J Risk Uncertainty (2007) 34:155–178
DOI 10.1007/s11166-007-9007-8

Paying for permanence: Public preferences for contaminated site cleanup

Anna Alberini · Stefania Tonin · Margherita Turvani · Aline Chiabai

Published online: 16 March 2007

Abstract We use conjoint choice questions to investigate the preferences of people in four cities in Italy for income and future/permanent mortality risk reductions delivered by contaminated site remediation policies. The VSL is €5.6 million for an immediate risk reduction. If the risk reduction takes place 20 years from now, the implied VSL is €1.26 million. Respondents' implicit discount rate is 7%. The VSL depends on respondent characteristics, familiarity with contaminated sites, concern about the health effects of exposure to toxicants, having a family member with cancer, perceived usefulness of public programs and beliefs about the goals of government remediation programs.

Keywords Value of a statistical life · Latent risk reductions · Individual discount rates · Conjoint choice questions · Contaminated sites · Remediation

JEL Classification J17 · I18 · K32 · Q51 · Q53

When setting cleanup standards or examining public programs that address hazardous waste sites, such as the U.S. Superfund program, it is useful to compare the (monetized) value of permanent reductions in the risks to human health with the costs of treating contaminated soil, groundwater and surface water. Doing so requires finding out how much the beneficiaries of these risk reductions are willing to pay to obtain them.

A. Alberini (✉)
AREC, 2200 Symons Hall, University of Maryland, College Park, MD 20742, USA
e-mail: aalberini@arec.umd.edu

S. Tonin · M. Turvani
Department of Planning, University of Venice-IUAV, Venice, Italy

A. Chiabai
Fondazione Eni Enrico Mattei, Venice, Italy

Because contaminated sites often entail exposure to carcinogens and other toxicants with long-term effects on health, remediation must be paid for now but the reductions in risks to human health are accrued in the future. It is thus of interest to find out if the willingness to pay for risk reductions is affected by such a delay ("lag"), and if so, by how much.

This paper focuses on the risks of dying associated with exposure to contaminants at hazardous waste sites. We use conjoint choice questions (Hanley et al. 2001) to study people's preferences for delayed and permanent risk reductions, such as those delivered by permanent remediation, as opposed to those delivered by contaminant containment mechanisms, such as capping and fencing a site, or land use restrictions. We survey a sample selected to be representative of the residents of four cities in Italy with significant contaminated site problems.

We ask three related questions. First, how much are people willing to pay for each unit of mortality risk reduction? In other words, what is the public's Value of a Statistical Life (VSL) that should be used for computing the benefits of contaminated site policies that save lives? Second, do people favor permanent cleanup policies, and are they willing to pay more for risk reductions that continue to occur for longer periods of time? Third, what is the effect on Willingness to Pay (WTP) of delaying the beginning of the mortality risk reductions?

Although the concept of VSL is reasonably well accepted in academic and policy circles, and the VSL has been estimated using a variety of approaches, there is surprisingly little empirical evidence about what VSL should be used in the context of contaminated site remediation. Using the hedonic pricing approach with homes in Grand Rapids, Michigan, Gayer et al. estimate the value of a statistical case of cancer to be \$3.9–\$4.6 million (1996 dollars) (2000) or \$4.3–\$8.3 million (2002). These values rely on specific assumptions about people's subjectively assessed risks and about how they change in response to the release of information by the agency.

There is reason to believe that people may value reductions in the risk of dying for causes associated with exposures to pollutants at contaminated sites differently than the risk of dying for other causes. The cancers and severe chronic diseases leading to death are presumably accompanied by a high level of dread, which may arise from, or be correlated with, the morbidity, pain and suffering preceding death, and the involuntariness of the risks, for whose existence people may blame other entities—e.g., corporations when the polluted site is an industrial plant, the government when the polluted site is a military installation (Fischhoff et al. 1978; McDaniels et al. 1992; Cropper et al. 1991, 1992). If the WTP for reductions in the health risks due to contaminated site exposures reflect such perceptions, it may be inappropriate to estimate the mortality benefits of cleanup by applying the WTP for risk reductions inferred from other, and completely different, contexts, such as workers' wage-risk tradeoffs (Viscusi 1993; Viscusi and Aldy 2003) or purchases and use of auto safety equipment (Blomquist 1979; Andersson 2005). Recent research (Chilton et al. 2002; Tsuge et al. 2005; Vassanadumrongdee and Matsuoka 2005) has examined the effects of risk perceptions (such as dread, degree of voluntariness, etc.) on the value of reducing these risks, but results are mixed and their implications for hazardous waste site risks unclear.

For these reasons, we use a stated-preference approach to elicit the tradeoffs that people make between income and risk reductions in the hazardous waste site context.[1] Specifically, we showed people pairs of hypothetical public programs described by five attributes—the annual risk reduction afforded by the program, the size of the population living in the area with the contaminated sites that would be addressed by the program, how soon such risk reductions would be observed, the number of years over which the risk reduction would be observed (and hence lives would be saved), and the cost to the taxpayer. We then asked them to indicate which they would prefer out of these two programs, and then again which they would prefer, program A, B, or neither.

Statistical modeling of the responses to these choice questions allows us to estimate the VSL—the first of our research questions. In addition, it allows us to answer two related questions: In the context of contaminated site policies, is the VSL affected by the individual characteristics of the respondent? Are the responses to the choice questions and the implied WTP figures internally valid, in the sense that they depend in predictable ways on variables suggested by economic theory and confirm opinions expressed by the respondent elsewhere in the questionnaire?

Because the time it takes before lives are saved and the number of years over which lives would be saved are varied to the respondents, the responses to the conjoint choice questions can be used to estimate the rate at which people discount future risk reductions. Were such a rate found to be low, we would conclude that people care for permanent risk reductions, and that their WTP for risk reductions is little affected by the lag until the risk reductions are incurred. The opposite conclusions would be reached if the discount rate was found to be relatively high. We are aware of no previous research on the valuation of permanence by the beneficiaries of cleanup, despite the relative abundance of earlier work that looked at the rates at which people trade off current income for future reductions in their own risk of dying (Horowitz and Carson 1990; Moore and Viscusi 1990; Hammitt and Liu 2004; Alberini et al. 2006a).

Finally, we note that one of the attributes of the hypothetical programs is the size of the population living in the areas with the targeted contaminated sites. This allows us to explore whether people care for *individual risks*—the target of the cleanup decisions made by the U.S. Environmental Protection Agency under the Superfund program, for example—or for *expected lives saved*. This question is of great interest not only in the context of hazardous waste policy, but also when comparing, say, air pollution policies, where the risk reductions are small and cover a very large population, with other environmental policies where the risk reductions are larger but targeted at very specific populations.

The remainder of the paper is organized as follows. In Section 1, we discuss policies and risks at contaminated sites, present the conjoint choice experiments and lay out the model of the responses to these questions. Section 2 describes the survey questionnaire and the administration of the survey. Section 3 presents the data and estimation results. Section 4 concludes.

---

[1] DeShazo and Cameron (2005) and Itaoka et al. (2006) are other recent applications of the conjoint choice approach to value mortality risk reductions.

1 Risks, methods and models

1.1 Risks and hazardous waste policies

Hazardous waste site programs purport to eliminate or reduce threats to public health and to reduce mortality risks. The VSL—the marginal rate of substitution between income and risk—is a summary measure of the WTP to pay to reduce these risks, and is generally deemed as the appropriate construct for ex ante policy analyses, when the identities of the people whose lives are saved by the policy are not known yet. The mortality benefits of a policy that saves L lives are equal to (VSL×L).

