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Does the Cause of Death Matter? The Effect of Dread, Controllability, Exposure and Latency on the Vsl

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Summary

The Value of a Statistical Life is a key input into the calculation of the benefits of environmental policies that save lives. To date, the VSL used in environmental policy analyses has not been adjusted for age or the cause of death. Air pollution regulations, however, are linked to reductions in the risk of dying for cancer, heart disease, and respiratory illnesses, raising the question whether a single VSL should be applied for all of these causes of death. We conducted a conjoint choice experiment survey in Milan, Italy, to investigate this question. We find that the VSL increases with dread, exposure, the respondents' assessments of the baseline risks, and experience with the specific risks being studied. The VSL is higher when the risk reduction is delivered by a public program, and increases with the effectiveness rating assigned by the respondent to public programs that address specific causes of death. The effectiveness of private risk-reducing behaviors is also positively associated with the VSL, but the effect is only half as large as that of public program effectiveness. The coefficients on dummies for the cause of death per se—namely, whether it's cancer, a road traffic accident or a respiratory illness—are strongly statistically significant. All else the same, the fact that the cause of the death is "cancer" results in a VSL that is almost one million euro *above* the amount predicted by dread, exposure, beliefs, etc. The VSL in the road safety context is about one million euro *less* than what is predicted by dread, exposure, beliefs, etc. These effects are large, but the majority of the variation in the VSL is accounted for by the public program feature, the effectiveness of public programs at reducing the indicated risk, and dread. The effects of exposure and experience are smaller. These results raise the question whether using VSL figures based on private risk reduction, which is usually recommended to avoid double-counting, severely understates how much a society might be willing to pay for public safety.

Keywords: VSL, Conjoint Choice Experiments, Mortality Risk Reductions, Cost-benefit Analysis, Forced Choice Questions

JEL Classification: I18, J17, K32, Q51

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DOES THE CAUSE OF DEATH MATTER? THE EFFECT OF DREAD, CONTROLLABILITY, EXPOSURE AND LATENCY ON THE VSL

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Abstract

The Value of a Statistical Life is a key input into the calculation of the benefits of environmental policies that save lives. To date, the VSL used in environmental policy analyses has not been adjusted for age or the cause of death. Air pollution regulations, however, are linked to reductions in the risk of dying for cancer, heart disease, and respiratory illnesses, raising the question whether a single VSL should be applied for all of these causes of death. We conducted a conjoint choice experiment survey in Milan, Italy, to investigate this question.

We find that the VSL increases with dread, exposure, the respondents' assessments of the baseline risks, and experience with the specific risks being studied. The VSL is higher when the risk reduction is delivered by a public program, and increases with the effectiveness rating assigned by the respondent to public programs that address specific causes of death. The effectiveness of private risk-reducing behaviors is also positively associated with the VSL, but the effect is only half as large as that of public program effectiveness.

The coefficients on dummies for the cause of death per se—namely, whether it's cancer, a road-traffic accident or a respiratory illness—are strongly statistically significant. All else the same, the fact that the cause of the death is "cancer" results in a VSL that is almost one million euro *above* the amount predicted by dread, exposure, beliefs, etc. The VSL in the road safety context about is about one million euro *less* than what is predicted by dread, exposure, beliefs, etc.

These effects are large, but the majority of the variation in the VSL is accounted for by the public program feature, the effectiveness of public programs at reducing the indicated risk, and dread. The effects of exposure and experience are smaller. These results raise the question whether using VSL figures based on private risk reduction, which is usually recommended to avoid double-counting, severely understates how much a society might be willing to pay for public safety.

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)

Keywords: VSL; conjoint choice experiments; mortality risk reductions; cost-benefit analysis; forced choice questions.

Does the Cause of Death Matter?
The Effect of Dread, Controllability, Exposure and Latency on the VSL

by Anna Alberini and Milan Ščasný

1. Introduction.

There is a reasonable degree of consensus in academic and policy circles that the Value of a Statistical Life (VSL) is the appropriate metric to estimate the mortality benefits of policies that reduce premature mortality, such an environmental and safety programs. There is much less agreement as to whether a single VSL figure should be used for all beneficiaries and for all causes of death covered by the policy.

In US environmental policy assessments, for example, analysts typically rely on estimates of the VSL based on labor market studies (US EPA, 2000; Viscusi, 1993; Viscusi and Aldy, 2003, and Aldy and Viscusi, 2007). Questions have been raised whether such practice is appropriate, since the beneficiaries of environmental regulations are usually the very old (Krupnick, 2007) or the very young, and the causes and timing of death are very different from workplace accidents.

Consider now air pollution. Recent research (US EPA, 1999a, 1999b, Hurley et al., 2005, National Academy of Science, 2008) indicates that the most important mortality effects of air pollution are those associated with cardiovascular disease, followed by cancer. Air pollution is also thought to trigger asthma attacks in asthmatic subjects, exacerbate the severity of asthma attacks, and increase asthma- and chronic obstructive pulmonary disease-related mortality.

Should a single VSL be used for such diverse mortality effects? Economic theory suggests a number of reasons why individuals might place a different value on them. Previous psychometric research further indicates that individual perceive risks along many dimensions, including voluntariness, controllability, and dread (Starr, 1969; Fischhoff et al., 1978, and Slovic, 1987), and such perceptions may influence their willingness to pay to reduce risks (McDaniels et al., 1992). In policy practice, the US Environmental Protection Agency uses a single VSL in its policy analyses.[1] By contrast, the Directorate-General Environment of the European Commission recommends a VSL figure that is 50% higher for cancer deaths than for other causes of death.[2]

In this paper, we report on the results of a choice experiment study that was specifically designed to investigate this issue. In our choice experiments, we created hypothetical alternatives defined by five attributes: i) the cause of death (respiratory illness, cancer, or road-traffic risks), ii) the size of the risk reduction, iii) whether the risk reduction was private or delivered by a public program, the latter case implying that there are other beneficiaries, iv) latency, expressed as the number of years until the risk reduction occurs, v) the one-time cost to the respondent, which must be paid now.

Respondents were to indicate their most preferred alternative out of a choice set that included two hypothetical alternatives and the status quo.[3] We use the responses to the choice questions to estimate the VSL, i.e., the Willingness to Pay (WTP) for a unit risk reduction. The conjoint choice experiment survey was administered to a sample of residents of the city of Milan, Italy, in late November to mid-December 2008.

Regarding i), we chose respiratory illness and cancer because these are risks associated with air pollution (and, in the case of cancer, other environmental exposures, including

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[1] In 2000, the Science Advisory Board-- Environmental Economics Advisory Committee to the US EPA advised the agency not to adjust the VSL (Dockins et al. 2004).

[2] See http://ec.europa.eu/environment/enveco/others/pdf/recommended_interim_values.pdf.

[3] Half of the sample was further asked a forced-choice question, in which they were to choose between two hypothetical alternative without being given an opt-out response category.

contaminated water and soil). We also focus on road traffic risks because virtually everyone is familiar with them, they can be addressed through both private behaviors and public programs, and people may hold various degrees of confidence about the controllability of such risks. Since i) and iv) are varied independently of one another, our study design allows us to investigate whether the cause of death has an effect on the willingness to pay to reduce risk that is above and beyond the mere futurity of the risk reduction.

We use attribute iii)—the private or public program nature of the risk reduction—combined with the respondent's assessment of the effectiveness of private behaviors and public program in reducing each of the three types of risk here studied, to examine whether the controllability of a risk influences the WTP to reduce such a risk. We elicit dread directly from the respondents.

McDaniels et al. (1992) introduce personal exposure as a determinant of the VSL, and find that the WTP to reduce a particular mortality risk increases when individuals feel personally exposed to it. We control for baseline risk as stated to the respondent in the survey, respondent assessment of baseline risks, personal exposure, and experience with the risk.

Briefly, we find that the VSL does increase with dread, with our construct of the respondent's exposure to the three types of risk, and with the respondents' assessments of the baseline risks and experience with the risks. The VSL is higher when the risk reduction is delivered by a public program, and increases with the effectiveness rating assigned by the respondent to public program in addressing that cause of death. The effectiveness of private risk-reducing behaviors is also positively associated with the VSL, but the effect is only half as large as that of public program effectiveness.

In our models, we control for the characteristics of the mortality risk reductions respondents were to value. Yet the cause of death per se—namely, whether it's cancer, a road-traffic accident or a respiratory illness—remains strongly statistically significant. All else the same, the fact that the cause of the death is "cancer" results in a VSL that is almost one million euro *above* what is predicted by dread, exposure, beliefs, etc. The VSL in the road safety context about is just over one million euro *less* than what is predicted by dread, exposure, beliefs, etc.

