure and is not sudden. Certain air pollutants, hazardous wastes, drinking water contaminants and chemicals contained in consumer products are known or suspected carcinogens. Exposure to these carcinogens can be avoided or reduced significantly through appropriate regulations, but it is unclear whether in benefit-cost analysis of such regulations cancer risks should be regarded in the same fashion—and should be attached the same value—as the risks of developing and dying from other illnesses (e.g., cardiovascular or respiratory illnesses).

Cancer is associated with suffering and pain, and is highly dreaded (Starr, 1969; Fischhoff et al., 1978; Slovic, 1987), and some observers have suggested that the VSL should be greater when the cause of death is cancer (Revesz, 1999; US EPA 2000). This is sometimes referred to as "cancer premium." The US EPA (2011) suggests the term "cancer differential,"

[2] They have also relied on a derived construct known as the Value of a Statistical Life Year (VOLY), but we are not concerned with the VOLY in this paper. See Cropper et al. (2011), and Robinson and Hammitt (2015).

which is considered more general than "cancer premium" and captures "elements of dread and fear of cancer, as well as pain and suffering from the period of illness preceding death. It might also include income and household productivity losses over this period of morbidity" (ibid.).[3]

The empirical evidence about such a premium is, however, mixed. Several risk-risk tradeoff studies have indeed found that people favor programs that reduce cancer mortality (e.g. Jones-Lee et al., 1985; Mendeloff and Kaplan, 1989; McDaniels et al., 1992; Savage, 1993; Tolley et al., 1994; Magat et al., 1996; Van Houtven et al., 2008). Stated-preference valuation studies have found either i) little evidence that the cancer VSL is higher than the VSL for other causes of death (Hammitt and Liu, 2004; Hammitt and Haninger, 2010; Chestnut et al., 2012), ii) modest cancer "discounts" (Tsuge et al., 2005, and Adamowicz et al., 2011), or iii) large variations associated with different causes of death (cancer, respiratory disease, road traffic accidents), resulting in cancer premia of 90-156% (Alberini and Ščasný, 2011; 2013). A meta-analysis by OECD (2012) concludes that there seems to be no systematic cancer premium, and notes that in benefit-cost analyses morbidity costs prior to death should be added to the mortality benefits.

These considerations have contributed to much recent interest in isolating the morbidity component of the VSL from the "pure" mortality value. Gentry and Viscusi (2016) propose a framework where the VSL is comprised of two components: the value of morbidity before death and that of reducing the risk of dying per se. They estimate these two components using data from the US labor market, combined with information about the risks of fatal and non-fatal workplace injuries, showing that the value of the fatality risk is the dominant component of the VSL. It is not clear, however, whether a similar breakdown applies in the cancer context.

[3] The European Commission (2001) recommended using a 50% cancer premium in DG-Environment cost-benefit analyses, while the US EPA (2000, 2010) –and European Commission– do not apply this differential in policy appraisal.

This is precisely one of our goals in this paper. We have two major objectives. First, we wish to elicit willingness to pay (WTP) figures that are useful and appropriate for policy analyses of environmental (carcinogen) regulations. Some policy analyses quantify the cancer *deaths* avoided by a policy, while others rely on risk assessments that predict lifetime excess *cancer risks* associated with the current and improved environmental exposures.[4] This suggests that there are two key metrics of interest for policy analysis purposes—the cancer VSL and the Value of a Statistical Case of Cancer (VSCC). Second, we wish to see if the quality-of-life and pain impacts of cancer affect risk valuation, as in Cameron and DeShazo (2013), Chilton et al. (2016) and Hammitt and Haninger (2017), and, if so, what the magnitude of their effect is compared to that from cancer risk or mortality risk alone.

We use stated-preference methods, asking respondents recruited from the general population in four countries in Europe to report information about their WTP for hypothetical "commodities" described by two probabilities—namely the risk of developing cancer, and the chance of surviving it, conditional on getting it in the first place—plus two qualitative risk attributes. The centerpiece of our valuation effort is a sequence of dichotomous choice questions that ask respondents to indicate whether they would stay with the current health risks, or choose a hypothetical plan that would reduce the risk of developing cancer, improve 5-year cancer survival, or both, at a specified cost to the respondent. Each such "choice card" was completed by a description of the associated impacts on quality of life, which we expressed as restrictions to daily activities (ranging from none to being bed-ridden half of the time), and pain (mild and

[4] An example of the former is the sequence of studies in which the US EPA estimated the benefits of the Clean Air Act and its 1990 amendments, both retroactively and prospectively (see https://www.epa.gov/sites/production/files/2015-06/documents/contsetc.pdf, https://www.epa.gov/sites/production/files/2015-07/documents/fullrept.pdf and https://www.epa.gov/sites/production/files/2015-07/documents/factsheet.pdf). Examples of the latter can be found in the Records of Decision for Superfund site cleanup, where the EPA selects remedies (e.g., removing hazardous wastes, pumping and treating contaminated groundwater, extracting contaminants from soil using vapor, etc.) to attain acceptable residual lifetime cancer risks.

moderate). Quality-of-life impacts and pain (in the event of cancer) were kept the same across the "current situation" and the hypothetical plan, but were varied from one choice card to the next and across respondents. We use the responses to these questions to estimate the cancer VSL and the VSCC.

Our approach is different from earlier work in that we decompose the risk of dying from cancer into the product of two probabilities: that of getting cancer, times that of dying from it. In general, asking people to place a value on reducing the risk of an adverse event is a dire proposition. There are issues of numeracy,[5] confusion between relative v. absolute risks, and number of lives saved (Baron, 1997), and laypeople have been shown to overestimate small risks (especially when they are of a technological nature, involve catastrophic consequences or are simply little known) while routinely downplaying much larger risks (such as that of car accidents or illnesses from smoking; Viscusi, 1991, 1992). Our questionnaire includes a probability tutorial, visuals and quizzes in hopes of reducing these difficulties.

One advantage of our approach is that it allows us to test whether i) respondents are processing the two risks correctly (under the maintained assumption that the WTP is proportional to the unconditional cancer mortality risk), and ii) the WTP is strictly proportional to the unconditional cancer mortality risk reduction (under the maintained assumption that people understand compound probabilities).

The results from our survey are striking. First, respondents appear to have a good grasp of the two probabilities. For example, the responses to the valuation questions indicate that they duly take into account the term ($\Delta R \times \Delta S$), where ΔR is the reduction in the chance of getting cancer and ΔS the improvement in survival stated to them in the questionnaire, which, as we

[5] See http://www.dailymail.co.uk/news/article-2469032/US-numeracy-literacy-survey-finds-Americans-average-maths-English.html, OECD (2013) and Hammitt and Graham (1999).

show analytically, is one of the three components of the unconditional cancer mortality risk reduction. In fact, they appear to weigh this interaction term slightly more heavily than the other two. Second, contrary to concerns expressed in Cropper et al. (2011) and Robinson and Hammitt (2015), the WTP grows in a proportional, or even more than proportional, fashion with the change in unconditional cancer mortality. Third, when we relax the assumptions that people process probabilities correctly or that WTP is normally distributed, the new VSL and VSCC figures are similar and well within the range induced by the experiment design.

We estimate the cancer VSL to be between € 1.9 and 5.7 million, our preferred estimate being € 2.2 million, and the VSCC to be up to € 0.551 million euro (2014 PPS euro), depending on the restrictions imposed on the model, the subsample of responses used, and the distributional assumption on the WTP. We interpret these as "pure" cancer mortality and cancer risk values, as our models factor out quality-of-life and pain attributes.