In the U.S., the Superfund statute spells out cleanup criteria to be adopted at the most egregious contaminated sites in the nation, which are placed on the so-called National Priorities List (NPL) and may qualify for publicly financed cleanup. The 1986 Superfund Amendments and Reauthorization Act (SARA) specifically directed EPA managers to select target risk reductions to protect human health and meet any “legally applicable” or “relevant and appropriate” standards (e.g., maximum contaminant limits in groundwater), regardless of cost (Revesz and Stewart 1995). EPA guidelines have interpreted SARA to warrant cleanup where excess lifetime cancer risks to an *individual* based on reasonable maximum exposure are greater than 10^{-4}, and to give discretion to project managers where risks are between 10^{-4} and 10^{-6} (U.S. Environmental Protection Agency 1991).[2] SARA also contains an explicit preference for permanent remediation, as opposed to simple containment to prevent migration of pollutant and to limit exposure. Permanent remedies are generally more expensive, but Gupta et al. (1996) find that the EPA has indeed heeded this preference for permanent cleanups in its remediation decisions.

Recent state programs, however, seem to be reversing this preference for permanence. State voluntary cleanup programs, for example, offer a variety of incentives in exchange for site cleanup, including simplified or variable cleanup standards linked to land use, engineering and institutional controls, in place of (more stringent) cleanups (Meyer 2000). The U.S. General Accounting Office (1997) surveyed 17 state voluntary cleanup programs and found that over 50% of the cleanups entailed non-permanent remedies and/or adopted industrial land use standards.

Several European countries face similar dilemmas. In Italy, the first piece of legislation addressing hazardous waste sites—the Waste Act—was passed in 1997 (Gazzetta Ufficiale 1997). The statute requires cleanup if the concentrations of certain pollutants exceed the maximum contaminants limits set by the law for soil and water. A subsequent law (Legislative Decree 152/2006) required that risk assessments be conducted at sites where pollutants exceed the maximum concentration limit, and that remedial plans be based on such risk assessments. Remediation is recommended when excess lifetime cancer risk exceeds 10^{-5} (Gazzetta Ufficiale 2006).

[2] Risk assessment procedures are spelled out in U.S. Environmental Protection Agency (1989). Also see Walker et al. (1995).

The Waste Act provides for only limited funding for cleanup,[3] places the burden of remediating orphan sites on the municipalities, and contains an explicit preference for permanent remediation and for on-site treatment of contaminated media. Recent analyses conducted by the Italian Environmental Protection Agency and environmental organizations point out that the majority of actions at NPL and non-NPL contaminated sites have, thus far, been short-term and impermanent (Agenzia per la Protezione dell' Ambiente e per i Servizi Tecnici (APAT) 2004; Legambiente 2005).

1.2 Conjoint choice questions

Conjoint choice experiments are a survey-based technique frequently used to place a value on a good or estimate the benefits of a public program (see Hanley et al. 2001). The approach asks individuals what they would do under hypothetical circumstances, rather than observing actual behaviors. An advantage of this approach is that it is flexible and can span goods/programs, levels of risk reductions and other aspects of environmental quality that do not currently exist.

In a conjoint choice survey, a good or public program is described in a stylized fashion by a vector of attributes. Respondents are shown $K \geq 2$ alternative variants of this good or program obtained by taking combinations of the possible values of the attributes, and are asked to choose the most preferred. The alternatives differ from one another in the levels taken by two or more of the attributes. If a "do nothing" or status quo option is included in the choice set, choice experiments can be used to estimate the WTP for each alternative.

We asked respondents to consider hypothetical public programs that would clean up sites where the responsible parties are no longer in existence or do not have the means to pay for remediation. Respondents were told that the government would be in charge of the remediation programs, and that the programs would be guaranteed to be effective.

The specifics of the programs are described using five attributes: (1) the risk reduction per year, expressed as the number of lives saved per million people, (2) the size of the population living in the areas with the contaminated sites targeted by the program, (3) the delay until the risk reduction begins, (4) the number of years over which the risk reduction would be observed, and (5) the cost of the program to the respondent, which would be incurred as an immediate, and one-time, tax. Clearly, attribute (3) gets at the heart of the latency issue, and attribute (4) captures the degree of permanence of the risk reductions.

The respondents were shown a total of four pairs of hypothetical programs constructed in this fashion. They were first asked to indicate which of the two programs—A or B—they prefer, and then indicate which they would choose out of program A, program B, or neither. This results in a total of eight conjoint choice questions where the size of the choice set is 2 (when choosing between A and B) or 3 (when choosing between A, B, and the status quo). An example of the conjoint choice questions is reported in the Appendix, and a summary of attributes and levels is reported in Table 1.

[3] The estimated cleanup costs for the sites on the Italian NPL are €3,149 million, but the available public funding tops off at €541 million.

Table 1 Attributes and attribute levels in the conjoint choice questions

Attribute	Levels of the attribute
Lives saved per million people (ΔR)	10, 20, 30
Population living in the areas with the contaminated sites covered by the program (N)	0.5 million, 1 million, 2 million
Delay (number of years until the risk reduction is incurred) (A)	2, 10
Duration of the health benefits (number of years) (T)	20, 30, 45
One-time tax payment for the respondent's household (C) (in Euro)	50, 100, 300, 500, 950

That risk reductions will be realized no earlier than two years from now (attribute (2) or "Delay" in Table 1) is consistent with the notion that the pollutants at most contaminated sites are carcinogens or cause long-term health effects, and with the fact that it takes some time to complete even the most efficient government remediation program.[4] To facilitate the respondents' task, we held the delay the same for all hypothetical pairs shown to a respondent, and employed a split-sample design where half the respondents were given $D=2$ and the other half $D=10$. It is also reasonable to assume that no remediation program can reduce risks forever: hence, we set the duration of the risk reductions at 20, 30 or 45 years. These may be interpreted as time to failure of the remedies. The delay and duration attributes provide variation in the timing of the mortality risk reductions across and within respondents, which we exploit for the purpose of estimating the rate at which people discount future risks.

We chose a one-time tax to be incurred immediately for two reasons. First, since risk reductions are incurred in the future, this allows U.S. to estimate the rate at which people discount risks. Second, in focus groups and during the survey development work, people voiced strong opinions against new taxes and against committing to pay annual taxes over a long period of time. We certainly did not want people to dismiss our scenarios outright, and a one-time tax was the most appealing option. The one-time tax amounts ranged between €50 and €950.[5] We chose these bid amounts because they cover a broad range of possible VSL values: Using the model described by equations (1) and (2) below, and assuming discount rates between 0% and 10%, our bid amounts correspond to VSL figures ranging between €37,000 and €11 million.[6]

We also vary the size of the population living in the areas with the contaminated sites that would be addressed by the program, and hence potentially affected by the

[4] In choosing delays of 2 and 10 years, we were hoping to strike a compromise between what participants in focus groups and one-on-one surveys judged reasonable, and lag ranges used in actual policy analyses. The EPA Science Advisory Board assumed a 20-year lag when examining the maximum contaminant limit allowable for arsenic in drinking water (see www.house.gov/science/ets/oct04/ets_charter_100401.htm, accessed 22 January 2006), and the model used by the U.S. Environmental Protection Agency for arsenic in water, which is adapted from a smoking cessation lag model, predicts that the majority of the reduction in the risk of cancer is incurred within the first five years following cessation (U.S. Environmental Protection Agency 2003).

[5] At the time of the survey (May 2005), one Euro exchanged on average for $1.25 U.S.