These effects are large, but the majority of the variation in the VSL is accounted for by the public program feature, the effectiveness of public programs in reducing the indicated risk, and dread. To illustrate, the VSL in a public program context is €2 million more than when the risk reduction is private, changing the perceived effectiveness of the government program from the lowest to the highest value increases the VSL by just under €2 million, and a change from the lowest to the highest dread raises by the VSL by €2 million. The effects of exposure, experience, etc. are smaller. These results raise the question whether using VSL figures based on private risk reduction, which is usually recommended to avoid double-counting, may severely understate how much a society might be willing to pay for public safety (see Nielsen et al., 2009).

The remainder of this paper is organized as follows. Section 2 presents background information and reviews the literature. Section 3 describes the research questions and study design. Section 4 presents the questionnaire and survey administration. Section 5 presents the theoretical and econometric model. Section 6 discusses the data. Section 7 presents the estimation results, and section 8 concludes.

2. Background and Previous Literature.

A. The VSL and the Cause of Death

The Value of a Statistical Life is defined as the marginal WTP for a small change in the risk of dying:

(1) $$VSL = \left.\frac{\partial WTP}{\partial R}\right|_{U=const.}$$

As a summary measure of the WTP for mortality risk reductions, the VSL is used to compute the monetized benefits of policies that save lives.[4] Implicit in (1) and in most standard expected utility models is the notion that R represents the total risk of dying for any cause.

Economic theory suggests several reasons why the VSL for one cause of death might be different from that for another. For starters, the VSL should increase with baseline risks (Pratt and Zeckhauser, 1996). All else the same, the VSL for a specific cause of death might be larger simply because the baseline risk of dying for that cause is higher.

The existence of competing risks might be another reason for different VSLs. Eeckhoudt and Hammitt (2001) consider competing risks and show that if the utility of a bequest at death is positive, then the marginal WTP for reducing one type of risk (i.e., the VSL for that cause of death) depends on the magnitude of the other risks of dying. Based on their model, a person in poor health with a high risk of dying from a chronic illness would have a very low willingness to pay for a small reduction in the risk of dying in a car accident or because of pollution exposures, which account for very small shares of this person's total risk of dying. Since a large competing risk reduces the chance to benefit from a reduction in the specific risk, Eeckhoudt and Hammitt dub this the "why bother" effect. Evans and Smith (2006) show that the effect of a competing risk is potentially ambiguous, because it depends on how the competing risks enter in the expected utility.

[4] By "saving lives," we mean "reducing or eliminating premature deaths."

Another reason why people might be willing to pay different amounts of money to reduce the risk of dying from different causes may simply lie in the timing of the risk reduction. Economic theory shows that the VSL at time t for a risk reduction to be incurred L periods later is equal to the VSL for an immediate risk reduction in period (t+L), discounted back to the present (Cropper and Sussman, 1990).

B. Perceptions

There are two main questions related to risk perceptions: a) Why are certain hazards considered worse than others? and b) Do some people consider certain hazards worse than others? The answer to the first question comes from the psychometrics literature, which shows that risk perceptions are influenced by the attributes of the risk beyond its sheer magnitude (e.g., its controllability, familiarity, dread, and whether it is voluntarily faced or not) (Fischhoff et al., 1978; Slovic, 1987; Chauvin et al., 2007, and Urban and Ščasný, 2007).

It is possible that such differences in perceptions influence the WTP to reduce the various types of mortality risks, even holding the magnitude of the risks and latency the same (Revesz, 1999; Rowlatt et al., 1998). For example, evidence from surveys suggests that people consider it very important to reduce cancer deaths (e.g., Jones-Lee et al., 1985), and might be willing to commit more resources to reduce risks with which they are not familiar and/or they consider outside of their own control (McDaniels et al., 1992, Savage, 1993a, and Rowlatt et al., 1998). McDaniels et al. (1992) introduce personal exposure as a determinant of WTP to reduce risks, and find that the WTP increases if a respondent is personally exposed to a particular risk of death.

The answer to the second question is less straightforward, in part because capturing individual characteristics that explain risk perception has turned out to be very difficult. Urban and Ščasný (2007) review empirical studies and group possible determinants of risk perceptions into several categories: socio-demographic characteristics, religious and quasi-religious beliefs, general trust level, cultural factors, personal facets, experience or information learning process.

Debate continues on the magnitude of the effects attributable to perceptions. While perceptions did affect respondents' priorities over safety programs, Chilton et al. (2002) conclude that "the impact of these perceptions is a great deal less pronounced than has been by the value differentials that are currently implicit—and in some cases, explicit—in public policy making."

C. Survey Effects and Aspects of the Provision of the Risk Reduction

In stated preference studies, the VSL is approximated from the WTP for a finite reduction in mortality risks or is inferred from the tradeoffs between hypothetical risk reduction profiles made by survey respondents (Alberini, 2005). Aspects of the scenario may influence the WTP, and hence the VSL.

Stated preference studies about mortality risk reductions need to devise a credible mechanism for delivering the risk reduction. In many cases, the most plausible or appropriate mechanism for delivering risk reductions is a public program. One problem with this approach, however, is that the respondents' altruistic considerations may result in double-counting. Economic theory (Jones-Lee, 1991, 1992) has worked out the conditions under which double-counting will and will not occur, showing that they depend crucially on (i) the type of altruism affecting the responses (paternalistic or non-paternalistic), and (ii) what the respondent is told to assume about the payments made by other people.

Unfortunately, in applied work it is very difficult to observe the nature of each respondent's altruism, and efforts to tell respondents what to assume about other people's payments have proven awkward and confusing (Johannesson and Meltzer, 1998). This has prompted many researchers to turn to valuing private risk reductions (e.g., Dickie and Gerking, 1996, Krupnick et al., 2002), even though this is likely to produce only a lower bound for WTP.[5]

Altruistic considerations are not the only reason for differences in WTP across public and private risk reductions: Respondents may also attach a different probability of provision and/or effectiveness of the risk reduction to government programs and private actions. Valuation through stated preference studies is also affected by experience with the good to be valued and with the valuation task itself (Bateman et al., 2008).

D. Empirical Evidence

Since environmental exposures are often linked with cancer health endpoints, much research has focused on whether the cancer VSL is different than that for other causes of death. Cancer is associated with suffering and pain, and is highly dreaded (see Starr, 1969, Fischhoff et al., 1978; Slovic, 1987), which is often taken to imply that the VSL should be greater when the cause of death is cancer (Revesz, 1999; US EPA 2000). Some studies have found that people favor programs that reduce cancer mortality (e.g., Jones-Lee et al., 1985; Mendeloff and Kaplan,

[5] Private risk reductions are generally thought to result in conservative estimates of the VSL, but we are aware of at least one study (Johannesson et al., 1996b) that actually found them to be *larger* than the VSL estimate for a comparable risk reduction in a public program context.

1989; McDaniels et al., 1992; Savage, 1993, and Tolley et al., 1994), and others report no such cancer “premium.”

In Magat et al. (1996), the median respondent was indifferent between reducing the risk of terminal lymph cancer and reducing the risk of automobile death, whereas terminal lymph cancer risk is about 1.33 worse than the risk of curable lymph cancer (and automobile death). Using a similar approach (risk-risk questions), Van Houtven et al. (2008) find that individuals have a strong preference for avoiding cancer risks, but that this preference wanes as the cancer latency period increases.

None of the abovementioned studies estimated the VSL directly. The few studies that have attempted to value mortality risk reductions have found surprisingly little evidence that the cancer VSL is higher than the VSL for other causes of death. In a contingent valuation study in Taiwan, Hammitt and Liu (2004) find that the WTP to reduce the risk of cancer is about one-third larger than that to reduce the risk of a similar chronic, degenerative disease. However, the coefficient on the cancer dummy is not significant at the conventional levels. Likewise, Hammitt and Haninger (2010) elicit the WTP to reduce fatal-disease risks in adults and children caused by consuming pesticide residue in foods. They find that the WTP for cancer and non-cancer diseases is similar to the WTP to reduce motor-vehicle crashes.

One possible reason for these empirical findings is that low baseline risks may offset the effect of dread (or other perceptions) on the VSL. Chilton et al. (2006) use a variant on the “risk-risk” approach to identify the separate effect of (contextless) baseline risk and dread effects for various risks, including that of dying in a pedestrian accident, in an automobile driver/passenger accident, or by murder. The respondents in their study reported substantial dread for certain types of death (especially for rail accident, fire in a public place, and drowning), which in some cases was cancelled out by the low baseline risks.

Tsuge et al. (2005) conducted conjoint choice experiments where the alternatives are defined by four attributes: cost, the size of the risk reduction, the type of risk (all causes of death, accident, cancer and heart disease) and latency. Tsuge et al. elicit the respondent's perceptions along many dimensions, including what they term "controllability" ("Government can reduce this risk"), "dread" ("Pain accompanies this risk" and "This risk is terrible."), a subjective assessment of exposure, and subjective assessments of public and private knowledge. Tsuge et al. conclude that "it is almost unnecessary to adjust the VSL according to the difference in the type of risks if the VSL is adequately calculated."