In practice, however, the survey responses show that impacts on daily activities and pain have little or no effect on the WTP to reduce the adverse health risks, which depends exclusively on the cancer risk reductions and improvements in 5-year survival. Our survey results suggest that either cancer is cancer, no matter how light or serious the quality-of-life and pain consequences are, or that, after all, respondents are more sensitive to quantitative aspect of cancer risks than the qualitative ones.

We believe that these results are important, and reassuring, for policy analysis purposes. Policymakers cannot possibly have information about the course of illness, recovery, relapse, and duration and severity of symptoms as in Cameron and DeShazo (2013) or Chilton et al. (2016), and for this reason they cannot use benefit-cost analysis metrics that rely on individual, ex-post outcomes and the associated values. Our results suggest that even if they did,

conditioning on them would make little or no difference with respect to using more "stylized" ex ante values.

These results must, of course, be interpreted with caution. Practical considerations suggested that we keep pain at the mild and moderate level in our questionnaire and that most risk-reducing options portray relatively moderate impacts of cancer on quality of life. Very severe cancer scenarios could have resulted in very different findings.

The remainder of the paper is organized as follows. Section 2 provides background information on the VSL. Section 3 describes our approach. Section 4 presents the data and section 5 the estimation results. Section 6 offers concluding remarks.

2. Background on the VSL

The Value of a Statistical Life is defined as the willingness to pay (WTP) for a marginal change in the risk of dying (from any cause). In a static, one-period model, where U(y) and V(y) are the state-dependent utilities of income when alive and dead, respectively, and *p* is the probability of dying, it is easy to show that the VSL is equal to the differential between the two state-dependent utilities, divided by the expected marginal utility of income:

$$VSL = [U(y) - V(y)]/[(1-p)U'(y) + pV'(y)] \cdot$$

When the change in risk is very small, the WTP for any given risk reduction is thus the VSL times the risk reduction itself. An alternative and intuitive way to present the same concept is that if the members of a group are prepared to pay \$X to obtain a mortality risk reduction of 1/n, where n is the size of the group, then the VSL is X/(1/n)=X·n. For X=30 and n=10,000, the VSL is \$300,000. If a proposed policy is predicted to reduce the risk by 3 in 10,000, then the policy saves 3 "statistical" lives and produces \$900,000 worth of benefits for that community.

One issue implicit in the above definition is that it does not accommodate for different causes of death and competing risks. Eeckhoudt and Hammitt (2001) and Evans et al. (2006) note that the VSL for one cause of death may indeed be affected by competing risks, and the direction and magnitude of that effect depends on whether people process the competing risks in a multiplicative or additive fashion. The possibility that the VSL might be affected by co-morbidity (illness, pain, suffering and discomfort for more or less significant periods before death (Gentry and Viscusi, 2016) or other attributes of this risk (Slovic, 1987), and the fact that many environmental and safety policies are aimed at reducing cancer risks are important reasons why there has been much attention to the cancer VSL in research and policy circles.

3. Approach

In most stated-preference research about mortality risks, survey respondents are asked to consider a specified reduction in their risk of dying and report information about their willingness to pay to obtain such a reduction. Our study differs from many others in three respects.

First, we focused on one cause of death—cancer. Second, we presented cancer mortality risks as the product of the chance of getting cancer, times the chance of dying from cancer (which is one minus the chance of surviving it). Cancer mortality risks can thus be reduced by lowering the chance of getting cancer and/or increasing the chance of surviving cancer. We felt that this presentation of risk is logical, makes intuitive sense, and is consistent with the format adopted by many medical and public health organizations and intended for both health professionals and laypeople.[6] Quantifying mortality risks and risk reductions in this way does, of

[6] See, for example, http://www.cancer.org/cancer/lungcancer-non-smallcell/detailedguide/non-small-cell-lung-cancer-key-statistics for lung cancer or https://www.cancer.gov/melanomarisktool/ for a risk calculation tool.

course, imply that we must display two probabilities to survey participants, not just one. Third, along with the two cancer risks, we describe the health status before death using two attributes—pain, and quality-of-life impacts from cancer.

We asked respondents to engage in a total of 7 valuation tasks. In each task, the respondents were asked to consider the current situation, which was described to them as entailing a given risk of developing cancer (25 in 1,000 over 5 years), a given probability of survival at 5 years (60%), and, if the respondent gets cancer, a given level of pain (mild or moderate) and quality-of-life impact (ranging from fully active to confined to bed half of the time). He was then asked to consider a scenario where, at a cost, either the chance of getting cancer is reduced, or the probability of survival is increased, or both. This alternative scenario kept the same level of pain and impact on life as in the current situation. Which of these two options would the respondent choose—the current situation (at no cost) or the improved situation (at the specified cost)?

We changed the level of pain and impact on life from one valuation task to the next, but within each valuation task we kept them identical across the current situation and the improved scenario. The current situation always presented the same chance of getting cancer (25 in 1,000 over 5 years, which is equivalent to 5 in 1,000 per year) and the same probability of survival at 5 years (60%) to all respondents and in all valuation tasks. The improved scenario varied these two probabilities across respondents and across the seven valuation tasks within a respondent.

The valuation portion of the questionnaire is thus comprised of 7 single-bounded dichotomous-choice valuation tasks. We presented these tasks to the respondents using a graphical format similar to that used in many discrete choice experiments, in that the current situation and the risk reduction “package” were compared side by side and attribute by attribute

(see Figure 1). Table 1 summarizes the attributes of the risk reduction to be valued by the respondents and their levels.

The respondents were instructed to think of these seven valuation tasks as independent of one another. They were also told that they would be the only person in their family to experience the risk reduction offered in each valuation task, and that the risk reduction was a private good. In other words, it would not be delivered by a government policy. We also avoided any explicit mention of or link to environmental policies or exposure to chemicals.

One important feature of our study is that we ask respondents to value exclusively cancer outcomes. We are looking for factors that systematically affect the magnitude of the cancer VSL and VSCC within a cancer context, and we are not seeking to estimate the so-called cancer premium, which has been investigated, with mixed results, in earlier studies (Jones-Lee et al., 1985; Hammitt and Haninger, 2010; Adamowicz et al., 2011; Lindhjem et al., 2011; OECD, 2012). Moreover, in past research we have found that cancer values trump those for any other cause of death (Alberini and Ščasný, 2011, 2013) making it difficult to investigate issues of scope and attributes associated with illness and death.

Another important feature of our valuation scenario is that it is about "cancer," but does not identify the type of cancer or the affected organ. We felt that it was necessary to avoid specifics, lest the respondents replace the probabilities stated to them in the valuation questions with others of their own invention, perhaps based on experience or family history or, conversely, complete lack of knowledge of the specified type of cancer.

Regarding the experiment design, we created a total of 32 blocks (i.e., different versions of the 7 status quo-risk reduction pairs) by selecting pairs at random from the full factorial design. We imposed restrictions to avoid presenting the same pair more than once to the same

respondent. We also imposed the requirement that in blocks 1-16 the risk-reducing options that appear in first three valuation tasks feature cancer risk reductions, but hold survival at 5 years at the baseline (60%). In choice cards 4-7, both the risk of getting cancer and survival were improved compared to the current situation. By contrast, in blocks 17-32 the first three valuation tasks entailed improvements in survival at 5 years while holding the chance of getting cancer at the baseline level (25 in 1,000 over 5 years). Valuation tasks 4-7 varied both (see table 2). Each respondent was assigned at random to one of these 32 blocks.