[6] If the discount rate is assumed to be zero, our bids correspond (depending on the duration and delay) to VSL values ranging from €37,000 to €4.750 million. If the discount rate is assumed to be 2%, the bids correspond to VSL amounts ranging from €56,000 to €5.76 million. For a discount rate of 5%, the VSL range is €93,000 to €7.5 million, and for a discount rate of 10%, it is €169,000 to €11 million.

risk reductions. We chose hypothetical populations of 0.5, 1 and 2 million because these levels were judged credible by focus group participants, especially when compared with the total population living in areas with NPL sites (7 million; see Section 3), and because we felt that respondents could easily form a sense of the size of these populations by comparing them with those of the cities they live in.

We created a total of 32 sets with four pairs of programs each. We began this task by creating all of the possible alternative programs (i.e., all possible combinations of the levels of the attributes). We then formed all of the possible pairs, but excluded pairs that contained dominated alternatives.[7] The 32 sets we used for the survey were obtained by selecting four pairs at random (without replacement) out of this universe of non-dominated pairs. Respondents were randomly assigned to one of the 32 sets.

1.3 The model

We assume that in the conjoint choice questions respondents choose the alternative with the highest indirect utility, and that the indirect utility depends on the discounted stream of risk reductions and on residual income. Formally,

$$\overline{V}_{ij} = \alpha \cdot \mathrm{DR} + \beta\left(y_i - C_{ij}\right), \tag{1}$$

where $\overline{V}_{ij}$ denotes the deterministic component of the indirect utility function, DR is the discounted flow of risk reductions delivered by program j, y is income and C is the cost of the program to the respondent. Coefficients α and β denote the marginal utility of the discounted flow of risk reductions and the marginal utility of income, respectively. We assume constant exponential discounting and define DR as

$$DR = \exp(-\delta A) \cdot \int_0^T \Delta\mathrm{R} \cdot \exp(-\delta t)\mathrm{d}t = \Delta\mathrm{R} \cdot e^{-\delta A}\left[\frac{1 - e^{-\delta T}}{\delta}\right], \tag{2}$$

where ΔR is the annual risk reduction (which is varied to the respondents but constant over the years), δ is the discount rate, A is the number of years one must wait before the risk reductions are observed, and T is the number of years over which lives are saved. Expression (2) shows the effect of a delay in the beginning of the risk reduction (captured by the term $\mathrm{e}^{-\delta A}$) and the effect of more or less permanent risk reductions (captured by term in brackets).

On appending an error term ε_{ij}, Eq. 1 becomes a random utility model, which in turn results in a conditional logit model if we further assume that the error terms ε_{ij} are independent across alternatives within the same respondent and follow the standard type I extreme value distribution. The probability that option k is selected out of K alternatives when answering a choice question is thus

$$\Pr(k) = \frac{\exp\left(\overline{V}_{ik}\right)}{\sum_{j=1}^{K} \exp\left(\overline{V}_{ij}\right)}, \tag{3}$$

[7] A pair has a dominated alternative if one of them is obviously better (e.g., saves more lives over a longer period of time) and no more expensive than the other.

and the log likelihood function of our sample is

$$In\,L = \sum_{i=1}^{n}\sum_{m=1}^{M}\sum_{k=1}^{K_m} y_{mik} \cdot In\,\Pr(i \text{ chooses } k \text{ in question } m) = \sum_{i=1}^{n}\sum_{m=1}^{M}\sum_{k=1}^{K_m} y_{mik} \cdot In\frac{\exp\left(\overline{V}_{ikm}\right)}{\sum_{j=1}^{K_m}\exp\left(\overline{V}_{ijm}\right)} \quad (4)$$

where y_{imk} is a binary indicator that takes on a value of 1 if the respondent i selects alternative k in choice question m, and 0 otherwise, K_m is the number of the alternatives the respondent is faced with in choice question m (so K_m=2 for m=1, 3, 5, and K_m=3 for m=2, 6, and 8), and M is 8, the total number of choice questions asked of the respondent. Equation 4 thus describes a non-linear conditional logit. It assumes that the choice responses are independent within and across respondents.

The maximum likelihood estimates of the coefficients can be used to compute the Willingness to Pay (WTP) for any given program:

$$\text{WTP} = \frac{\widehat{\alpha}}{\widehat{\beta}}\text{DR}. \quad (5)$$

The VSL, i.e., the willingness to pay for a marginal risk reduction to be incurred in the current year, is equal to $\left(\widehat{\alpha}/\widehat{\beta}\right)$.

1.4 Hypotheses

Clearly, the model described by equations (1) and (2) assumes that the VSL is constant with respect to the size of the risk reduction and the size of the population that would benefit from the cleanup. In other words, according to this model people look at *individual* risks. In this paper, we wish to test if the VSL does indeed vary with the number of beneficiaries of the program. To do so, we amend Eq. 1 to obtain:

$$\overline{V}_{ij} = \alpha_1 \cdot \text{DR}_{0.5} + \alpha_2 \cdot \text{DR}_1 + \alpha_3 \cdot \text{DR}_2 + \beta\left(y_i - C_{ij}\right), \quad (6)$$

where $\text{DR}_{0.5}$=DR if the size of the population affected by the program is 0.5 million and 0 otherwise, DR_1=DR if the size of the population affected by the program is 1 million and 0 otherwise, and DR_2=DR if the size of the population affected by the program is 2 million and 0 otherwise. We then test the null hypothesis that $\alpha_1=\alpha_2=\alpha_3$. Failure to reject the null implies that Eq. 6 is simplified to Eq. 1, i.e., the marginal utility of a risk reduction is not affected by the size of the population of beneficiaries of the program, N.

If the above null is rejected, we further wish to test the null hypothesis that $\alpha_2=2\alpha_1$ and $\alpha_3=2\alpha_2$. This null hypothesis implies that what enters in the utility function is the discounted number of *lives* saved, rather than discounted *individual risk*. The indirect utility function would thus be

$$\overline{V}_{ij} = \gamma \cdot L + \beta\left(y_i - C_{ij}\right), \quad (7)$$

where L is discounted lives saved:

$$L = \exp(-\delta A) \cdot \int_0^T \Delta R \cdot N \cdot \exp(-\delta t)\text{d}t = \Delta R \cdot N \cdot e^{-\delta R}\frac{1 - e^{-\delta T}}{\delta}. \quad (8)$$

Equations 7 and 8 mean that the VSL is strictly proportional to N, the size of the population living in the areas targeted by the hypothetical program. Equation 7 is similar to the social net benefit of cleanup (expected number of cancers avoided, minus cleanup cost) posited, and empirically rejected, by Viscusi and Hamilton (1999) as the objective function for the U.S. EPA. Viscusi and Hamilton concluded that the agency was consistent neither with its own mandate requiring exclusive focus on maximum individual risks, nor with social efficiency.

We are also interested in testing whether the marginal utility of risk reductions and the marginal utility of income depend on individual characteristics. To see if this is the case, we amend Eq. 1 (or Eq. 6) to allow for heterogeneity among the respondents.[8] Specifically, we posit that the marginal utility of risk reduction for respondent i is $\alpha_i = \alpha_1 + \boldsymbol{x}_i\alpha_2$ and that the marginal utility of income is $\beta_i = \beta_1 + \beta_2 P_i$, where $\boldsymbol{x}_i$ is a vector of individual characteristics such as age, gender, education, own health, familiarity with contaminated sites and remediation, acceptance of government policies addressing hazardous waste sites, etc., and P is a low-income dummy. In other words, we form interaction terms between the arguments of Eq. 2—DR and residual income—and $\boldsymbol{x}_i$ and P, respectively, and add these interactions in the right-hand side of the indirect utility function:

$$\overline{V}_{ij} = \alpha_1 \cdot \mathrm{DR}_{ij} + \left(\mathrm{DR}_{ij} \times \boldsymbol{x}_i\right)\alpha_2 + \beta_1 \cdot \left(y_i - C_{ij}\right) + \beta_2\left[\left(y_i - C_{ij}\right)P_i\right]. \qquad (9)$$

Finally, it is possible to replace δ with a function of individual characteristics $\boldsymbol{z}_i$ of the respondent, such as age, whether he or she is married and has young children, etc.: $\delta_i = \boldsymbol{z}_i\pi$.