3. Research Questions and Study Design.

A. Research Questions and Approach

In this paper, we focus on three research questions. First, all else the same, does the VSL vary with the cause of death? Second, all else the same, are people willing to pay different amounts of money when the risk reductions are delivered by public programs? Third, are the differences in the VSL by cause of death (if any) explained away by latency, dread, controllability, exposure and salience of the risks to the respondents? And how large is the contribution to the VSL from each of these factors?

To answer these questions, it is important to use a single valuation method (e.g., conjoint choice experiments) to avoid confounding true differences in VSL with valuation method-induced effects. We chose conjoint choice experiments (see Bateman et al., 2002) because by varying risk attributes across and within respondents, we can disentangle the effect of such variations on the responses. We developed a questionnaire based on conjoint choice experiments that included several "treatments," and administered it to a sample of residents of Milan, Italy. We conducted the study at one locale to reduce heterogeneity due to unobservables.

Using the responses to the conjoint choice questions, we examine whether the VSL is systematically related to risk attributes—those assigned by design to the respondent as well as the respondent's subjective assessments—and individual characteristics of the respondents. We also attempt to quantify the portion of the VSL that is accounted for by each of these factors.

B. Estimating the VSL Using Conjoint Choice Experiments

Choice experiments are a stated preference method, and as such they rely on what people *say* they would do under hypothetical, but realistic, circumstances to place a value on non-market goods (see Bateman et al., 2002). An advantage of stated preference approaches over revealed preference approaches is that the former do not assume that people's quantitative and qualitative subjective risk perceptions are the same as the objective risks. Respondents can be educated about existing risk levels and about opportunities for mitigating risks.

Stated preference approaches can cater to a variety of causes of death, beneficiaries of the risk reduction, and latency. Another important advantage is that they allow analysts to circumvent the lack of variation in risk reductions that can plague revealed preference studies, as well as the correlation between cause of death, latency and other risk attributes, which makes it difficult to interpret results. Disadvantages include the possibility of hypothetical bias, and cognitive difficulties affecting respondents' processing of small probabilities.

In conjoint choice experiments, respondents are asked to select one of K hypothetical scenarios ($K \geq 2$), where the scenarios are described by a vector of attributes, including cost and, in this study, mortality risk reductions. Individuals are assumed to pick the alternative to which they attach the highest utility. Conjoint choice experiments were used to value mortality or cancer risk reductions in Tsuge et al. (2005), Itaoka et al. (2006), Alberini et al. (2007), and Tonin et al. (2009).[6]

C. Our Conjoint Choice Experiments

We started the conjoint choice experiment portion of our questionnaire by informing the respondent that he or she would be the beneficiary of the risk reductions we were about to describe (and the sole beneficiary, in the case of private risk reductions).

The hypothetical alternatives in the conjoint choice experiments were described by 5 attributes: (i) the cause of death (respiratory illnesses, cancer, road traffic accidents), (ii) whether the risk reduction is attained by a public program or is private, (iii) the risk reduction itself, (iv) latency, expressed as the number of years that must elapse before the risk reduction begins, and (v) cost. Attributes and attribute levels are summarized in table 1. A sample conjoint choice question is reproduced in Figure 1.

Regarding (i), we focused on cancer and respiratory causes of death because these have been linked to environmental exposures and are addressed by many environmental programs. We also include mortality risks for road traffic accidents for three reasons. First, virtually everyone uses the roads, and people are generally aware of road traffic risks, so scenarios focusing on such

[6] Contingent Valuation (CV) is another stated preference method that is sometimes used to estimate the VSL. In CV surveys about risk reductions, respondents are usually queried directly about their willingness to pay for a public program, product or good that reduces their risk of dying. CV surveys were used, among others, by Johannesson et al. (1996a), Johannesson et al. (1997), Krupnick et al. (2002), and Alberini and Chiabai (2007a, 2007b) for samples of adults and the elderly. Dickie and Gerking (2006) present the results of a CV survey that elicits WTP to reduce the risk of developing fatal skin cancer in adults and children.

risks are salient and plausible to most people. Second, they can be addressed through both individual behaviors and public programs.

Third, there is no question that most people would regard road traffic risks as familiar and controllable (at least to some extent). They are thus well suited for the purposes of our survey, and can serve as a useful comparison with less common risks (such as respiratory risks) and risks that are accompanied by morbidity, pain and dread (cancer risks). In earlier stated-preference studies conducted in other countries, such as the U.K. (Jones-Lee, 1989), Sweden (Johannesson et al., 1996b; Persson et al., 2001) and India (Bhattacharya et al., 2007), people were willing and capable to trade off money for road traffic risk reductions.

Public v. private risk reductions (item (ii) above) were presented to the respondents with a reminder that the former imply that there are other beneficiaries of the risk reduction beyond the respondent, whereas the respondent is the sole beneficiary of the risk reduction when the action is private. We described the public programs as being "nationwide."

Our interest in the public v. private nature of risk reduction is driven by two reasons. First, much earlier stated-preference research has asked people to value private risk reduction in hopes of avoiding double-counting (see section 2), but environmental and other safety regulations are part of public programs, and it is of interest to determine how widely the estimates of the VSL based on private risk reductions differ from those with a public program. Second, private behaviors v. public programs provide us with an opportunity to study if controllability of risks—which depends on how effective people judge the risk-reducing measures—influences the WTP to reduce them.

Latency is expressed as the number of years that elapse before the risk reduction begins. To avoid confounding between the cause of death and the latency aspect, we used latency levels of 0 (=immediate risk reduction), 2, 5 and 10 years, and we varied this attribute independently of the context of death and the other attributes.

We used four possible levels for the risk reduction, namely 2, 3, 5 and 7 in 10,000 over 5 years. Finally, each alternative risk reduction plan had a price tag. This cost would be incurred by the respondent's household immediately and would be paid this one time only. We used four possible cost amounts ranging from 200 to 2000 (see table 1). Under alternative assumptions about the discount rates, these cost amounts correspond to VSL of a few hundred thousand to several million euro.

Each respondent was randomly assigned to a set of 5 pairs of risk reduction profiles. There were a total of 32 possible sets, and we imposed certain restrictions on them to ease the respondent's task. For example, the first two pairs viewed by the respondents (profiles A and B, and C and D) focused on the same cause of death, which was selected at random between the three studied in this project. In addition, within each pair, the latency period was restricted to be the same for both alternatives to keep the respondent's task manageable. Identification of the discount rate relies on within- and between-respondent variation in the time horizon when the risk reduction would be realized.[7, 8]

[7] These 32 sets of pairs were selected at random and without replacements from the full universe of non-dominated pairs that satisfied all of the abovementioned requirements. Due to a software error, however, the last pair in set 8 contained a dominated choice. In the analyses reported in this paper, for good measure we check the robustness of results of the non-linear conditional logit after deleting the responses to the questions about this pair from the sample.

[8] We also created an additional treatment whereby about one half of the respondents first faced a forced choice question (choose between A and B), and then were asked which they would prefer between A, B and the status quo (no payment and no risk reduction). The remainder of the respondents was asked to choose directly between A, B and the status quo. Assignment to one or the other variant of this treatment is random. Respondents assigned to treatment TFORMAT=1 thus engaged in a total of 2×5=10 conjoint choice tasks each; respondents assigned to TFORMAT=2 engaged in 1×5=5 conjoint choice tasks each. The purpose of this split sample treatment is to check whether the forced choice exercise induced response effects that changed the VSL. In practice, we found that it did not (see Alberini et al., 2009), and for this reason in this paper we pool the responses from both versions of the questionnaire.

4. Questionnaire, Sampling Frame and Survey Administration.

A. Structure of the Questionnaire

The questionnaire is self-administered by the respondent using the computer. The computer interview starts with the respondent entering his or her gender, age, and the name, age, and gender of each of his or her children.

Section A asks questions about the health status of one of the respondent's children (selected at random among those aged 17 or younger), and section B about the respondent's own health. Section C of the questionnaire elicits extensive information about use of roadways, lifestyle, environment, genetic predisposition to cancer and familiarity with it. The purpose of this section is to understand the salience of certain risks to the respondent and to get a sense of the exposure to certain risk factors.

Section D contains a probability tutorial. We start with a simple and intuitive presentation based on tossing a coin or casting a die, but point out that the notion of chance also applies in other familiar situations (e.g., the weather forecast and the chance of rain). This is followed by a simple quiz to make sure that people have grasped the basics of probability.

We then move on to the notion of mortality risks. We use two visual representations of risk: (i) a grid with 10,000 squares, which we use when attention is restricted to a reference group or population,[9] and (ii) bar charts, which we use when we want to show how risks vary across age groups (and hence change as a person ages).

[9] When we first introduce the notion of risk of dying, we illustrate it using the grid of 10,000 squares, where white squares denote the people who survive and blue squares denote the people who die. We first display a handful of blue squares scattered at random on the grid to convey the notion of randomness, then the blue squares move on the grid until they are aligned in the northwest corner of the grid. The purpose of this animation is to convey the sense of the magnitude of the risks. Corso et al. (2001) examine the effect of differential visual aids on the sensitivity of willingness to pay to reduce risks.