It is important to note that the probabilities shown to the respondent in the "current situation" are true population rates based on cancer registries and Europe-wide medical statistics (Ferlay et al., 2010; Eurostat, 2014). The cancer risk reductions and the improvements in the survival rates at 5 years are hypothetical, and were selected to deliver unconditional mortality risk reductions comparable to those typically delivered by environmental policies. We also strived to be as practical as possible. For simplicity, we used integers throughout (e.g., 3 in 1000 over 5 years, rather than 0.6 in 1000 pear year, although the two are equivalent) and selected improvements in survival rates that would be meaningful to the respondents (e.g., an 10% increase, which brings the 5-year survival rate from 60% to 70%) One consequence of this decision and our design is that the reduction in the unconditional cancer mortality risk are similar across blocks 1-16 and 17-32, but smaller in choice questions 1-3 in blocks 1-16.[7]

4. The Model

A. Key Metrics

[7] In blocks 1-16, the unconditional risk reduction was on average $1.455*10^{-4}$ per year, and the standard deviation was $0.905*10^{-4}$. In blocks 17-32, the average was $1.889*10^{-4}$ and the standard deviation $0.845*10^{-4}$. These are averages and standard deviations based on all seven choice questions. Among choice questions 1-3 in blocks 1-16, however, the average unconditional risk reduction was $0.64*10^{-4}$ per year, or less than half the overall average.

The purpose of our research is to estimate the Value of a Statistical Life in the cancer context and establish its relationship with the Value of a Statistical Case of Cancer. We remind the reader that the (unconditional) chance of dying from cancer is the product of the chance of getting cancer, times the probability of dying from it, conditional on getting it in the first place. The cancer VSL is a summary measure of the WTP for a small change in the unconditional risk of dying from cancer.[8]

We seek to place a value on a reduction in the (unconditional) probability of dying from cancer, which we denote as $\Delta M=M_0-M_1$, where M_0 is the baseline risk of dying from cancer, M_1 is a reduced level of such risk, and $M_1<M_0$ because reducing the risk of getting cancer, or increasing survival if one gets cancer, unambiguously reduces the risk of dying from cancer. ΔM is thus positive.

Since $M_0= R_0\cdot(1-S_0)$, where R denotes the chance of getting cancer and S the probability of survival, $M_1= R_1\cdot(1-S_1)$, $\Delta R = (R_0 - R_1) > 0$ and $\Delta S = (S_1 - S_0) > 0$ (where the subscripts 0 and 1 denote the current situation and post-reduction levels, respectively), it is easy to show that:

(1) $$\Delta M = \Delta R \cdot (1 - S_0) + R_0 \cdot \Delta S - \Delta R \cdot \Delta S .$$

As shown in equation (1), the change in cancer mortality risk is comprised of three terms. In our survey, $(1-S_0)$ and R_0 are clearly specified and identical for all respondents, while ΔR and ΔS are varied to them by design. Equation (1) is simplified to $\Delta M = R_0 \cdot \Delta S$ if ΔR =0 (if only the conditional survival rate is changed to respondents) and $\Delta M = \Delta R \cdot (1 - S_0)$ if ΔS =0 (when only the risk of getting cancer is reduced). Since the valuation literature generally expresses the VSL

[8] The VSL can also be thought of as the WTP for a "micromort," namely a one-in-a-million change in the risk of dying (Howard, 1984; 1989).

on an annual basis, in our statistical models below R and S, and hence M, are all expressed on an annual basis.

B. Main Econometric Model

As is customary with single-bounded dichotomous choice contingent valuation questions, we assume that the responses to our valuation questions are driven by an underlying and unobservable WTP for the risk reduction:

$$(2) \qquad WTP_{ij}^{*} = \alpha + \mathbf{QOL}_{ij}\boldsymbol{\beta} + PAIN_{ij}\gamma + \Delta M_{ij}\delta + \varepsilon_{ij} .$$

This model assumes that the WTP changes in proportion to a change in the mortality risk reduction (Robinson and Hammitt, 2015). Regressors **QOL** and PAIN contain dummy variables that describe the impact of having cancer on quality of life and pain associated with cancer, respectively. Term ε is assumed to be normally distributed with mean zero and variance σ^2. On substituting (1) into (2), we get

$$(3) \qquad WTP_{ij}^{*} = \alpha + \mathbf{QOL}_{ij}\boldsymbol{\beta} + PAIN_{ij}\gamma + \delta \cdot [\Delta R_{ij} \cdot (1 - S_0) + R_0 \cdot \Delta S_{ij} - \Delta R_{ij} \cdot \Delta S_{ij}] + \varepsilon_{ij}$$

The VSL is defined as the WTP for a marginal change in the (unconditional) chance of dying from cancer, which means that it is equal to coefficient δ.

It is now possible to derive the Value of a Statistical Case of Cancer, which we define as the willingness to pay for a marginal change in the risk of getting cancer:

$$(4) \qquad VSCC = \frac{\partial WTP^{*}}{\partial \Delta R} = \delta(1 - S_0) - \delta \Delta S$$

This expression shows that one should expect the VSCC to depend on the initial (conditional) cancer mortality—the higher such mortality, $(1\text{-}S_0)$, the more one should be willing to pay to avoid cancer—and on the improvement in survival—the greater such improvement, the

less one is prepared to pay to avoid cancer. Expression (4) also contains δ, which is the VSL, and shows clearly the relationship between the VSL and the VSCC. If ΔS is equal to zero (as is the case with the first three valuation questions in questionnaire variants 1-16,), then the $VSCC=VSL\cdot(1-S_0)$, which implies that when the chance of surviving cancer is extremely high (approaching one) the VSCC is low (approaching zero), and when the chance of surviving cancer tends to zero the VSCC tends to the VSL.

We do not observe the true WTP for a specified risk-reduction package: All we know is whether someone would or would not pay for it the amount of money specified in the choice question. Since the WTP figures underlying the seven valuation questions are likely to be correlated within a respondent, the appropriate statistical model is thus a random-effects probit where the dependent variable is whether someone said he or she would pay for each of the seven risk reductions. In the simplest specification of the random-effects probit, the regressors include country, pain and quality-of-life dummies, ΔM, *and* cost. More complex specifications further include individual characteristics likely to affect the willingness to pay, such as income, gender, education, familiarity with and dread associated with this illness and cause of death.

As shown in Cameron and James (1987), δ, the cancer VSL, is obtained by dividing the random-effect probit coefficient on ΔM by the negative of that on cost. We compute the standard errors around these estimates of the cancer VSL using the delta method.

The country effects plus the other attributes of the risk reduction scenarios (pain and quality of life) allows us to interpret δ as the “pure” VSL—after cultural or cost-of-living factors, and other attributes of the illness have been controlled for. Similarly, we interpret expression (4) as the “pure” VSCC, which accounts for the chance of dying from cancer, but assumes away any additional morbidity considerations.