2 Structure of the questionnaire and survey administration

Our conjoint choice questions are at the heart of our questionnaire and are accordingly placed in the middle of the survey instrument. The questionnaire is comprised of five sections. In Section 1 we ask people whether and how they are acquainted with contaminated sites. Since a respondent's notion of contaminated site may be different from our own, we then provide the following definition: "A contaminated site is a parcel or an area with hazardous substances that pose risks to human health or the environment, now or in the future. These hazardous substances are the result of human activities. Electromagnetic fields/pollution and air pollution are not considered contaminated sites in this questionnaire."

In Section 2, we briefly describe the problem of contaminated sites in Italy and provide succinct information about the total population living in areas with sites on the National Priorities List and thus potentially exposed to contaminants, current legislation and government policies.

[8] As shown below, although we find that the marginal utility of risk reduction is different for different population sizes, in practice the VSL is constant with respect to population size. For this reason, we incorporate covariates only in the simpler specification of the indirect utility function, allowing α and β to vary across respondents but not across the size of population in the conjoint choice questions.

In Section 3 we explain, using animation, how people are typically exposed to contaminants. A list of the possible short- and long-term health effects of exposure to certain substances follows. For example, respondents are told that heavy metals have been linked with kidney damage, adverse effects on the neurological and immune systems, and may cause cancer.

In sum—we continue—exposure to pollutants at or migrating from contaminated sites can cause cancer and other serious illnesses that may be fatal. At this point, we focus on mortality endpoints and provide an estimate of the baseline, pre-remediation mortality risks associated with exposure to pollutants found at contaminated sites. Specifically, respondents are told that exposures to pollutants at contaminated sites result in 243 deaths per million people a year and that a total of about 7 million people live in the areas with National Priorities List sites, resulting in an estimated 1,700 deaths per year linked to contaminated site exposures.[9]

We use a bar chart to compare the pre-remediation risk of dying as a result of contaminated site exposures for the populations living near such sites with the risk of dying for other causes. These other causes include cardiovascular diseases, which account for 4,480 deaths per million people every year; cancer, which accounts for 2,290 deaths per million people every year, and less frequent but familiar causes of death, such as road-traffic accidents (125 in a million per year) or carbon monoxide poisoning (35 in a million per year) (see Figure 1). For these other causes, we displayed risks based on the mortality rates for all of Italy, assuming that road traffic accidents, carbon monoxide poisonings and other pathologies not associated with contaminated site exposures occur in the four cities of the survey at the same rate as they do in the rest of the country. Respondents are subsequently tested for risk comprehension.

Section 4 is dedicated to remediation. We provide examples of possible remediation technologies, pointing out that they vary in terms of cost and completion time, and that different sites and pollutants require different remedies (e.g., pump-and-treat for groundwater, bioremediation at petroleum sites).

This is followed by the conjoint choice experiment portion of the questionnaire. A reminder of the baseline risks is shown at the top of each screen with the pairs of programs and the associated choice questions. Finally, we ask people to express their agreement or disagreement with statements spelling out possible priorities for cleanup and risk reductions. Section 5 concludes the questionnaire with the usual sociodemographic questions.

The survey was self-administered using the computer by respondents drawn from the general population in four cities in Italy (Venice, Milan, Bari and Naples) in May

[9] We were unable to find estimates of the risks and population at risk for the sites on the Italian NPL or other government-compiled list. We calculated an estimate of the baseline risks before cleanup by transferring estimates of risks in other contaminated areas in Italy. Specifically, we relied on a World Health Organization study which identifies highly industrialized and polluted areas in Italy, computes mortality rates for men and women in these areas in 1990–1994, and compares them with those of the surrounding regions. This study concludes that in those years the highly industrialized areas experienced about 800 excess deaths per year (Martuzzi et al. 2002; Mitis et al. 2005). When this figure is divided by the exposed population (3,295,380 people), we obtain an excess risk of about 243 per million, which we posit to be our baseline risk.

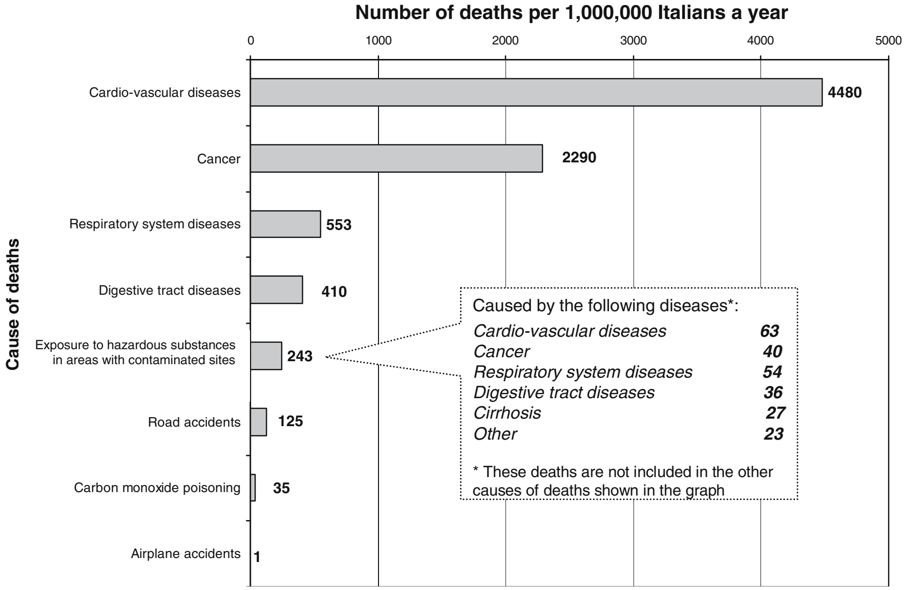

Fig. 1 Baseline risks

2005, for a total of 804 completed questionnaires.[10] Our respondents were recruited by a professional survey firm that maintains a database of potential respondents reasonably representative of the population of the major Italian cities for income, gender, age and education. Potential survey respondents were contacted by telephone and offered a gasoline coupon worth €20 for their participation in the survey. To

[10] These cities were selected to ensure geographic representativeness and because each has one or more sites on the National Priorities List. The chemical and oil refining complex of Porto Marghera in the Venice hinterland is probably the most egregious contaminated site on the NPL, with soils, groundwater and Lagoon sediments contaminated by polycyclic aromatic hydrocarbons (PAHs), heavy metals and many other pollutants. The former Fibronit complex, an asbestos-processing facility, is located in downtown Bari, while the NPL site in Naples is a closed steel mill. The Milan area has several NPL sites. The four cities also have a number of non-NPL sites. Ideally, to ensure surveying the beneficiaries of a cleanup program that matches as closely as possible the one in the questionnaire, we would have liked to draw our respondents from the population living within a short distance from one or more orphan sites (whether or not such sites are on the NPL, since the language in the questionnaire does not restrict the program to NPL sites). Unfortunately, this was not possible for two reasons. First, the universe of contaminated sites in the four cities is simply not made available to the general public by the National and Regional environmental protection agencies (the Regions are jurisdictions roughly comparable for lawmaking power and environmental programs to the States in the U.S. or the Provinces in Canada). Second, even if we had such a comprehensive list of sites, the agencies do not disclose information about the sites' current ownership or orphan status. We therefore opted for the general population of the four cities on the assumption that there are numerous sites needing remediation in those cities and that the population density in those cities is sufficiently high so that most people live near one such site. We did, however, ask respondents whether they were aware of a contaminated site in the neighborhood or near work, and which parties they considered to be the beneficiaries of the program in the survey—themselves, their families, or other people.

avoid self-selection into the sample, prospective participants were not told what the exact topic of the survey would be.