In section E of the questionnaire we inform the respondent that it is possible to reduce one's own risk of dying in many ways. Using respiratory illnesses, cancer and road traffic accidents as examples, we explain that risk reductions may result from individual actions (e.g., getting a flu shot, purchasing a car with safety equipment) and government programs (e.g., an air pollution control program). We also emphasize that some actions are specific for men (e.g., prostate cancer tests), some are specific for women (e.g., pap smears), and others apply only to children (child seats in cars).

Section F contains an exercise that strips risks of all other attributes and makes respondent focus on the magnitude of the risks. In section G of the questionnaire we zero in on the three causes of death that are at the heart of this questionnaire, namely cancer, respiratory illnesses, and road-traffic accidents. In addition to providing some basic information about them, we also ask for people's subjective assessments of the comparative magnitude of these risks for people their age. In section H, the respondents express their opinions on the effectiveness of private actions and public programs in reducing the risk of dying for each of the three causes of death studied in this project, and also assess the futurity v. immediateness of risks.

Section I is dedicated to the conjoint choice questions. In the first screen of this section, we summarize the five attributes of the alternatives being compared, remind respondents of their own baseline risks, and point out that the choice experiments will contain relatively small risk reductions.

After the conjoint choice questions, we ask debriefing questions and explore reasons for the observed choices. The final section of the questionnaire elicits information about the respondent's socio-economic circumstances.

B. Administration of the Survey and Sampling Plan

As mentioned, our questionnaire is self-administered by the respondent using the computer. We chose this option, instead of in-person interviews, for cost reasons and because our study design involves numerous treatments, questionnaire variants and visuals. Respondents took the survey in two facilities in Milan, Italy, and were paid €10 for their participation in the survey.

The final survey was preceded by two pilot studies, which were conducted in Milan in June (N=200) and September 2008 (N=100), respectively. Both pilots used the same sampling frame as the final survey. Our universe was Milan residents aged 20-60 who had at least one child of age 17 or younger.[10] The sample was to be evenly divided among three age groups, namely persons aged 20-34, 35-44, and 45-60.

The sample was to have an even number of mothers and fathers, and to mirror the city's population in terms of education and income. For example, in Milan, 23% of the residents aged 20-60 have a college degree, and mean (after tax) household income is about €30,000 a year. We also specified that no more than 20% of the persons in the sample should be homemakers.

We chose to restrict attention to Milan, rather than to a nationally representative sample, for two reasons. For starters, limiting the survey to a single city was significantly less expensive and allowed us to increase the sample size, albeit at the expense of national representativeness. Second, Milan suffers from a serious air pollution problem. Residents are well aware of this and well informed about bad air pollution episodes, which are generally covered by the local news. Focus groups held in 2006 also suggested that Milan residents are well informed about the health

[10] Our universe was parents with at least one legally minor child because this survey was part of a broader research project on parents' valuation of own or their children's mortality risk reductions. In this paper, attention is restricted to those adult respondents who had to engage in tradeoffs about their own risk of dying.

effects of air pollution and other types of environmental exposures (e.g., contaminated sites).[11] These considerations suggested that examples of public programs that reduce air pollution and hence mortality risks (mentioned in section G of the questionnaire) would be understood and accepted by the respondents.

5. The Model.

A. The Random Utility Model

We assume that the responses to the conjoint choice experiment questions are driven by a random utility model. We posit that the deterministic portion of the indirect utility function is:

$$\overline{V}_{ij} = \alpha \cdot DR_{ij} \cdot \pi(L) + \beta \cdot (y_i - C_{ij}), \tag{2}$$

where DR is the discounted risk reduction (see below), π(L) is the probability of surviving L years, until the risk reduction begins, α is the marginal utility of a unit of risk reduction, β is the marginal utility of income, (y-C) is residual income, and subscripts i and j denote the individual and the alternative, respectively.

Assuming constant exponential discounting, the discounted risk reduction is defined as:

$$DR = \Delta R \cdot e^{-\delta \cdot L}, \tag{3}$$

where ΔR is the risk reduction, L is the number of years that elapse before the risk reduction begins and δ is the discount rate.

On appending an error term, which captures aspects of the indirect utility that are known to the respondent but not the analyst, we obtain the random utility model:

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[11] The evidence from the focus groups was confirmed by the results of a pen-and-paper questionnaire that participants in Pilot 1 took once they had completed their computer questionnaire.

(4) $$V_{ij} = \overline{V}_{ij} + \varepsilon_{ij} .$$

In each conjoint choice experiment question, the respondent is asked to examine K alternatives and to indicate the most preferred option.[12] We assume that the respondent will choose the one with the highest indirect utility. If we further posit that the error terms in (4) are i.i.d. and follow a standard type I extreme value distribution, the probability that the respondent chooses alternative k is:

(5) $$\Pr(k) = \frac{\exp(\overline{V}_k)}{\sum_{j=1}^{K} \exp(\overline{V}_j)} .$$

Expression (5), where we have omitted the subscript i to avoid notational clutter, is the contribution to the likelihood of a conditional logit model. The only difference with respect to the conventional conditional logit is that here $\overline{V}$ is non-linear in the attributes and the parameters.

Since the VSL is the marginal utility of the risk reduction divided by the marginal utility of income, we estimate it as

(6) $$VSL = \frac{\hat{\alpha}}{\hat{\beta}} \times 10{,}000 ,$$

where the hats denote maximum likelihood estimates. Multiplication by 10,000 is necessary because in our estimation routine we express the risk reduction as, say, 3 or 4 (in 10,000) instead of 0.0003 or 0.0004.

Equations (2)-(6) assume that the VSL is constant for all individuals in the sample, and that the cause of death or the source of the risk reduction does not matter. The model is easily

[12] K is equal to 2 in the forced choice questions, and to 3 in all other questions, which offer the status quo as well as two hypothetical risk reduction profiles.

amended to allow for the cause of death, and for the mechanism in which the risk reduction is attained (a public program versus a private behavior) to affect utility and to result in potentially different VSLs:

(7) $$\overline{V}_{ij} = \left[DR_{ij} \cdot \pi(L)\right] \cdot \left[\alpha_1 + \alpha_2 \cdot CANC_{ij} + a_3 \cdot RESP_{ij} + \alpha_4 \cdot PUBL_{ij}\right] + \beta \cdot (y_i - C_{ij}),$$

where CANC, RESP, and PUBL are dummies denoting cancer, respiratory illnesses, and a public program, respectively, and the αs are marginal utilities.

Finally, we wish to examine whether subjective and researcher-assessed attributes and perceptions of risk influence the VSL. For this purpose, we enter in the second brackets of equation (7) additional variables capturing perceptions and individual characteristics of the respondents. We discuss them in the next subsection.

B. Additional Effects

We wish to investigate whether the VSL varies with the cause of death, and, if so, whether this effect is explained away by other attributes of the risk (including researcher- and respondent-assessed exposure, sensitivity, experience, and dread) and aspects of the provision of the risk reduction. To find out, we include in the model variables that measure (i) the effectiveness of public programs and private behaviors in reducing the stated risks, (ii) baseline risks, (iii) exposure, (iv) beliefs about baseline risks of dying for a specific cause of death for a person the respondent's age, (v) sensitivity, which depends on current health status, (vi) previous experience with the risks being valued, and (vii) dread.

To measure (i), we create dummies for whether the respondent indicated that he thinks that public programs are "very effective" at reducing the risk of dying for each of the three causes consider in the questionnaire. PUBEFF for alternative A will then take a value of one if the alternative posits that the risk reduction would apply to cause *h* and would be incurred through a public program, and the respondent rated public programs as "very effective" in reducing the risk of dying from cause *h*. PRIVEFF is similarly constructed for private behavior alternatives. These variables capture both aspects of the scenario and controllability of the risks.

To control for (total) baseline risk, we enter the age-specific risk of dying for all causes as we stated it to the respondent in the survey. EXPOSURE varies with alternative and the respondent. Based on the responses to section C of the questionnaire, if the respondent lives in a high pollution area and smokes, and if alternative A is about respiratory illness, then exposure for alternative A is equal to 1. We constructed similar measures if an alternative is about road traffic risks and the respondent reports that he or she uses the road every day and does not necessarily use seatbelts all the time. Exposure to cancer takes on a value of 1 when the respondent believes that cancer runs in his or her family, a blood-related immediate family member has or has cancer, and the alternative is about cancer risks.

Likewise, MORECOMMON varies with the alternative. In section G of the questionnaire, respondents were asked which were more common among people their age, deaths in road traffic accidents or for cancer. Suppose that a respondent indicates that he believes that deaths in road traffic accidents are more common among people his age than cancer deaths. If alternative A is about road traffic accidents and B about cancer, then MORECOMMON will be equal to one for alternative A and to zero for alternative B. (This variable is coded to zero for respiratory risks.)