C. Robustness Checks

Expression (3) provides us with an excellent opportunity to empirically test whether survey participants process conditional v. unconditional risks correctly and form WTP values accordingly. We simply re-arrange equation (3) as follows:

(5) $$WTP_{ij}^{*} = \alpha + \mathbf{QOL}_{ij}\boldsymbol{\beta} + PAIN_{ij}\gamma + [(\Delta R_{ij} \cdot (1 - S_0))\delta_1 + (R_0 \cdot \Delta S_{ij})\delta_2 - (\Delta R_{ij} \cdot \Delta S_{ij})\delta_3] + \varepsilon_{ij},$$

estimate the corresponding econometric model (a random-effect probit) by entering separate terms for $\Delta R \cdot (1\text{-}S_0)$, $R_0 \cdot \Delta S$, and $\Delta R \cdot \Delta S$, and then test whether $\delta_1 = \delta_2$, $\delta_2 = \delta_3$, and $\delta_1 = \delta_3$. These three coefficients should all be equal to one another, and each is the VSL, if respondents have perfect command of compound probabilities (under the maintained assumption that WTP is linear in ΔM). We compute the VSL and VSCC based on the estimated δ_1, δ_2 and δ_3, respectively, for a total of three sets of such metrics, and examine whether they are similar or very different from one another.

We conduct two more robustness checks. In one, we simply enter polynomials in ΔM in the right-hand side of the random-effects probit corresponding to WTP equation (2) to make sure that we haven't misspecified the functional form for ΔM. In the other, we let the unobserved WTP be lognormally (rather than normally) distributed and revise the random-effects probit accordingly, entering log ΔM and log cost in the right-hand side of the model. Among other things, this allows us to test whether the WTP is proportional to the size of the risk reduction (under the maintained assumption that respondents construct ΔM correctly).

5. Questionnaire and Administration of the Survey

A. Structure of the Questionnaire

The valuation questions were placed roughly in the middle of the questionnaire. The questionnaire opened with a section meant to "warm up" the respondent and elicit basic information about his or her health. This was followed by a probability tutorial, which deployed graphical depictions to help people visualize the notion and magnitude of risks. We used a grid of squares as well as bar charts (especially when we need to show that certain risks increase as one gets older).

Next we asked people to rate various types of risks (including the risk of fires, accidents, etc.) on a scale from 1 to 5, where 1 denotes the lowest possible level of dread and 5 the highest. The questionnaire then switched to cancer. People were told about the risk of getting cancer and five-year survival rates, and were shown such probabilities by age group. The age groups were sufficiently broad to ensure that all our survey participants would fall in the same age group and would see the same risks, regardless of their age within this group and gender.

An entire section of the questionnaire discusses and calls attention to the pain and quality-of-life impacts of cancer. Although the valuation questions only included two levels of pain and four levels of quality-of-life effects, significant amounts of text dealt with issues such as social isolation, depression, becoming dependent on others for daily activities, mobility impairment, etc. We asked people to rate their level of concern about each such aspect on a scale from 1 to 5.

The subsequent section asked people to link certain factors (e.g., genetics, lifestyle, etc.) with increased or decreased cancer risks, and described a number of initiatives (public programs and individual actions) that can prevent cancer or increase the chance of surviving it, if someone gets cancer. This was followed by the valuation question section and debriefing questions. The final section of the questionnaire elicited the usual socio-demographics.

B. Survey Administration

Prior to administering the survey, we conducted a pilot study in the Czech Republic and the UK on Feb. 25 - March 9, 2014, for a total of 275 completed questionnaires. The pilot used Computer-Assisted Web Interviewing (CAWI), and, based on the responses to the key questions and on the feedback offered by our test subjects, we felt comfortable that the questionnaire was ready for deployment in the field.

The main survey was self-administered by respondents using CAWI in four countries—the Czech Republic, Italy, the UK and the Netherlands in March-April 2014. Sample sizes are displayed in table 3. In each country, survey participants were recruited from the national panels of consumers maintained by IPSOS. We imposed gender, income, region and age quotas, with age being restricted to 45-60 years.

6. The Data

Our empirical models are based on the samples from the final survey. We exclude the 444 "speeders," namely persons who completed the questionnaire in less than 13 minutes (12.29% of the 3,612 completes), and those who failed a simple probability "quiz" at the end of the probability tutorial (24.65% of the 3,612 completes).[9, 10] Our "cleaned" sample is comprised

[9] Based on extensive testing and the pilot, we judged 13 minutes to be the shortest amount of time needed to read all materials carefully. This is a longer time than that recommended by Survey Sampling International (2013), which identifies as a potential speeder a respondent who completes the questionnaire in less than 48% of the median completion time (22 minutes in our survey).

[10] Specifically, we asked people to indicate whether person A or person B was more likely to get a certain illness, if person A's risk was 5 in 1,000 (shown by colored squares in a grid of white squares) and B's 10 in 1,000. We used a similar question in earlier studies (Krupnick et al., 2002; Alberini and Chiabai, 2007, and Alberini and Ščasný, 2011, 2013, and in those studies the share of the sample that failed the probability quiz was lower. Hammitt and Graham (1999) report that 32% of the respondents who were asked which risk is higher, 5 in 100,000 or 1 in 10,000, gave an incorrect answer.

of 2,414 respondents and 16,873 responses to the valuation questions. Table 4 presents descriptive statistics of the sample by country.

Table 5 presents information about our subjects' degree of familiarity with cancer. Between 6 and 12% of the respondents, depending on the country, had experienced cancer themselves, 13 - 18% had had a benign tumor. Moreover, 50 - 61% of the respondents, depending on the country, had a close family member who had or had had cancer, and even higher shares of the samples reported that friends or acquaintances had had cancer. This suggests that the majority of our respondents were familiar with cancer. About 41% of the respondents assigned the highest level of dread to cancer (table 6), a percentage that is much higher than that for domestic and car accidents (9.7% and 16.3% respectively), heart attacks (23.3%) and is exceeded only by that for developing an illness that "makes me completely dependent" on a caregiver (50.5%).

Turning to the responses to the valuation questions, the percentage of valuation questions where the risk-reducing program is accepted is between 49% and 55% (see table 7). These shares are smallest in the Netherlands and largest in Italy. The share of "yes" responses is increased only slightly when the respondents who failed the probability quiz were excluded, resulting in "yes" shares between 50% and 56%.

6. Results

Table 8 reports the results from our basic random-effects probit model, where we enter country fixed effects, pain and quality-of-life dummies, ΔM, and cost. We fit this model using three alternate samples: i) one that includes only the responses from those subjects who received blocks 1-16 and to the first three valuation questions only (panel (A)), ii) one for blocks 17-32

and the first three valuation questions therein (panel (B)), and iii) the full sample (all blocks, all valuation questions; panel (C)). We always pool the data from the four countries, but exclude speeders and persons who failed the probability quiz.

The results show clearly that, all else the same, people were less likely to choose more expensive risk-reduction scenarios and more likely to choose scenarios with larger mortality risk reductions. This indicates that the responses to our valuation questions are consistent with economic theory and "scope" requirements (Corso et al., 2001; Hammitt and Graham, 1999).[11] However, the coefficients on pain and quality-of-life indicators are estimated imprecisely, are non-monotonic with respect to severity (in the case of quality of life), and even have counterintuitive signs.[12]

When the sample is restricted to the responses to valuation questions 1-3 from the subset of respondents who received blocks 1-16, the cancer VSL is € 5.676 million (2014 PPS €) and the VSCC € 0.551 million (table 8, panel (A)). The former figure is in line with estimates of the VSL used in or recommended for policy analyses (OECD, 2012) and with our own estimates from earlier studies at the same locales (Alberini and Ščasný, 2011). The VSCC is somewhat

[11] Briefly, the responses meet the "scope" requirement if the WTP is proportional to the size of the risk reduction, which means there is a single VSL. A "weak" scope test is met if the WTP increases with the size of the risk reduction, even if in a less than proportional manner (Cropper et al., 2011). We report in Appendix B a simple random-effects probit model where the responses to the valuation questions are regressed on all attributes of the risk-reducing packages, including ΔR and ΔS entered separately. The results from this simple model show that respondents prefer packages with larger reductions in the risk of getting cancer and larger improvements in the chance of surviving it.