The sample was stratified by age, with an equal number of respondents in each of three broad age groups (25–44, 45–54, 55–65), and was comprised of a roughly equal number of men and women. We did not expect all respondents to be familiar with computers, so two interviewers were present at the survey facilities at all times to provide assistance if requested.

3 Results

3.1 The sample

Descriptive statistics of the respondents are displayed in Table 2. The split by gender and the distribution of age in the sample are consistent with the sampling plan. The average annual household income is approximately €27,000, which is close to, but slightly lower than, the national average (€29,483, Banca d'Italia 2006).

Almost 50% of our sample has a high school diploma and 13.43% has a college degree or higher education. Comparison with population statistics reveals that our sample has a larger share of persons with high school diploma than the population, but is similar to the population in terms of share of persons with college degree or post-graduate education. (The population statistics are 32 and 11%, respectively.)

Regarding their familiarity with contaminated sites (shown in Table 3), 90% of the respondents stated that they had heard about contaminated sites before (usually on the television news). Forty-three percent of the sample indicated that they are aware of contaminated sites near their homes or workplaces. Fully 80% of the respondents were acquainted with the concept of cleanup, and 37% stated that they were personally aware of previously contaminated sites that had been subsequently cleaned up.

In Table 4 we report the respondents' views of possible priorities for contaminated site policies, answers to debriefing questions, and concern about mortality risks, which we use to examine the internal validity of the responses to the

Table 2 Descriptive statistics of the respondents (N=804)

Variable description	Mean	Stand. devn.	Min	Max
Dummy equal to 1 if the respondent is a male	0.51	0.50	0	1
Respondent age	47.02	11.25	25	65
Dummy equal to 1 if respondent is married	0.73	0.44	0	1
Respondent is aged 25–34 (dummy)	0.19	0.39	0	1
Respondent is aged 35–44 (dummy)	0.18	0.38	0	1
Respondent is aged 45–54 (dummy)	0.29	0.46	0	1
Respondent is aged 55 or older (dummy)	0.34	0.47	0	1
Dummy equal to 1 if respondent has a college degree or post-graduate education	0.13	0.34	0	1
Number of household members	3.26	1.17	1	8
Dummy equal to 1 if respondent has children of ages ≤15	0.28	0.45	0	1
Take-home household income	26,955	16,872	5,000	100,000

Table 3 Knowledge of contaminated sites

Variable description	Percent of the sample
Respondent has heard about contaminated sites before	90.0
Respondent is aware of a contaminated site near home or the workplace	43.2
Respondent has heard about cleanup of contaminated sites before	80.0
Respondent is aware of a contaminated site that has been cleaned up	36.7

N=804

conjoint choice questions. As shown in Table 4, almost 89% of the respondents stated that it is "very important" to them personally to reduce the human health risks posed by contaminated sites. Only 7% of the respondents indicated that they only thought of future generations when answering the conjoint choice questions. Indeed, the majority (76%) of the respondents thought about their own exposure, that of their family members, of other people and of future generations, with only 2.86% focusing exclusively on themselves and 2.99% focusing exclusively on other people's exposure.

Eighty percent of the respondents deemed direct government cleanup of orphan sites very useful. Fully 40% of the sample strongly agreed that cleanups should take place, even if their benefits are experienced only 30 years from now, and 80% expressed strong agreement with the statement that cleanups should be as permanent as possible, even if they cost more. At the same time, 69% of the sample deemed policies based on fencing off and prohibiting access to contaminated sites "very helpful." Taken together with Table 3, these statistics suggest that most people have at least some rudimentary information about contaminated sites and cleanup programs, that the latter should be meaningful to them, and that they should accept our hypothetical scenarios, which depict public remediation programs. They also suggest that permanent remediation matters to people, but respondents are not indiscriminately accepting of *any* length of futurity in the risk reductions.

Finally, about 30% of the sample reported that a family member has had or has cancer, and 45% claimed that they do use a seatbelt when riding in the back seat of a

Table 4 Opinions on contaminated sites policies and concern about mortality risks

Variable description	Percent of the sample
Respondent deems it very important to reduce the adverse effects on human health of hazardous wastes	88.9
Respondent only thought of future generations when he answered conjoint choice questions	7.2
Favorable to cleanup even if its benefits are experienced 30 or more years from now	40.6
Respondent strongly agrees that remediation should be as permanent as possible even it costs more	79.6
Respondent deems policies based on fencing off contaminated sites and preventing access very helpful	68.5
Respondent's family members have had cancer	30.0
Respondent uses seatbelts when travelling in the back seat of a car	45.0

N=804

Table 5 Frequencies of observed responses to the question "Which would you prefer between A, B, and neither program?"

Pairs of program	Percent choose A	Percent choose B	Percent choose "neither"
1	42.41	37.69	19.9
2	43.66	37.81	18.53
3	42.16	40.67	17.16
4	42.79	39.05	18.16

car. We interpret familiarity with cancer as a proxy for concern about this illness, and use of seatbelts as concern for, and willingness to undertake action against, mortality risks (albeit of a different nature than cancers and other illnesses associated with exposures to contaminants).

3.2 Responses to the choice questions

Following Viscusi et al. (1991), we checked how many people always pick plan A in all of the eight choice questions (87 people, or 10.82% of the sample), plan B in all eight choice questions (60 people, for 7.46% of the sample), and exhibited preference "reversals" in one or more choice questions (65 people, or 8.31% of the sample). A preference reversal would be observed if, for example, when asked to choose between A and B, the respondent states that B is the more preferred program, and then, when asked which he prefers among A, B, and the status quo, he chooses A.

Always choosing the plan on the left or the plan on the right may well be a legitimate response, and a "reversal" is consistent with random utility model (1) for new draws from the distribution of the error terms at each choice question. Respondents exhibiting these response patterns are thus not necessarily violating the basic tenets of the random utility model, but at any rate these behaviors account for very small fractions of the sample.

In Table 5 we examine the choice frequencies when people were given the option to choose between program A, program B, and the status quo. The frequency of "neither program" responses is less than 20%, suggesting that people were not dismissing the public programs being shown to them without giving them due consideration. The remainder are rather evenly split between program A and B, suggesting that there were no obvious choices between the hypothetical programs.

3.3 VSL estimates

The results of the non-linear conditional logit models of the responses to the conjoint choice questions are reported in Table 6. The indirect utility function underlying the two logits is Eq. 7, and the two regressions differ solely for the criteria we used to clean the sample. Model I uses the full sample, which consists of 782 respondents and 6,256 usable observations.[11] For good measure, in Model II we discard those

[11] A total of 804 respondents completed the questionnaire, but we discarded the choice responses of the 22 individuals who were shown a conjoint choice question screen with a typographical error in the risk reduction.