To create SENSITIVITY, we consider a respondent "sensitive" to cancer if he does have cancer. We consider a respondent "sensitive" to respiratory illnesses if he reports having asthma, emphysema, chronic bronchitis or other chronic respiratory conditions, and these conditions impair daily activities. We coded this variable to zero for road-traffic risks. We interpret this variable as the respondent's adjustment to the population risks indicated in MORECOMMON.

EXPERIENCE is coded as a one if the respondent has a relative, a spouse or close friend who has cancer (and the alternative in the conjoint choice task is about cancer). We also code it as a one when the respondent has had to go to the emergency room or be hospitalized as a result of a road traffic accident or a respiratory illness (and the alternative focus on road traffic risks or respiratory illnesses).

Regarding dread, recall that we asked respondents to rate the level of dread associated with several causes of death on a scale from 1 to 5, where 1 means no or minimal dread and 5 means the highest degree of dread. Suppose that a respondent rates the dread associated with road-traffic accident deaths as a 2 and that of cancer as a 4. If alternative A involves reducing risks in the road traffic accident context and B is a cancer risk reduction, then the DREAD assigned to each alternative will be 2 and 4, respectively.

We use about these alternative- and beneficiary-specific variables to test two main hypotheses. First, we wish to see if they enter in the model significantly and if their coefficients have the expected positive signs. If these expectations are borne out in the data, they suggest that the responses to the conjoint choice experiments are internally valid.

Second, *if* these variables capture all dimensions of risk, further labeling the risks as "risk of dying in road traffic accidents," "for cancer" and "for respiratory causes" should not convey any additional information, and dummies for the cause of death for the alternatives being considered would not be important predictors of the choice between the alternatives. This is an important issue for benefit transfer purposes, i.e., for using VSL figures in different contexts. We therefore wish to see if the coefficients on the causes of death remain significant even after we include all of these alternative- and beneficiary-specific variables.

6. The Data.

We interviewed a total of 983 respondents in Milan, Italy.[13] Descriptive statistics of this sample are reported in table 2. As per our sampling plan, we have a roughly even number of men and women, and the respondents are uniformly distributed in the 20-34, 35-44 and 45-60 age groups. The average age is 39. The sample is in line with the population of Milan for education and income. Mean (after tax) household income is about €30,000 a year.

The respondents are generally in good health. About 53% of them indicated that they were in "excellent" or "very good" health compared to other people their age. About 18% of the respondents reported having a chronic respiratory illness (e.g., asthma or chronic bronchitis), and only 1.47% had or had previously had cancer.

Our questionnaire included several questions designed to test whether respondents understood the probability material that was presented to them. Only 7% failed question D1, which asked them to compute the probability of winning a lottery where 10,000 tickets were sold (and there is only one winning ticket). Fifteen percent failed question D2, which asked respondents to read a bar chart with the chance of dying over the next 5 years for children aged 0-4, young adults aged 25-29, and adults aged 40-44, and indicate which of these age groups had the highest chance of dying. Finally, question D3 checks basic numeracy with probabilities. If the chance of dying over the next 5 years for 20-24-year-olds is 30 in 10,000, how many deaths

[13] An additional 923 respondents completed a variant of the questionnaire that was virtually identical, but where the beneficiary of the risk-reducing measures in the conjoint choice experiments was one of the respondent's children. We do not examine these latter 923 interviews in this paper.

do we expect to see in a population of 100,000 people in this age group? About 10.5% of the sample failed this quiz.

Since this questionnaire focuses on the cause of death, we asked people to rate the dread they associate with various causes of death on a scale from 1 to 5. The results of this exercise are reported in table 3. They show that the cancer scores very highly on the dread scale, with 56% of the respondents regarding a cancer death as “very high dread.” Surprisingly, however, people did not have the same reaction to leukemia, although the latter is a form of cancer of the blood. Regarding the other causes of death examined in the conjoint choice experiments, 28% of the respondents considered road traffic accidents to be “high dread” and 12% assigned a similar rating to respiratory illnesses.

We also asked respondents to rate the effectiveness of private behaviors and actions, and public programs, respectively, in reducing the risk of dying for each of the three causes studied in this questionnaire. The results of this exercise are displayed in Figure 2. The figure shows that people are willing and capable of assessing the effectiveness of different ways of reducing mortality risks. It appears that people regard individual actions as somewhat more effective than public programs for road traffic risks and cancer, but this judgment is partially reversed for respiratory risks.[14]

Descriptive statistics about various measures of exposure, sensitivity and experience with the various risks are displayed in table 4. Table 4 confirms that people dread cancer more highly than the other causes of death. It also shows that, based on individual behaviors, “everyday” exposure is highest for road traffic risks, followed by respiratory illnesses and cancer. Most of

[14] Almost 24% of the respondents consider public programs highly effective in reducing respiratory risks. Only 13.8% of the sample considers private behaviors very effective at reducing the risks of dying from respiratory illnesses.

the respondents consider road traffic risks larger than cancer risks. Based on health status, about 20% of the respondents are classified as “sensitive” to respiratory illnesses, and only 1.5% are “sensitive” to cancer risks. Experience with the cause of death—directly or via another person—is highest for cancer.

7. Estimation Results.

A. Basic Models

We fit a conditional logit corresponding to indirect utility (2), and estimate the VSL to be €4 million (standard error €0.257 million). Importantly, the estimation results (displayed in table 5, panel (A)) indicate clearly that the marginal utility of a risk reduction is positive and statistically significant, which confirm that the survey responses are well-behaved and pass a “scope” test.

When we account for the cause of death (i.e., we estimate the model of equation (7) with $a_4 = 0$; see table 5, panel (B)), we get VSL figures of €3.360 million (respiratory illness), €5.280 million (cancer) and €2.874 million (road traffic accidents). The discount rate is not statistically different from zero. Clearly, cancer mortality risk reductions are valued more highly than the other causes of death, an effect that may be due to high dread, high baseline risk, and/or low perceived controllability.[15]

B. The Effect of Risk Characteristics

[15] For the sake of simplicity, we only display results for the runs where we assigned survival probabilities equal to those implicit in the mortality risks shown to the respondents in the survey. The results are robust to replacing them with the respondent-assessed probabilities, and to setting the probability of survival to 1. The results displayed in table 6 and 7 are robust to excluding from the sample those respondents who failed one or more of the probability quizzes.

Is accounting for these factors sufficient to explain away the differences in VSL? In table 6 we report the results of models where we add the variables described in section 5.B. The simplest of these models is specification (A) of table 6, where we simply enter an interaction between DR and a public program dummy (see equation (7)). The coefficient on this variable is positive and significant, and implies that the VSL for any given cause of death is €0.918 million greater when the risk reduction is delivered by a public program.

We check for possible heterogeneity in this effect by entering two interactions in run (B), namely whether the risk reduction comes via a public program interacted with respondent rating of the effectiveness of public programs at reducing that type of risk, and private behavior times the effectiveness rating of private behaviors.[16] The result of adding these variables is striking. First, the coefficient on public program is dramatically larger than in specification (A). Second, both effectiveness measures are positively and significantly associated with the VSL. Third, respondents seem to treat the effectiveness of public and private programs asymmetrically and the impact of the former is almost twice as large as that of the latter.

In (C) and (D), we check whether the value of a unit of risk reduction depends on the baseline risk of dying (for all causes), assuming that respondents accept the average mortality risks for people their age shown to them in the questionnaire. Whether DR is interacted with baseline risks (model (C)), log baseline risks (run (D)), or dummies for each baseline risk level (not reported), the results are the same: The VSL does not depend systematically on total baseline risks.

The model in (E) enters interactions between DR and a researcher-constructed measure of exposure (EXPOSURE), the respondent's assessment about the magnitude of the risks of dying

[16] Both of these interactions are further multiplied by the size of the risk reductions.

for specific causes among people his or her age (MORECOMMON), whether the respondent has chronic respiratory illnesses or cancer, which would raise their risks of dying for the indicated causes (SENSITIVITY), and EXPERIENCE with each of the three causes of death. Baseline risk remains insignificant, but at least two of these newly added variables (EXPOSURE and EXPERIENCE) do have significant additional explanatory power. With the exception of SENSITIVITY, all of them enter in the model with a positive coefficient.

Specifically, for people who are highly exposed to the risk being valued the VSL is €0.422 million higher, and those with experience with the risk being valued have VSL figures that are €0.516 million larger than those with no experience. When the risk being valued is thought to be more common for people one's age, the corresponding VSL is about €0.394 million larger, but this effect is significant only at the 10% level.

We add cause-specific dread ratings in (F), along with a dummy denoting whether the respondent reported the highest level of dread for this particular risk. Doing so reduces slightly the coefficients on exposure, common cause of death, and experience. Even more importantly, dread enters positively and significantly in the regression. Each additional dread point increases the VSL by €0.322 million. If a cause of death received the highest dread score, its VSL is an additional €0.402 million greater. The effect of the highest dread dummy is large, but not statistically significant at the conventional levels.