[12] Since the descriptions of the quality-of-life impacts and pain are the same across the "current situation" and risk reduction within a choice card, the coefficients on these variables are identified from the variation across the choice cards within a respondent and across respondents. We also fit models where the quality of life and pain indicators are interacted with the unconditional mortality risk reductions (or with ΔR and ΔS separately), but the coefficients on the interactions were individually and jointly insignificant. Models with seven pain-and-quality-of-life/combination dummies likewise suggested that the coefficients on these dummies were insignificant. These additional results are available from the authors.

lower than the estimates from other stated-preference studies, including Tonin et al. (2009), and revealed-preference studies such as Gayer et al. (2000, 2002) and Davis (2004).[13]

The results displayed in table 8, column (B), are based on a sample that contains solely the responses from choice questions where only the chance of surviving cancer was increased (blocks 17-32, valuation questions 1-3). This time, the cancer VSL is lower (€ 1.887 million), whereas the VSCC cannot be computed from this sample of responses. The model run that uses all observations (table 8, column (C)) produces a cancer VSL of € 2.144 million and VSCC figures ranging from € 93,000 (for the largest increase in the chance of 5-year survival) to € 208,000 (when the chance of survival is kept at the baseline level; see table 9).

The models in columns (A) and (B) of table 8 take advantage of our statistical design, which allows us to estimate VSL and VSCCs separately when a cancer mortality risk reduction is attained by reducing the risk of getting cancer alone (column (A)) or improving the chance of surviving cancer for a fixed risk of getting it (column (B)). We are not surprised that the VSL from (A) is greater than that from (B). Earlier experience suggests that the VSL tends to be larger when it is estimated from settings with smaller risk reductions, as is the case for our choice questions 1-3 in blocks 1-16.[14] [15] The VSL from (C) is between that from (A) and from (B). We interpret this VSL range to be "design-induced," and note that the largest value is three times the

[13] The literature about the willingness to pay to reduce the risk of getting cancer (whether or not one dies from it) is relatively thin. Estimates of the value of a statistical case of cancer range from several hundred (Fu et al., 1999; Hammitt and Liu, 2004) to a few million dollars or Euro (Cropper et al. 1992; Jeanrenaud and Priez, 1999; Gayer et al., 2000; Davis, 2004, Tonin et al. 2009).

[14] For example, Braathen (2012) conducts a meta-analysis of stated-preference studies, finding that the VSL is negatively related to the (average) size of the risk reduction shown to the respondents. Alberini and Ščasný (2011, 2013) and Alberini and Chiabai (2007) report similar findings from choice experiments and contingent valuation surveys in Italy and the Czech Republic.

[15] Another way of interpreting these findings is that in choice questions 4-7, respondents were offered both cancer risk reductions *and* increases in the chance of surviving at "posted prices" similar to those in choice questions 1-3. In other words, they were offered more for similar prices.

minimum. When the sample is restricted to the responses to choice questions 4-7 (see Appendix C), the cancer VSL is around € 2.2 million, virtually the same figure as in table 8, column (C).

Adding regressors suggests that the WTP for a risk-reducing package does not depend on gender, educational attainment or age (table 10, columns (A)-(F)). The WTP does, however, grow with household income, when the latter is reported by the respondent. Finally, we created a dummy denoting whether cancer is rated as having the highest level of dread, and, as expected, the coefficient on this variable is positive and significant at the conventional levels. All else the same, respondents who rate cancer as very highly dreaded are willing to pay € 185 more than the others for a given risk reduction package.

In specifications not reported in this paper, we also experimented with adding dummies denoting someone has had cancer or a benign tumor themselves, or is familiar with cancer because family members or friends have had it. However, these factors do not seem to further influence the WTP.

B. Robustness checks

Our first order of business is to estimate the random-effects probit corresponding to WTP equation (5), where ΔM is replaced by the three terms it is comprised of. We then test whether the coefficients on these three terms are equal to one another. Wald tests reject the null hypotheses that 1) $\delta_1=\delta_2$ (Wald statistic 16.6, p value 4.6E-05), 2) $\delta_2=\delta_3$ (Wald statistic 45.31, p value 1.7E-11) and 3) $\delta_1=\delta_3$ (Wald statistic 44.48, p value 1.54E-11).

We report the cancer VSL and VSCC corresponding to each of the three estimated δs in table 11. Depending on the estimate of δ used, the cancer VSL ranges from € 2.4 million to € 5 million. This may seem like a wide range, but in fact this range is similar to (and in fact slightly

smaller than) to that displayed in Table 8 (€ 1.9 million to € 5.7 million)—the "design-induced" range, which is based simply on random assignment of the respondents to valuation questions that varied only one risk (that of getting cancer) or the other (of not surviving for at least five years after getting cancer).

Moreover, the largest of the three estimated δs is δ_3, the coefficient on the interaction term $\Delta R \cdot \Delta S$, which shows that not only were respondents at least intuitively realizing that such interaction enters in the unconditional chance of dying from cancer—they were even assigning it a heavier weight than for other terms. It is also striking that the signs of the three estimated coefficients are the same as those in equation (5). In other words, the coefficient on $\Delta R \cdot \Delta S$ is negative, while the other two are positive.

The VSCC estimates are one order of magnitude smaller than the respective VSL, which is consistent with the fact that the chance of surviving each year after getting cancer is approximately 90% (and hence the annual chance of dying ($1-S_0$) is 9.712%).[16] The figures based on the model that imposes the restriction that $\delta_1=\delta_2=\delta_3$ (i.e., there is a single δ, and only ΔM is entered in the model) are closest to the VSL and VSCC based on δ_2, the lowest among the three sets of values shown in table 11.

As shown in table 12, adding ΔM square and ΔM cube does not improve the fit of model and results in insignificant coefficients on these terms. When the sample is restricted to the responses to valuation questions 4-7, the VSL is approximately € 2.2 million—whether the sample is limited to those respondents who were assigned to blocks 1-16 (€ 2.201 million, s.e. 0.190 million), those who were assigned to blocks 17-32 (€ 2.163 million, s.e. 0.212 million), or uses all blocks (€ 2.185 million, s.e. 0.137 million). If we use the responses to all questions from

[16] We remind the reader that $(1-0.09712)^5$ equals 0.60, the baseline 5-year survival rate.

all blocks, but include a “block1-16” dummy and a “pair 4-7” dummy, the VSL is € 2,283 million (s.e., 0.113 million) (available from the authors).

There remains, of course, the possibility that the latent WTP is not normally distributed. We fit random-effects probit with log ΔM and log cost in the right-hand side, which imply that latent WTP is lognormal. When the model is parsimonious and includes only log ΔM and log cost, the median VSL at the sample average of the mortality risk reduction is € 3.174 million (s.e. 0.318 million). This VSL figure increases to € 3.879 million (s.e. 0.586) if we further control for country fixed effects, pain and quality of life. Again, these figures are well within the variation in the VSL estimates induced by the study design.