Table 6 Conjoint choice questions: Conditional logit models

Variable	Model I: All data		Model II: Cleaned data (no preference reversals, no allwrong=1)	
	Coefficient	*t* stat.	Coefficient	*t* stat.
α_1(marginal utility of DR if affected population is 500,000)	0.0049	8.19	0.0045	7.104
α_2(marginal utility of DR if affected population is 1,000,000)	0.0053	8.187	0.0051	7.228
α_3 (marginal utility of DR if affected population is 2,000,000)	0.0044	7.85	0.0041	6.838
β (marginal utility of income)	0.0009	11.595	0.0009	11.29
δ (discount rate)	0.0689	9.542	0.0685	8.284
Log *L*	−5,370.13		−4,558.36	
N obs	6,256		5,296	
N respondents	782		662	

subjects who failed all of the four probability comprehension quizzes ($N=58$) and/or exhibited reversals ($N=65$). The estimation results are very similar to those of Model I.

Briefly, Table 6 shows clearly that risk reductions are positively and significantly valued by the respondents. Within a model, the estimated α_j coefficients (where j denotes the population size, ranging from half a million to 2 million) are within 10–20% of one another. The marginal utility of income is positive and significant, and the discount rate is pegged at 6.9%.

Wald test statistics of 66.69 (for the full sample; p-value<0.0001) and 51.09 (for the "cleaned" sample; p-value<0.0001) reject soundly the null hypothesis that $\alpha_2=2\alpha_1$ and $\alpha_3=2\alpha_2$, providing evidence against indirect utility (Eq. 8). Wald test statistics of 10.02 (p-value=0.001) and 12.45 (p-value=0.0005) for the full and "cleaned" samples, respectively, also reject the null that the marginal utility of discounted risk reductions is the same regardless of the size of the population.

The VSL for a risk reduction to be incurred in the current year implied by the coefficients of Model I in Table 6 is €5.547 million (standard error around the VSL €0.806 million) when the affected population is 0.5 million, €5.996 million (s.e. €0.929 million) when the population is 1 million, and €5.056 million (s.e. €0.840 million) when the affected population is 2 million.[12] However, these three VSL figures are *not* statistically different from one another, so in what follows we estimate (non-linear) conditional logit models that restrict the marginal utility of the risk reductions—the αs—to be the same for all population sizes used in the questionnaire.

We argue that doing so should bring only negligible biases upon the estimated VSL. The results of such a restricted model are reported in Table 7 for the full sample. All coefficients are close to their counterparts in Table 6, and the implied

[12] The VSL is here estimated as $(\alpha/\beta)\times 1$ million. The multiplication by one million is necessary because in our dataset for estimation purposes the risk reduction was coded as 10, 20, or 30, instead of 10, 20, or 30×10^{-6}. The standard errors were computed using the delta method (described in Alberini et al. 2006b, Appendix D).

Table 7 Non-linear conditional logit model

Variable	coefficient	t stat.
α (marginal utility of DR)	0.0050	8.38
β (marginal utility of income)	0.0009	12.36
δ (discount rate)	0.0741	9.82
Log L	−5,369.20	

Full sample (N obs=6,256, Number of respondents=782)

VSL for a risk reduction to be incurred in the current year is €5.58 million (s.e. €0.771 million).[13]

3.4 Implications for latency and permanence

As shown in Table 7, the discount rate in the simplified model is 7.41%. This figure is significantly different from zero, suggesting that our respondents do indeed discount risk reductions that occur in the future. This estimate of the discount rate is reasonable, but not too low, confirming that a unit of risk reduction is valued less if it occurs in the future, and suggesting that people care about permanence, but not at *any* cost. Our respondents discount future risk reductions at a rate that is well within the range estimated in earlier studies (typically 1–14%; see Alberini et al. 2006a).

The implications of a discount rate of this magnitude can be illustrated in several ways. For example, for a risk reduction of 1 in a million in the current year, the VSL is €5.6 million, but if this risk reduction were to be incurred in 10 years, the applicable VSL would be €2.66 million (s.e. around the VSL €0.296 million), and if it were to be incurred 20 years from now—the lag used in analyses of arsenic maximum contaminant limits in drinking water—the applicable VSL would fall to only €1.26 million (s.e. €0.158 million). This is because a one-time risk reduction of one in a million a year occurring 10 years from now is equivalent to an immediate, one-time risk reduction of 0.4766 in a million. The same one-in-a-million risk

[13] We cross-validated these estimates by re-estimating the model after dropping one observation at the time. The "jackknife" mean VSL over these replications was €5.583 million and the standard deviation of the distribution of the VSL estimates, which serve as robust standard error around the estimate of the VSL, is €1.08 million. The estimates of the VSL and the discount rate are robust to, among other things, (1) restricting the sample to the responses to the questions where the choice set includes the status quo (VSL= €6.065 mill., s.e. 1.136 mill., δ=6.24%); (2) omitting the responses to the choice questions about the first pair of programs (VSL=€5.000 mill., s.e. 0.810 mill., δ=7.0%); (3) using only the four responses to the questions about the third and fourth pair of programs (VSL=€5.250 mill., s.e. 1.030 mill., δ=7.1%), (4) using only the two responses to the last pair of programs (VSL=€5.780 mill., s.e. 1.390 mill., δ=8.4%), (5) dropping the responses to questions about plans with cost equal to €50 or €100 (VSL=5.141 mill., s.e. 1.371 mill., δ=6.6%), (6) excluding people who exhibited preference reversals (5,736 obs., VSL=€5.160 mill., s.e. 0.745 mill., δ=7.4%), (7) excluding people who failed the mathematical/cognitive quiz (5792 obs, VSL=€5.250 mill., s.e. 0.750 mill., δ=7.2%, and (8) excluding those who exhibited a "reversal" and those who failed the cognitive quiz (5,296 obs, VSL=€4.870 mill., s.e. 0.740 mill., δ=7.2%). The VSL does fall a bit if we (9) exclude the responses to questions where one or both of the plan cost €950, the largest bid used in this survey. The purpose of (2), (3), (4), (6), (7) and (8) is to check for possible learning, fatigue or other survey response effects that might alter the preferences for income and risk reduction over the course of the survey, and possible "anchoring" effects to the cost of the program (see Carlsson and Martinsson 2006, for a discussion of the potential of such effects in conjoint choice experiments, and Ladenburg and Olsen 2006, for an empirical investigation).

reduction occurring 20 years from now is equivalent to an immediate, one-time risk reduction of 0.2272 in a million.

As a second example, consider a program that delivers an annual risk reduction of ten in a million, and begins in 2 years. If the risk reduction were to continue for 10 years, the typical respondent's one-time WTP would be €340. This would increase to €502 if the duration of the program doubled, €579 if it lasted 30 years, €616 if it lasted 40 years, and €626 if it lasted 45 years. Clearly, the WTP is less than proportional to the duration of the program (and to total nominal—undiscounted—risk reduction).

3.5 The effect of individual characteristics

The results from the model with individual-specific marginal utilities of risk reduction, income and discount rates are displayed in Table 8. We remind the reader that these results refer to Eq. 9, which posits that the VSL is "individuated" (Sunstein 2004), but constant with respect to the size of the population living in the areas with the sites that would be affected by the hypothetical policy.

Table 8 presents two alternative specifications. In both specifications the low-income dummy takes on a value of 1 if the respondent's income is below the sample average, and zero otherwise. Clearly, in both specifications people with income below the sample average have a higher marginal utility of income, which is consistent with prescriptions from economic theory.[14]

Turning to the marginal utility of risk reductions, Table 8, specification (A), shows that males value risk reductions more highly, all else the same, but that having a college degree does not imply a statistically different marginal utility of risk reductions. Likewise, the α coefficients on age group dummies are insignificant.

In our sample men and women were just as likely to have a college degree and had similar household incomes and ages, so the positive coefficient on the male dummy is unlikely to be an econometric artifact due to correlation between gender and other individual characteristics. If respondents replaced the baseline pre-remediation risks stated to them in the surveys with their perceived risks, and the latter were higher for males, then males might place a higher value on risk reductions.