Comparison across models (A)-(F) shows that the effects of the main attributes of risk are robust to the changes in specification. Moreover, there is evidence of considerable heterogeneity in valuation, since as we add additional controls the effect of a risk reduction per se (i.e., α_1) first vanishes and then is replaced by the effects of the risk interactions. Importantly, models (A)-(F) show that while exposure, sensitivity, experience with the risk in question and one's dread of it affect the VSL and indeed account for a sizeable portion of it, reductions in cancer mortality risks are valued *more* than a respiratory risk reduction of comparable size and similar characteristics, including dread rating.

To get a sense of the contribution of each regressor to the VSL, we begin with using specification (F) to compute the respiratory-illness VSL for a 35-39 person who is in good health, has no exposure or experience with this risk, examines a private risk reduction, rates the latter's effectiveness a 3, and has the average dread (3.758) for respiratory illnesses. For this respondent, the VSL is €0.382 million. Increasing the effectiveness to 4 raises the VSL by €0.248 million, bringing it to €0.630 million (a 65% increase).

Changing the provision to a public program brings the VSL to €2.070 million for the lowest level of effectiveness (1), and each additional point of public-program effectiveness raises the VSL by €0.494 million. Suppose now that the dread score was 5, holding the effectiveness at 2. This would further raise the VSL to €3.366 million. Changing the cause of death to cancer (which typically elicits high dread ratings, so we leave the dread score at 5) while holding all else the same would raise the VSL to €5.866 million. In other words, the cancer VSL is worth €0.952 million *more* than a respiratory risk reduction with otherwise similar characteristics. By contrast, the VSL for road traffic risks is about €1.214 million *less* than that for respiratory risk, all else the same.

The calculations show that the public program attribute has a larger effect on the VSL (€2 million) than cancer (a little less than one million), and that changing the belief in the effectiveness of a public from 1 to 5 increase the VSL by almost as much (€1.976 million). Changing the level of dread from 1 to 5 increases the VSL by roughly the same amount (€2.012 million).

C. The Effect of Individual Characteristics

Do individual characteristics of the respondent further account for heterogeneity in mortality risk valuation? We investigate this question in table 7. We restrict attention to gender, education and income.[17] The results of panel (A) of table 7 suggest that the VSL increases with the respondent education, although not in a monotonic fashion (it is higher for those with a few years of college than for those with a college degree), and that is lower among women. Since our data indicate that dread of any given cause of death is actually higher among women, we suspect it might be due to lower incomes or women's reluctance to commit to spending money for themselves without checking with other family members first.[18]

In panel (B) of table 7 we allow the marginal utility of income to be different across people whose household income is above or below the citywide average (€30,000 a year). Those with household income below the average indeed have a marginal utility of income that is about 20% higher than the others, an effect that is consistent with the predictions of economic theory.[19] This decreases the marginal values of risk reductions by 20% among lower-income respondents, but does not explain away why women should be willing to pay less than men, all else the same.[20]

In sum, there is evidence that certain individual characteristics such as gender, education and income do affect the VSL. Including these variables, however, does not change the marginal

[17] Much attention has been devoted as of late to the relationship between the VSL and age to empirically check whether the elderly (who are often the primary beneficiaries of environmental policies) have a lower VSL. Earlier work (summarized in Krupnick, 2007) finds that the decline in the VSL, if any, is observed primarily among individuals aged 70 and older. We do not interview individuals over age 60, and for this reason we found little evidence of an association between age and the VSL. In runs not reported, we also entered interactions between the risk reduction and age dummies, but the results were ambiguous, and the relationship with the VSL non-monotonic and non-quadratic.

[18] Alberini et al. (2007) report a similar effect in an earlier survey on mortality risks in Italy.

[19] This is calculated by summing coefficients β and β_2.

[20] We also estimated a model where the marginal utility of income is a linear function of income, but did not find the coefficient on income to be significant.

effect of other attributes or risk perceptions on the VSL, and does not change the result that, all else the same, the cancer VSL is higher than the respiratory-illness VSL, which, in turn, is greater than the VSL in the road-traffic risks.

D. Robustness Checks

In table 8, run (A), we enter interactions of DR with variables that further capture the controllability of risks and the ability of the respondent to identify triggers of these risks. These measures of controllability are AUTOAVD×DR×whether the risk is for road traffic accidents and CANCCOMM×DR×whether the risk is cancer, where AUTOAVD is a dummy equal to one if the respondents agrees very strongly that it is possible to avoid most road traffic accidents, and CANCCOMM represents agreement (with strength 4 or 5) with the statement that “cancer is so common that in most family someone will get cancer.”

The respondent’s ability to identify causes of disease and death are captured by MANYYRS, a dummy equal to one if the respondent agrees with strength 4 or 5 that it takes exposure to carcinogens for many years before one develops cancer, and POLLRESP, which is a equal to one if the respondent agrees strongly with the statement that the only consequence of exposure to air pollution is that someone will develop respiratory problems. These variables are positively associated with the likelihood of choosing an alternative, but the only one that is statistically significant is whether one thinks that cancer will become more and more common.

In (B), we include in the model an alternative-specific intercept for the status quo, which has is negative and significant, implying that people choose the status quo less frequently than is predicted by a model where the status quo is simply obtained by coding all attributes to zero. Including this variable changes the estimates of a_1 but leaves most other coefficients virtually the same. The VSL for a specified risk reduction profile changes, but the qualitative results about the influence of various factors on the VSL hold. The additional effect of cancer on the VSL is €0.850 million more than that predicted by the other attributes of risk, and that of road accidents €0.780 million less.

One concern with our regressions is that there may be an element of arbitrariness in the construction of the regressors. For this reason, in (C) we experiment with alternative definitions of the exposure, sensitivity, and experience variables, as described in the Appendix. We find that the results are virtually unchanged when these new definitions are used: The coefficient estimates in panel (C) are very close to their counterparts in panel (F) of table 6.

8. Conclusions.

We have used conjoint choice experiments, which we administered to a sample of persons aged 20-60 in Milan, Italy, to study whether the VSL—the WTP for a unit reduction in the risk of dying—varies with the cause of death, the mode of provision of the risk reduction, the futurity of the risk. We focused on three types of risk of dying—for respiratory illnesses, cancer, and in road-traffic accidents. We have attempted to see if the "cause of death" per se retains explanatory power for the responses to the conjoint choice questions after we account for subjective risk perceptions, including dread, exposure, controllability (measured by the perceived effectiveness of public and private measures), perceived baseline risk, and sensitivity to risk, which we measure with the presence or absence of the relevant chronic health conditions. We also control for experience with the risk in question.

The results of this investigation are striking. We find that the responses to the conjoint choice questions exhibit a remarkable degree of internal validity. The VSL increases with dread, our construct of the respondent's exposure to the three types of risk, and perceived cause-specific baseline risks, and experience with the risk.

Perhaps the most striking result is that the VSL is much higher when the risk reduction is delivered by a public program, and even higher when the respondent believes that a government program is likely to be effective in reducing the indicated risk. Importantly, the respondent's assessment of the effectiveness of a private behavior in reducing risk is positively associated with the VSL, but the marginal effect of a one-point change in the effectiveness score is only half as much as public program effectiveness.

Even more important, despite carefully characterizing the mortality risk reduction using the above mentioned variables, the cause of death per se—namely, whether it's cancer, a road-traffic accident or a respiratory illness—has an additional effect on the VSL. All else the same (including the degree of dread and controllability that the respondent ascribes to this risk), the fact that the cause of the death is cancer results in a VSL that is just under one million euro *above* what is predicted by dread, exposure, beliefs, etc. The VSL in the road traffic accident context is a just over one million euro *less* than what is predicted by dread, exposure, beliefs, etc.

Clearly, this has potentially important policy implications, and raises the question whether the lives saved by environmental regulations should be valued differently, depending on what the cause of death is. In the case of air pollution, which has been linked with increased risk of dying for cancer, cardiovascular disease, and respiratory disease, this issue appears to be particularly important. Currently, in its policy analyses, the European Commission applies a 50% cancer premium to the "general" VSL. This practice is consistent with our findings.

The magnitude of these effects, however, is smaller than that of the public program alone, that of public program effectiveness, and that of dread. This raises the question whether relying on the VSL estimated from private risk reduction, as is often done in an effort to avoid double contain, may seriously understate society's willingness to pay for safety improvements brought by regulations and environmental programs.

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Figure 1. Example of a Conjoint Choice Experiment question (for TFORMAT=2).