Even more important, the coefficient on log ΔM is greater than one in all specifications. For example, in the latter, the coefficient is 1.2192 (s.e. 0.0617, t statistic 19.77). A Wald test rejects the null that it is equal to one (Wald statistic 12.64, for a p value of 0.0004). This means that the WTP grows slightly more than proportionately with the size of the risk reduction, a result that is consistent with the possibility that 1) the WTP responses satisfy “scope” in the sense of Robinson and Hammitt (2015), and 2) perhaps the respondents’ own intuitive calculations of the unconditional mortality risk reductions slightly overstate the “true” risk reductions.

7. Conclusions

We developed an original survey instrument and administered it to representative samples of 45-60-year-olds in four European Union countries—the UK, the Czech Republic, the Netherlands and Italy for the purpose of estimating the cancer VSL and the VSCC, two key metrics for assessing the health benefits of environmental and health regulations. We used a

sequence of dichotomous-choice questions that asked respondents to indicate whether they would choose a health risk reduction at a specified cost.

Our health risk reductions are different from earlier valuation work because they are comprised of two probabilities—that of getting cancer, and that of dying from it (conditional on getting it in the first place). The product of these two probabilities is the unconditional cancer mortality risk. In addition to these two probabilities, our risk-reducing "packages" also included two qualitative attributes (quality of life impacts and pain). The respondent was asked to assume that these effects would be experienced, in the event of cancer, even if they did not choose the risk-reducing package.

The results from our survey are striking. People did appear to have an intuitive grasp of compound probabilities, and took into account each of the three components of the unconditional cancer mortality risk when answering the valuation questions. If anything, they appeared to put slightly heavier weight on the interaction term $\Delta R \cdot \Delta S$ than on the ΔR and ΔS terms (where ΔR denotes the reduction in the risk of cancer and ΔS the improvement in survival that were stated to them in the questionnaire). Under the maintained assumption that respondents processed the compound probabilities correctly, the WTP for the risk reductions passes a strong "scope" test (Robinson and Hammitt, 2015) and grows even slightly more than proportionally with the size of the unconditional mortality risk reductions.

Various robustness checks show that imposing or relaxing the assumption that people were processing the two risk correctly, or changing the distributional assumption on the WTP, result in changes in the VSL and VSCC that are well within the range of figures induced by the experiment design alone (i.e., by restricting the sample to the responses to questions where only one probability was changed, while keeping the other fixed). The cancer VSL is € 1.9 – 5.7

million, and the VSCC, which depends on the 5-year survival rate after diagnosis, is up to € 0.551 million euro (all figures in 2014 PPS euro).

We interpret these as "pure" mortality and pure cancer values, stripped of morbidity, pain or quality of life effects. However, we find that the quality of life and pain attributes do not have an appreciable influence on the WTP. Perhaps "cancer is cancer" or people paid more attention to the numerical attributes of the risks. Either way, we believe that these results are important for policy analyses. In policy analyses, agencies cannot possibly use individual information about the course of the illness, recovery and relapse, and duration and severity of symptoms to quantify the benefits of preventing cancer. Our research suggests that even if they did, the values to be used in benefit-cost analyses would not be appreciably affected by them.

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Appendix A. Descriptive statistics of the respondents. Full samples, including "speeders" and respondents who failed the probability quiz.

	Czech Republic		**United Kingdom**		**Italy**		**Netherlands**		**pooled**	
	N	mean	N	mean	N	mean	N	mean	N	mean
Age	1,145	52.53	733	52.30	824	51.55	910	51.91	3,612	52.10
Age 50-54 dummy	1,145	0.28	733	0.32	824	0.29	910	0.36	3,612	0.31
Age 55-60 dummy	1,145	0.34	733	0.30	824	0.25	910	0.24	3,612	0.29
Education: tertiary (dummy)	1,145	0.14	733	0.45	824	0.25	910	0.30	3,612	0.27
Education: secondary (dummy)	1,145	0.33	733	0.51	824	0.59	910	0.43	3,612	0.45
Female dummy	1,145	0.50	733	0.50	824	0.50	910	0.48	3,612	0.50
Household size	1,145	2.65	733	2.38	824	3.09	910	2.58	3,612	2.68
Household income*	1,042	1,522	617	2,117	748	2,079	716	1,976	3,123	1,877
No information about income (dummy)	1,145	0.09	733	0.16	824	0.09	910	0.21	3,612	0.14

* After-tax monthly household income in 2014 PPP EUR.

Appendix B. Estimation results: Random-effects probit model of the responses, all attributes entered additively, All countries, clean sample (no speeders or persons who failed the probability quiz), Number of observations=16,873.

	Coefficient	Std. error	t stat.
Italy	0.3554	0.1063	3.34
Netherlands	-0.1143	0.1032	-1.11
United Kingdom	0.2276	0.1099	2.07
Czech Republic	0.2123	0.0961	2.21
QOL=1 dummy	-0.0384	0.0418	-0.92
QOL=2 dummy	-0.0670	0.0468	-1.43
QOL=3 dummy	-0.1637	0.0430	-3.81
Moderate pain dummy	0.0431	0.0310	1.39
Reducing risk of getting cancer	0.1008	0.0096	10.50
Increasing chance of survival	0.0601	0.0022	27.49
COST	-0.0025	0.0001	-24.97

Appendix C.

Estimation results: Random-effects probit of the response to the valuation questions. Robustness checks based on specific subsets of the responses (only choice cards 4-7 used). T statistics in parentheses, unless otherwise indicated.

	(A) Blocks 1-16 Choice cards 4-7 $\Delta R \neq 0$ and $\Delta S \neq 0$ (Nobs: 4,628)	**(B)** Blocks 17-32 Choice cards 4-7 $\Delta R \neq 0$ & $\Delta S \neq 0$ (Nobs.: 5,003)	**(C)** All blocks Choice cards 4-7 (Nobs.: 9,631)
QOL=1 dummy	-0.3028*** (-3.30)	0.1232 (1.37)	-0.1032* (-1.64)
QOL=2 dummy	-0.3099*** (-3.08)	-0.0995 (-0.94)	-0.2486*** (-3.54)
QOL=3 dummy	-0.2914*** (-2.92)	-0.1427* (-1.67)	-0.2460*** (-3.99)
Moderate pain dummy	-0.1070 (-1.35)	-0.0174 (-0.26)	0.0690 (-1.44)
ΔMORTRISK	7262.04*** (13.98)	5834.38*** (12.80)	6418.10*** (19.37)
COST	-0.0033*** (-12.62)	-0.0027*** (-13.36)	-0.0029*** (-18.89)
Implied VSL (mil. PPP euro)	**2.201** (s.e. 0.190)	**2.163** (s.e. 0.212)	**2.185** (s.e. 0.137)

***: p<.01, **: p<.05, *: p<0.1. The models include country fixed effects.

Figure 1. Example of Choice Card.