However, earlier literature on risk perceptions has found that males tend to have a *lower* dread of certain risks (including cancer) and that dread correlates well with perceived exposure (Savage 1993). Davidson and Freudenburg (1996) found that for most environmental risks, except for those associated with nuclear or radioactive waste (not covered in this survey), men and women have similar risk perceptions. Hakes and Viscusi (2004) found that men's estimates of the number of deaths for certain causes in the U.S. are *higher* than women's for more frequent causes of death, including heart diseases and cancer.

If Hakes and Viscusi's findings are applicable to Italian men, this would imply, if anything, that men might overstate the competing risks of death (i.e., the risk of

[14] We experimented with different ways of constructing the low income dummies (for example, a low-income person is one with annual household income less than €15,000, which corresponds to about a quarter of the sample), and found that the results are qualitatively robust to these changes.

Table 8 Non-linear conditional logit with individual-specific marginal utility of risk reduction, income and discount rate

Variable	Specification (A)		Specification (B)	
	Coefficient	*t* stat.	Coefficient	*t* stat.
Marginal utility of DR				
α_1	0.003704	3.168	0.003753	3.243
Aware of nearby contaminated site (dummy)	−0.00092	−2.271	−0.00097	−2.271
Important to reduce health risks from cont. sites (dummy)	−0.00199	−2.559	−0.00033	−0.658
College degree (dummy)	−0.00038	−0.764	0.000416	1.146
Aware of nearby contaminated site that has been cleaned up (dummy)	0.000433	1.206	−0.00207	−1.623
Age 55 and older (dummy)	−0.00137	−1.194	−0.00175	−1.307
Age 45–54 (dummy)	−0.00111	−0.976	−0.00296	−2.348
Age 35–44 (dummy)	−0.00178	−1.469	0.002212	2.617
Male (dummy)	0.002868	3.314	0.003753	3.243
Policies based on fencing off cont. sites and preventing access very helpful (dummy)	−0.00102	−2.485		
Government remediation of orphan sites very helpful (dummy)	0.001959	3.704		
A family member has or has had cancer (dummy)	0.002955	2.800	0.003762	3.038
Uses seatbelts when in the back seat of car (dummy)	0.002242	5.221	0.002149	4.982
Marginal utility of income				
β (marginal utility of income)	0.00063	6.122	0.00062	6.080
$\beta\times$Dummy equal to 1 if household income is below sample average	0.00044	3.865	0.00044	3.822
Discount rate				
δ	0.091449	5.326	0.075871	4.714
Children younger than 15 (dummy)	−0.00988	−1.988	−0.00566	−1.074
Married (dummy)	0.010502	1.972	0.006053	1.079
In strong agreement that remediation should be as permanent as possible even if it costs more (dummy)	−0.0351	−4.130		
Favorable to cleanup even if benefits are experienced 30 or more years from now (dummy)	0.005837	1.253		
Respondent thought only of future generations in answering the conjoint choice questions (dummy)	−0.0066	−0.834		
Male (dummy)	0.017756	1.672	0.006907	0.591
Age 55 and older (dummy)	−0.01859	−1.282	−0.02219	−1.345
Age 45–54 (dummy)	−0.02879	−2.003	−0.0319	−1.832
Age 35–44 (dummy)	−0.02214	−1.399	−0.03768	−2.312
A family member has or has had cancer (dummy)	0.025818	2.164	0.035177	2.646

dying for all causes other than those associated with contaminated site exposures), which would *reduce*, not raise, their VSL for the mortality risks valued here (Eeckhoudt and Hammitt 2001). Given the ages and relative good health of the people we survey, this effect would, however, be small. We speculate that men have a higher WTP for a given risk reduction simply because they feel freer than women in (hypothetically) committing household resources. This speculation is corroborated by the fact that 44% of the women in our sample are homemakers.

Surprisingly, persons who told us they knew about contaminated sites in their neighborhood or near their workplace and persons who care about the health effects of exposure to contaminants appear to value risk reductions *less* than the other respondents. Perhaps the former effect is due to the fact that familiarity with contaminated sites reduces the perceived severity of risk. Alternatively, it is possible that people may have self-selected into areas with contaminated sites, so that the negative sign captures the fact that people living close to such sites are less bothered by their presence. We do not have a good explanation for why people who worry about the health risks of contaminants should value risk reductions less highly.[15] At any rate, both effects are sizeable: They lower the VSL by €0.850 million and €1.860 million for a respondent with relatively low income.

We conjectured that acceptance of government contaminated site remediation programs should affect the marginal utility of risk reductions, and ultimately the WTP for the program, and indeed these expectations are borne out in the data. Respondents who believe that the government should take care of orphan sites value the risk reductions and the program more highly than the other respondents, whereas people who deem it "very useful" to fence and prohibit access to contaminated sites are willing to pay less, all else the same. Perhaps doing so is judged sufficient to reduce risks, so that no additional long-term remediation is deemed necessary. For a lower-income person, holding such an opinion lowers the VSL by €0.950 million.

Finally, respondents whose family members have had cancer and respondents who profess to use seatbelts when they travel in the back seat of a car—which we interpret as indicating concern about mortality risks—value risk reductions more highly. The corresponding increases in WTP for a less wealthy person are €2.76 million and €2.09 million, respectively.

Regarding the determinants of the personal discount rates, we find that, all else the same, discount rates are 1 percentage point lower for persons with young children, 1 percentage point higher for married persons, and almost 3 percentage points lower among people of ages 45–54. They are also 1.8 percentage points higher for males, but this effect is statistically significant only at the 10% significance level, whereas the abovelisted associations are all significant at the 5% level or better.

That people are internally consistent is confirmed by the fact that the discount rate is 3.5 percentage points lower for those persons who strongly agree with the statement that remediation should be as permanent as possible, even if it costs more. By contrast, the coefficient on a dummy capturing whether the respondent favors remediation even if its benefits are experienced 30 or more years from now and that on a dummy capturing sole concern for future generations as a driver of the responses to the conjoint choice questions are not statistically significant. Finally, people whose family members have had cancer tend to have significantly higher discount rates (by about 2.6 percentage points).

In specification (B), we re-estimate the model after dropping all variables capturing the subjectively assessed effectiveness of the policy, opinions on policy priorities and survey debriefs. This specification thus focuses on individual characteristics of the respondents, plus knowledge of contaminated sites and concern for cancer and road safety. This specification confirms that people's marginal utility

[15] We conjectured that such a negative coefficient might reflect the negative correlation between importance given to the health effects of exposure and the educational attainment of the respondent, but found that the correlation coefficient between the former variable and having a college degree is very low (−0.07). We conclude that this is an unlikely explanation.

of risk reductions, and thus the WTP for a marginal risk reduction, is lower among people that are aware of contaminated sites and announce that they are very concerned about them. As in (A), males, people with family members with cancer and persons who use a seatbelt when riding in the back seat of a car value risk reductions more highly. This time, however, age does matter, in that the marginal utility of risk reduction is significantly lower among younger respondents. The results in terms of the determinants of the discount rate are similar to those for specification (A).

4 Discussion and conclusions

We have deployed conjoint choice questions to investigate the tradeoffs people are prepared to make between income and mortality risk reductions delivered by contaminated site remediation programs. Our survey questionnaire was designed to investigate the value that people place on permanent risk reductions, and to assess the effect of lag (or latency), i.e., people pay now, but the risk reduction is incurred in the future. The questionnaire was self-administered using the computer by residents of four Italian cities with serious contaminated site problems.