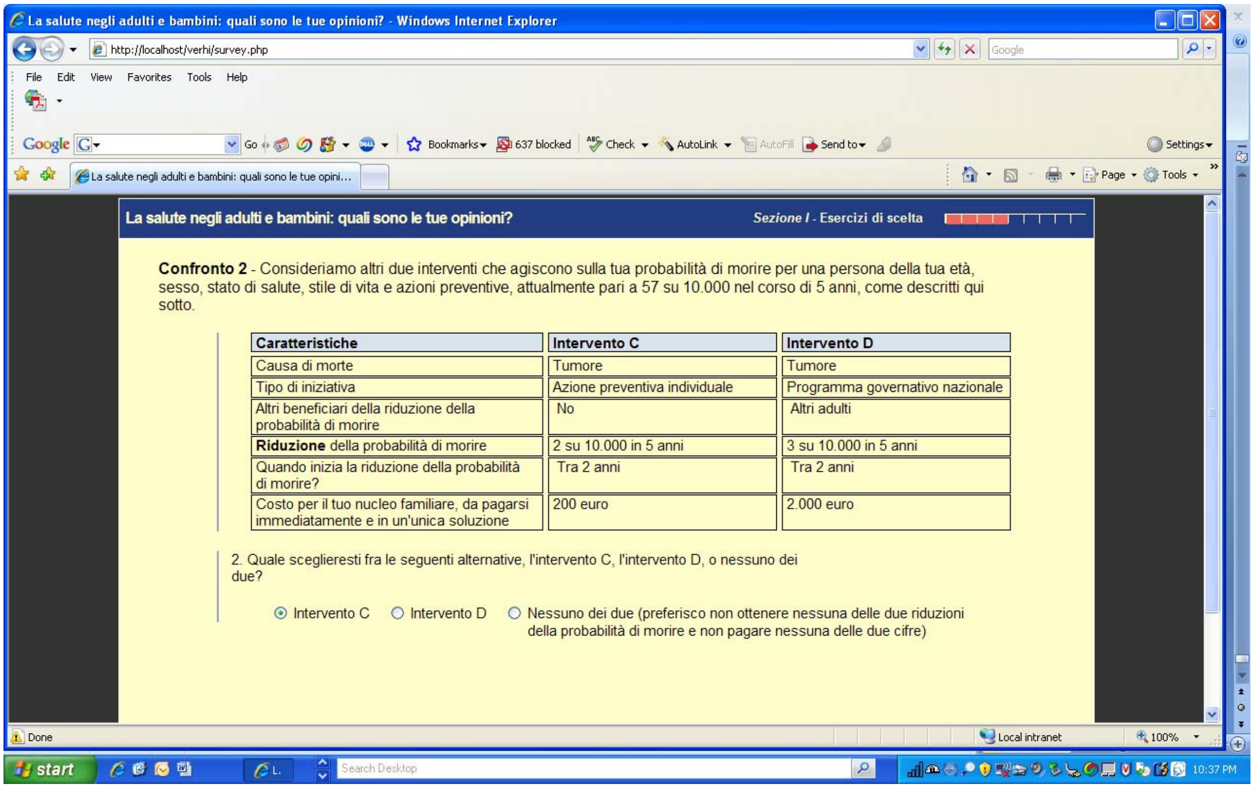

Figure 2. Respondent rating of the effectiveness of behaviors and public programs in reducing mortality risks.

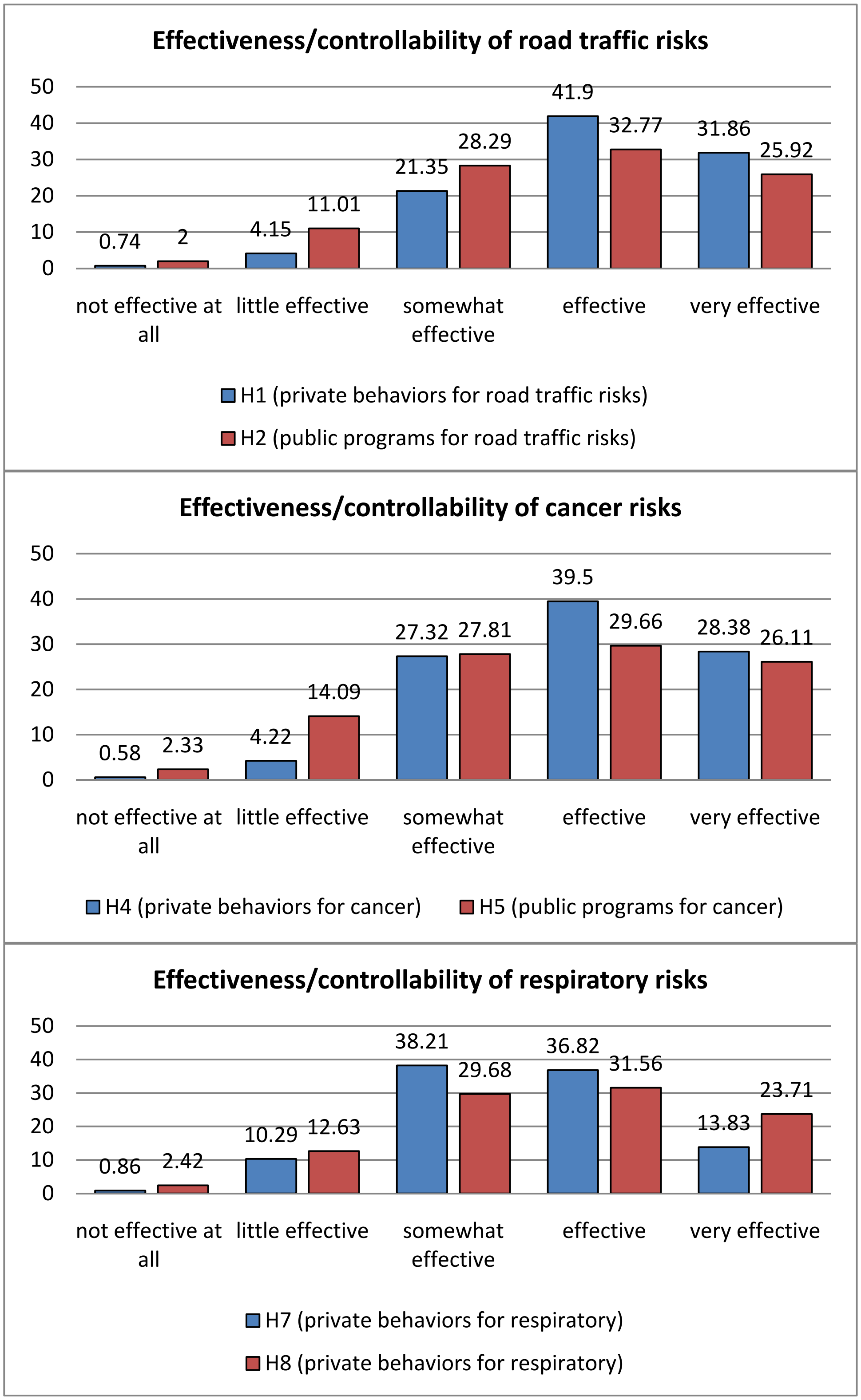

Table 1. Summary of attributes and attribute levels in the conjoint choice experiments.

Attribute	No. levels	Levels
Context (cause of death)	3	Cancer road traffic accidents respiratory illnesses
Private good or public program	2	private good (no other beneficiaries); nationwide public program (other beneficiaries)
Latency	4	0, 2, 5, 10 years
Size of the risk reduction	4	2, 3, 5, 7 in 10,000 over 5 years
(one-time) Cost to the respondent	4	200, 500, 1000, 2000 euro

Table 2. Descriptive statistics of the sample.

Variable	Description	N	Mean	Std. dev.	Min.	Max.
age	age of the respondent	983	39.211	9.965	20	60
female	dummy=1 if female	983	0.505	0.5	0	1
single	dummy=1 if single	983	0.077	0.267	0	1
married	dummy=1 if married	983	0.879	0.326	0	1
income	annual net household income in euro	974	30,008	11,371	5,000	80,000
homemaker	dummy=1 if homemaker	983	0.07	0.256	0	1
Matura	dummy=1 if high school diploma	983	0.4	0.49	0	1
somecoll	dummy=1 if some years at university without degree	983	0.052	0.222	0	1
College	dummy=1 if college (university) degree	983	0.25	0.433	0	1

Table 3. Dread ratings assigned by the respondents to various causes of death.

	Percent of the respondents				
	no dread		medium dread		high dread
	1	2	3	4	5
road traffic accident	2.86	7.96	27.55	33.78	27.86
leukemia	7.16	18.94	21.19	25.28	27.43
cardiovascular disease	3.58	13.82	31.93	35.62	15.05
chronic respiratory illnesses	7.26	18.92	33.95	27.61	12.27
cancer	2.35	3.99	13.61	24.46	55.58
fire	14.31	25.97	23.21	18.51	18.00

Table 4. Exposure and sensitivity variables.