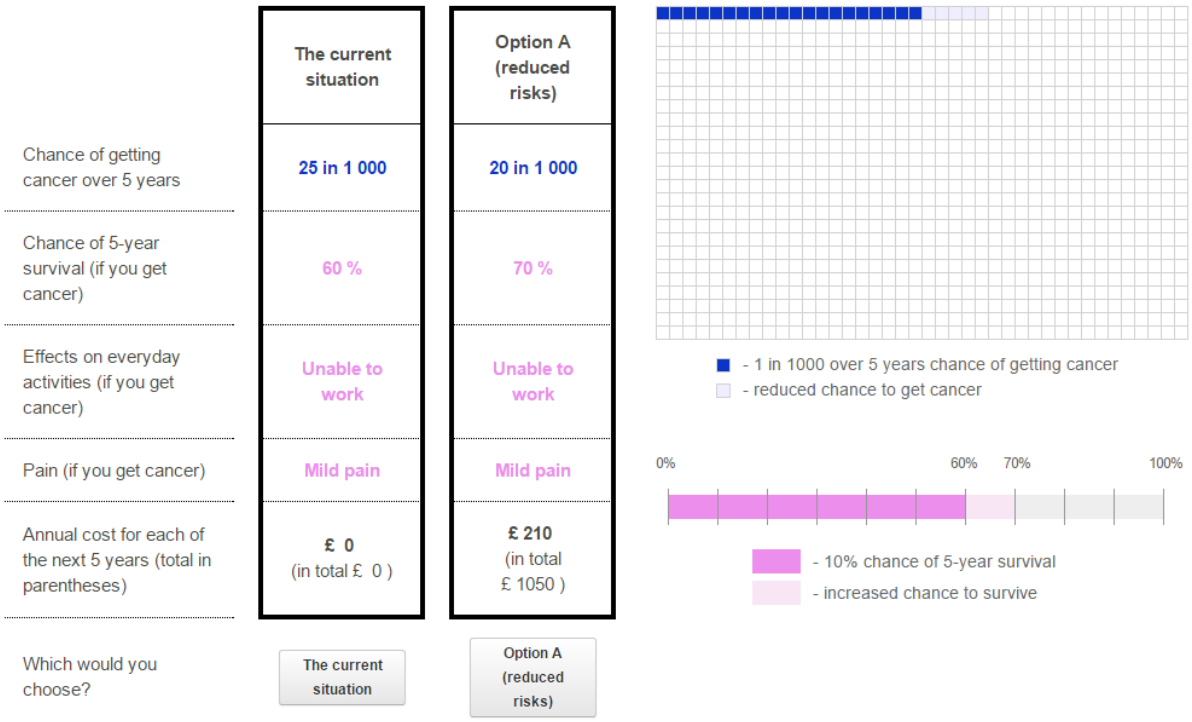

Table 1. Attributes and their levels in the dichotomous-choice valuation tasks.

Characteristics	**Levels**		
Chance of getting cancer within the next 5 years	Reduce the baseline by 0, 2, 3, 5 in 1000 over 5 years		
Chance of survival at 5 years from the diagnosis (if you get cancer)	Increase the baseline (60%) by 0%, 5%, 10%, 20% to 60%, 65%, 70% and 80%		
Effects on everyday activities (if you get cancer)	Fully active (qol=0) No heavy physical work (qol=1) Unable to work (qol=2) Confined to bed half of the time (qol=3)		
Pain (if you get cancer)	Mild pain Moderate pain		
Cost per year for each of the next five years	Italy & the Netherlands	United Kingdom	Czech Republic
	€ 110	£ 100	CZK 2,000
	€ 225	£ 210	CZK 4,000
	€ 370	£ 340	CZK 6,600
	€ 540	£ 500	CZK 9,600

Table 2. Design of the dichotomous-choice experiments

	Blocks 1-16	**Blocks 17-32**
First 3 choice cards	$\Delta S=0$; $\Delta R\neq 0$	$\Delta R=0$, $\Delta S\neq 0$
Choice cards 4-7	ΔS and ΔR both different from zero	ΔS and ΔR both different from zero

Table 3. Sample sizes.

	Total observations	Cleaned sample (no speeders or respondents who failed the probability quiz)
Czech Republic	1,145	753
United Kingdom	733	504
Netherlands	910	598
Italy	824	559
Total	3,612	2,414

Table 4 Descriptive statistics. Clean samples (no speeders or respondents who failed the probability quiz).

	Czech Republic		**United Kingdom**		**Italy**		**Netherlands**		**pooled**	
	N	mean	N	mean	N	mean	N	mean	N	mean
Age	753	52.62	503	52.41	558	51.73	597	51.88	2,410	52.19
Age 50-54 dummy	753	0.28	503	0.31	558	0.29	597	0.36	2,410	0.31
Age 55-60 dummy	753	0.35	503	0.32	558	0.26	597	0.23	2,410	0.29
Education: tertiary (dummy)	753	0.18	503	0.48	558	0.27	597	0.34	2,410	0.30
Education: secondary (dummy)	753	0.34	503	0.49	558	0.59	597	0.43	2,410	0.45
Female dummy	753	0.46	503	0.49	558	0.48	597	0.44	2,410	0.47
Household size	753	2.66	503	2.39	558	3.11	597	2.55	2,410	0.11
Household income*	698	1,574	430	2,155	516	2,168	497	2,010	2,141	1,935
No information about income (dummy)	753	0.07	503	0.14	558	0.08	597	0.17	2,410	2.68

Note: * After tax per month household income in PPP EUR.

Table 5. Respondent experience with cancer. Based on clean samples.

	Czech Republic (n=753)	United Kingdom (n=504)	Italy (n=559)	Netherlands (n=598)	Pooled data (n=2,414)
Have you ever had a benign tumor	16.7%	15.9%	13.2%	17.7%	16.0%
Have you ever had cancer	6.0%	11.7%	5.9%	5.7%	7.1%
Do you believe that there is a predisposition to cancer in your family?	30.9%	20.4%	25.9%	25.8%	26.3%
Have any of your closest family members (e.g., parents, siblings, spouse, or children) ever been diagnosed with cancer?	50.3%	56.5%	57.6%	60.5%	55.8%
Have any of your friends ever been diagnosed with cancer?	66.8%	66.3%	73.5%	60.7%	66.7%

Table 6. Dreaded risks: Percent of respondent who selected the highest level of dread for each type of risk. Based on clean samples.

	Czech Republic (n=753)	United Kingdom (n=504)	Italy (n=559)	Netherlands (n=598)	Pooled data (n=2,414)
Dying in a car or road traffic accident	18.2%	18.3%	20.4%	8.5%	16.3%
Dying in a domestic accident	10.4%	14.5%	9.1%	5.2%	9.7%
Surgery on an emergency basis	9.0%	14.1%	15.0%	3.3%	10.1%
Developing chronic respiratory illnesses (asthma, chronic bronchitis, emphysema)	10.9%	17.7%	11.6%	5.4%	11.1%
Getting cancer	**43.2%**	**47.6%**	**54.4%**	**18.7%**	**40.6%**
Becoming paralyzed	36.5%	56.0%	50.4%	15.6%	38.6%
Having a heart attack	28.7%	26.8%	28.4%	8.9%	23.3%
Developing an illness that makes me completely dependent on being taken care of by someone else	51.9%	66.1%	59.9%	26.9%	50.5%

Note: A Likert scale from 1 to 5 used, where 1 = lowest or no dread and 5 = highest dread.

Table 7. Percentage of responses in favor of paying to get the risk reductions. Based on clean samples.

	Total number of valuation responses	Percent in favor of obtaining the risk reduction %
Czech Republic	5,270	53.1%
United Kingdom	3,522	53.9%
Italy	3,904	56.0%
Netherlands	4,177	49.7%
Pooled data	16,873	53.1%

Table 8. Estimation results, basic specifications. Random-effect probit of the responses to the choice questions. T statistics in parentheses, unless otherwise indicated.

	(A) Blocks 1-16 Choice cards 1-3 (where only ΔR≠0) (No. obs: 3,483)	**(B)** Blocks 17-32 Choice cards 1-3 (where only ΔS≠0) (No obs.: 3,759)	**(C)** All blocks All choice cards (No obs.: 16,873)
QOL=1 dummy (no heavy physical work)	-0.1343 (-1.067)	0.1625 (1.269)	-0.0486* (-1.175)
QOL=2 dummy (unable to work)	0.0026 (0.018)	0.1762 (1.107)	-0.0892* (-1.918)
QOL=3 dummy (confined to bed half of the time)	-0.1701 (-1.148)	0.1357 (0.827)	-0.1756*** (-4.083)
Moderate pain dummy	0.1246 (1.311)	0.0867 (0.977)	0.0190 (0.620)
ΔM (change in unconditional cancer mortality risk)	15023.03*** (8.070)	6136.54*** (10.175)	5324.53*** (30.271)
COST	-0.00265*** (-9.223)	-0.00325*** (-7.938)	-0.00249*** (-25.181)
Implied VSL (mill. PPP euro)	**5.676** (s.e. 0.866)	**1.887** (s.e. 0.284)	**2.144** (s.e. 0.102)
Implied VSCC (mill. PPP euro)	**0.551** (s.e. 0.084)	n/a	Varies with ΔS

***: p<.01, **: p<.05, *: p<0.1. The models include country fixed effects.

Table 9. VSL and VSCC from the model of column (C) in table 8, with $\delta_1 = \delta_2 = \delta_3$, All figures in million EUR PPS. Standard errors in parentheses.

	Figure in million euro
VSL	2.141
	(0.102)
VSCC for …	
ΔS=0	0.208
	(0.010)
ΔS=5%	0.177
	(0.008)
ΔS=10%	0.147
	(0.007)
ΔS=20%	0.093
	(0.004)

Table 10. Estimation results, models with individual characteristics. Random-effects probit models of the responses to the choice questions. N=16,873 observations. T statistics in parentheses.

	(A)	**(B)**	**(C)**	**(D)**	**(E)**	**(F)**
Italy	0.3046	-0.4683	-0.3659	-0.6830	-0.4100	-0.6631
	(2.71)	(-3.06)	(-2.1)	(-1.3)	(-2.26)	(-3.54)
Netherlands	-0.1682	-0.8691	-0.8015	-1.1191	-0.8422	-0.9331
	(-1.56)	(-5.92)	(-4.89)	(-2.14)	(-4.88)	(-5.41)
UK	0.1776	-0.5779	-0.5144	-0.8356	-0.5665	-0.7945
	(1.53)	(-3.7)	(-2.83)	(-1.56)	(-2.98)	(-4.08)
Czech Republic	0.1647	-0.4161	-0.3512	-0.6731	-0.4058	-0.5999
	(1.62)	(-3.24)	(-2.55)	(-1.29)	(-2.73)	(-3.92)
QOL=1 dummy	-0.0486	-0.0482	-0.0481	-0.0482	-0.0483	-0.0490
	(-1.18)	(-1.17)	(-1.16)	(-1.16)	(-1.17)	(-1.18)
QOL=2 dummy	-0.0892	-0.0878	-0.0882	-0.0882	-0.0883	-0.0878
	(-1.92)	(-1.89)	(-1.9)	(-1.9)	(-1.9)	(-1.89)
QOL=3 dummy	-0.1755	-0.1755	-0.1751	-0.1752	-0.1754	-0.1766
	(-4.08)	(-4.08)	(-4.07)	(-4.08)	(-4.08)	(-4.11)
pain: moderate	0.0190	0.0199	0.0202	0.0203	0.0204	0.0203
	(0.62)	(0.65)	(0.66)	(0.66)	(0.66)	(0.66)
ΔM (uncond. cancer mort. Risk)	5,300	5,300	5300	5300	5300	5300
	(30.27)	(30.28)	(30.28)	(30.28)	(30.28)	(30.26)
COST	-0.0025	-0.0025	-0.0025	-0.0025	-0.0025	-0.0025
	(-25.18)	(-25.18)	(-25.19)	(-25.19)	(-25.19)	(-25.19)
female	0.0330	0.1059	0.1020	0.0995	0.0975	0.0663
	(0.38)	(1.22)	(1.17)	(1.14)	(1.12)	(0.76)
income		0.0004	0.0003	0.0003	0.0003	0.0003
		(7.34)	(6.77)	(6.78)	(6.78)	(6.74)
missing income		0.5415	0.4931	0.4951	0.4948	0.4993
		(3.25)	(2.94)	(2.95)	(2.95)	(2.99)
education_ secondary			-0.1534	-0.1514	-0.1485	-0.1276
			(-1.32)	(-1.31)	(-1.28)	(-1.11)
education_ tertiary			0.1157	0.1170	0.1215	0.1651
			(0.89)	(0.9)	(0.94)	(1.28)
age				0.0061		
				(0.64)		
age50-54					0.0160	0.0216
					(0.16)	(0.21)
age55-60					0.1393	0.1260
					(1.32)	(1.20)
dread						0.4636
						(5.10)

Table 11. VSL and VSCC based on the different deltas (based on eq. (5), All figures in million EUR PPS. Standard errors in parentheses.

	δ_1	δ_2	δ_3
VSL	3.484	2.392	4.965
	(0.361)	(0.151)	(0.986)
VSCC for …			
	0.338	0.232	0.480
ΔS=0	(0.035)	(0.015)	(0.096)
	0.288	0.197	0.408
ΔS=5%	(0.030)	(0.012)	(0.081)
	0.240	0.165	0.340
ΔS=10%	(0.025)	(0.010)	(0.068)
	0.152	0.104	0.215
ΔS=20%	(0.016)	(0.006)	(0.043)

Table 12. Robustness check for polynomial functions of ΔM .Random-effects probit model of the responses to the choice questions. Nobs=16,873. T statistics in parentheses.

	(A)	**(B)**
Italy	-0.7610	-0.8453
	(-3.84)	(-3.73)
Netherlands	-1.0316	-1.1154
	(-5.60)	(-5.20)
UK	-0.8925	-0.9765
	(-4.35)	(-4.20)
Czech Republic	-0.6981	-0.7821
	(-4.20)	(-3.93)
QOL=1 dummy	-0.0428	-0.0426
	(-1.03)	(-1.03)
QOL=2 dummy	-0.0863	-0.0845
	(-1.86)	(-1.81)
QOL=3 dummy	-0.1740	-0.1735
	(-4.04)	(-4.03)
pain: moderate	0.0136	0.0154
	(0.44)	(0.49)
ΔM	6700	8800
	(7.44)	(3.03)
ΔM squared	-3700	-18000
	(-1.52)	(-0.95)
ΔM cube		280000
		(0.76)
COST	-0.0025	-0.0025
	(-24.49)	(-24.44)
female	0.0661	0.0660
	(0.76)	(0.76)
income	0.0003	0.0003
	(6.75)	(6.75)
missing income	0.5004	0.5006
	(3.00)	(3.00)
education_secondary	-0.1276	-0.1272
	(-1.11)	(-1.10)
education_tertiary	0.1648	0.1645
	(1.27)	(1.27)
age50-54		
age55-60	0.0219	0.0219
	(0.21)	(0.21)
dread	0.1261	0.1260
	(1.20)	(1.20)

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