Variable name	Variable type	ROAD TRAFFIC ACCIDENT	RESPIRATORY PROBLEMS	CANCER
DREAD	scale (1 to 5)	3.758	3.187	4.269
HIDREAD	dummy	0.279	0.123	0.556
EXPOSURE	dummy	0.852	0.795	0.494
MORECOMMON	dummy	0.710	0	0.511
SENSITIVITY	dummy	0	0.204	0.016
EXPERIENCE	dummy	0.119	0.044	0.518
CONTROLLABILITY*	dummy	0.280	0	0.427 (CANCCOMM) & 0.306 (MANYYRS)

* For road traffic accidents, dummy AUTOAVD=1 if the respondent agrees strongly that "most road traffic accidents could be avoided." For cancer, MANYYRS=1 if the respondent agrees strongly or very strongly that "it takes exposure to carcinogens for many years before developing cancer," CANCCOMM=1 if respondent agrees strongly or very strongly that "cancer is so common that in virtually all families someone will get cancer."

Table 5. Estimation results: Simplest Models. No dominated pair.

	(A) Basic Model		(B) Controlling for cause of death	
	Coefficient	t stat	Coefficient	t stat
$\alpha 1$	0.1687	16.899	0.1539	14.881
$\alpha 2$ (cancer)			0.0880	8.152
$\alpha 3$ (road traffic)			-0.0223	-2.483
β	-0.0004	-16.112	-0.0005	-17.042
δ (discount rate)	-0.0052	-0.614	-0.0062	-0.766
	VSL (mill. euro)	Std. err. around VSL	VSL (mill. euro)	Std. err. around VSL
All causes	4.000	0.257		
Respiratory			3.360	0.222
Cancer			5.281	0.346
Road traffic			2.874	0.231
N	7261		7261	
mean log L	-6694.11		-6628.42	

Table 6. Estimation results: Effect of Exposure and Risk Perceptions. No dominated pair.

	(A)		(B)		(C)		(D)		(E)		(F)	
	coeff.	t stat	coeff	t stat	coeff	t stat	coeff	t stat	coeff	t stat	coeff	t stat
α1	0.1223	11.535	-0.0285	-1.019	-0.0362	-1.262	-0.0305	-0.74	-0.0431	-1.023	-0.0774	-1.705
α2 (cancer)	0.0853	8.393	0.0841	8.122	0.0842	8.125	0.0841	8.121	0.0693	5.176	0.0476	3.425
α3 (road traffic)	-0.0247	-2.878	-0.0342	-3.859	-0.0343	-3.867	-0.0342	-3.859	-0.0514	-4.14	-0.0607	-4.784
α4 (PUBLIC)	0.0459	7.007	0.1046	4.129	0.1038	4.095	0.1045	4.127	0.1004	3.947	0.0969	3.787
α5 PUBEFF			0.0273	5.622	0.0276	5.657	0.0273	5.622	0.0268	5.494	0.0247	5.025
α6 PRIVEFF			0.0143	2.252	0.0141	2.213	0.0143	2.25	0.0134	2.095	0.0124	1.928
α7 BRISK					0.0074	1.223						
α8 ln(BRISK)							0.0005	0.068	0.0007	0.094	-0.0003	-0.039
α9 EXPOSURE									0.0211	2.073	0.0177	1.726
α10 MORECOMM									0.0197	1.816	0.0161	1.479
α11 SENSITIVITY									-0.0009	-0.054	-0.0049	-0.288
α12 EXPERIENCE									0.0258	2.144	0.0215	1.766
α13 DREAD											0.0161	2.662
α14 HIDREAD											0.0201	1.388
β	-0.0005	-16.819	-0.0005	-16.64	-0.0005	-16.656	-0.0005	-16.64	-0.0005	-16.675	-0.0005	-16.646
δ	-0.0148	-1.932	-0.0163	-2.173	-0.0161	-2.149	-0.0163	-2.171	-0.0156	-2.089	-0.015	-2.017
N	7261		6970		6970		6970		6970		6970	
log L	-6603.65		-6304		-6303.24		-6304		-6296.27		-6282.04	

Table 7. Estimation results: Effect of the Individual Characteristics of the Respondents. No dominated pair.

	(A)		(B)	
	coeff.	t stat	coeff	t stat
α1	-0.0655	-1.39	-0.0572	-1.21
α2 (cancer)	0.0435	3.149	0.0428	3.096
α3 (road traffic)	-0.0612	-4.845	-0.0616	-4.877
α4 (PUBLIC)	0.0987	3.883	0.0993	3.907
α5 PUBEFF	0.0255	5.191	0.025	5.083
α6 PRIVEFF	0.0128	2.008	0.0132	2.064
α7 ln(BRISK)	0.0005	0.076	-0.0001	-0.016
α8 EXPOSURE	0.0175	1.716	0.0186	1.827
α9 MORECOMM	0.0173	1.597	0.0165	1.522
α10 SENSITIVITY	-0.0064	-0.378	-0.0103	-0.603
α11 EXPERIENCE	0.0223	1.849	0.0208	1.728
α12 DREAD	0.0158	2.638	0.0153	2.556
α13 HIDREAD	0.0229	1.595	0.0236	1.65
α14 MATURA	-0.0076	-0.558	-0.0093	-0.682
α15 SOMECOLL	0.0528	1.878	0.0506	1.803
α16 COLLEGE	0.0249	1.577	0.0203	1.283
α17 FEMALE	-0.0505	-4.389	-0.0513	-4.455
β	-0.0005	-16.617	-0.0005	-14.745
δ	-0.0167	-2.263	-0.0174	-2.349
β_2 (dummy if income below the average)			0.0001	2.334
N	6965		6910	
log L	-6261.35		-6204.88	

Table 8. Estimation results: Additional checks. No dominated pair. Specification (C) uses alternative definitions for EXPOSURE and EXPERIENCE (see the Appendix).

	(A)		(B)		(C)	
	coeff	t stat	coeff	t stat	coeff.	t stat.
α1	-0.0582	-1.222	-0.1623	-3.201	-0.084	-1.86
α2 (cancer)	0.0405	2.414	0.051	3.054	0.0641	4.444
α3 (road traffic)	-0.0554	-3.646	-0.0471	-3.036	-0.0608	-4.926
α4 (PUBLIC)	0.0988	3.875	0.1053	4.101	0.0972	3.806
α5 PUBEFF	0.0244	4.932	0.0256	5.005	0.0246	5.016
α6 PRIVEFF	0.0131	2.035	0.014	2.196	0.0124	1.934
α7 ln(BRISK)	-0.0007	-0.097	-0.0024	-0.314	-0.0005	-0.068
α8 EXPOSURE	0.016	1.561	0.0161	1.584	0.0255	2.382
α9 MORECOMM	0.0152	1.4	0.0161	1.489	0.0173	1.597
α10 SENSITIVITY	-0.0123	-0.718	-0.0122	-0.718	-0.003	-0.067
α11 EXPERIENCE	0.0169	1.385	0.0188	1.559	0.0036	0.336
α12 DREAD	0.0152	2.524	0.0151	2.484	0.0166	2.747
α13 HIDREAD	0.0215	1.492	0.0198	1.39	0.0198	1.375
α14 MATURA	-0.0091	-0.666	-0.0125	-0.88		
α15 SOMECOLL	0.05	1.776	0.0539	1.825		
α16 COLLEGE	0.0209	1.317	0.0143	0.869		
α17 FEMALE	-0.0514	-4.433	-0.059	-4.81		
α18 CANCCOMM	0.0375	2.249	0.0374	2.254		
α19 AUTOAVD	0.02	1.249	0.0197	1.247		
α20 MANYYRS	0.002	0.115	0.0002	0.01		
α21 POLLRESP	0.0196	1.369	0.02	1.405		
β	-0.0005	-14.73	-0.0006	-17.428	-0.0005	-16.63
δ	-0.0168	-2.274	-0.0221	-1.886	-0.0155	-2.083
β_2 (dummy if income below the average)	0.0001	2.292	0.0001	2.591		
NEITHER			-0.9587	-16.827		
N	6910		6910		6970	
log L	-6200.91		-6055.62		-6282.65	

Appendix

Table A.1: Alternative construction of variables to check for effects on the VSL

	Source	ROAD TRAFFIC ACCIDENT	RESPIRATORY PROBLEMS	CANCER
EXPOSURE(2)	constructed	driving at least once a week	Living in moderately or very polluted environment	cancer runs in respondent's family
SENSITIVITY(2)	respondent	**n.a.**	perception about bad actual or future health status	perception about bad actual or future health status
EXPERIENCE(2)	constructed	admitted to the hospital or taken to the emergency room in last 5 years for this reason	admitted to the hospital or taken to the emergency room in last 5 years for this reason, respondent has chronic respiratory illnesses.	close person or family member had cancer and respondent had cancer

Table A.2: Average values of factors used to explain VSL (see table A.1 for coding).

Variable name	Variable type	ROAD TRAFFIC ACCIDENT	RESPIRATORY PROBLEMS	CANCER
EXPOSURE(2)	dummy	0.852	0.748	0.204
SENSITIVITY(2)	dummy	0	0.020	0.020
EXPERIENCE(2)	dummy	0.119	0.224	0.685

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