We find that people *are* willing to pay for permanence, but not just *any* price. We estimate the VSL for an immediate risk reduction over the current year to be about €5.6 million, a figure that does not vary significantly with the size of the population that would be affected by the policy, suggesting that people's preferences were driven primarily by *individual* risks, rather than the expected *number* of lives saved by the hypothetical policy. Taken together with the evidence that the number of years over which the risk reductions would be realized matters, this suggests that people's preferences appear to be similar to the target risk reduction practice of environmental protection agencies in the U.S. and (more recently) Italy, which emphasize *individual lifetime* risks.

The VSL obtained in this study—€5.6 million—is in the ballpark of the values of a statistical case of cancer derived by Gayer et al. (2000, 2002) under alternate assumptions about how individuals form and update their priors about risks. Specifically, Gayer et al. (2000) find that a reduction of individual cancer risk by 1.81E-06 after the Remedial Investigation results in an implied value of a statistical case of cancer between \$3.9 and \$4.6 million. Assuming that the conditional mortality for cancer is 70% (see below) and adjusting to 2005 dollars yields a VSL of \$6.7–\$7.9 million.

Our estimate—€5.6 million—is also very close to the VSL figure (\$6.1 million, 1999 dollars) used by the U.S. EPA in its policy analyses (U.S. Environmental Protection Agency 2000) and higher than that used by the European Commission (whether or not a 40% cancer premium is added).[16] Our €5.6 million lies on the high end of the range of VSL found by Alberini and Chiabai (2007) in a previous CV study of Italians, where attention was restricted to the risk of dying for cardiovascular and respiratory causes, the risk reduction was private and there was no mention of environmental circumstances.

[16] See http://europa.eu.int/comm/environment/enveco/others/recommended_interim_values.pdf.

However, the VSL is lower if the risk reduction occurs in the future. Since people discount future risk reductions at a rate of 7.41%, for a risk reduction occurring exactly 20 years from now, for example, we estimate our respondents' VSL to be only €1.27 million.

We find evidence that the VSL *is* individuated, in that it depends on observable individual characteristics, either directly (e.g., age and gender) or via the marginal utility of income. It also depends on familiarity with contaminated sites, concern about the health effects of exposure to contaminants, and direct experience with cancer. In the broader specification of the econometric model, the VSL also depends on what the respondent thinks the goals of a remediation program should be, and on which government actions he or she deems appropriate.

The results of this study could be used in benefit-cost analyses of Superfund-like programs.We perform an illustrative benefit-cost analysis for a 43-hectare operating unit within the broader NPL site at Marghera, near Venice, Italy. In this operating unit—a former industrial waste dump owned by the City of Venice—soil and groundwater are heavily contaminated with PAHs, heavy metals, and many other toxicants (Patassini et al. 2003, 2005).

We focus on contaminated soil, restrict attention to capping (the least permanent of remedies) and to excavation and removal of soil (the most permanent and expensive), and assume reuse for residential purposes. Based on Patassini et al.'s estimate of excess lifetime cancer risks (4.78E-03) and a conservative assumption of 70% conditional mortality,[17] the annual mortality risk for residents is 4.54E-05. Assuming that risk reductions would begin 10 years from now and that the exposed population is 30,000 (Regione del Veneto and Comune di Venezia 2004), a permanent remedy like excavation and removal of the contaminated soil would require at least an 87% risk reduction for the mortality benefits to exceed the cost of remediation (€45.589 million).[18] By contrast, capping, which is estimated to cost about €5 million, results in positive net benefits even for 20% reductions from the baseline risk, even if the lifetime of the cap was only 10 years.

Of course, these are conservative estimates of the benefits of cleanup that omit other categories of benefits and other portions of the NPL site. Yet, they sound a common theme with Gayer et al. (2000), whose upper bound measure of welfare benefits of $10.1 million for reducing cancer risks is smaller than EPA's estimated total costs of remediation for the areas of investigation ($56.8 million). By contrast, less permanent measures such as fencing and deed restrictions cost about $5.4 million and result in positive net benefits.

Acknowledgments This research was supported by funding from CO.RI.LA and MIUR PRIN Grant 2005134530_002. We wish to thank seminar participants at the U.S. Environmental Protection Agency, FEEM Venice, the 3rd World Congress of Environmental and Resource Economists, Douglas Noonan and two anonymous reviewers for their comments and suggestions on earlier drafts of this paper.

[17] This rate is for the 1980s, the most recent period for which estimates are available (see http://www.istitutotumori.mi.it/menuistituto/diparclinici/epidemiologia, and Verdecchia et al. 2001).

[18] These calculations assume that the risk reductions would last 45 years. Patassini et al. suggest that excavation and removal of the contaminated soil affords a 95% risk reduction. This would imply benefits for €49 million, whereas the cost of the remedy is €45 million.

Appendix

Example of a conjoint choice question

Public Programs

Recall, every year
243 people out of 1,000,000
$\left(\frac{243}{1{,}000{,}000}\right)$
die for causes due to exposure to contaminants at contaminated sites

The table below shows two government programs, A and B, addressing contaminated sites. These programs are guaranteed to be effective and to save lives.

As you can see, each program has different effects and saves a different number of lives. Please choose the one you prefer.

Program features	**Program A**	**Program B**
Number of lives saved every year in 1,000,000 people	10 in 1,000,000 $\left(\frac{10}{1{,}000{,}000}\right)$	10 in 1,000,000 $\left(\frac{10}{1{,}000{,}000}\right)$
Population: the number of people living in the areas with the targeted contaminated sites	1,000,000	2,000,000
Delay: the number of years before the risk reduction begins	2 years	2 years
One-time tax payment: amount of tax household will have to pay for the remediation program	50 euro	100 euro
Duration: number of years over which lives are saved	20 years	20 years

16. Which program would you choose between A and B?
A ❑ **B ❑**

17. If you could choose between A, B or neither program, which would you choose?

A ❑ **B ❑** **NEITHER ❑**

References

Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici (APAT). (2004). "Metodologie, Tecniche e Procedure per il Supporto degli Interventi di Valorizzazione dei Siti Inquinati," Rome, June.

Alberini, Anna, and Aline Chiabai. (2007). "Urban Environmental Health and Sensitive Populations: How Much Are the Italians Willing to Pay to Reduce Their Risks?" *Regional Science and Urban Economics* 37(2), 239–258.

Alberini, Anna, Maureen Cropper, Alan Krupnick and Nathalie Simon. (2006a). "Willingness to Pay for Risk Reduction: Does Latency Matter?" *Journal of Risk and Uncertainty* 32(3), 231–245.

Alberini, Anna, Stefania Tonin, Margherita Turvani, and Aline Chiabai. (2006b). “Paying for Permanence: Public Preferences for Contaminated Site Cleanup,” *FEEM working paper 113.06*, Milan, Italy, September.
Andersson, Henrik. (2005). “The Value of Safety as Revealed in the Swedish Car Market: An Application of the Hedonic Pricing Approach,” *Journal of Risk and Uncertainty* 30(3), 211–239.
Banca d’Italia. (2006). “I bilanci delle famiglie italiane nell’anno 2004,” *Supplementi al Bollettino statistico anno XVI*, no. 7, Rome, January.
Blomquist, Glenn. (1979). “Value of Life Saving: Implications of Consumption Activity,” *The Journal of Political Economy* 87(3), 540–558.
Carlsson, Fredrik, and Peter Martinsson. (2006). “How Much is Too Much? An Investigation of the Effect of Number of Choice Sets, Starting Point and the Choice of Bid Vectors in Choice Experiments,” *Working papers in Economics 191*. Sweden: Göteborg University.
Chilton, Susan, Judith Covey, Lorraine Hopkins, Michael Jones-Lee, Graham Loomes, Nick Pidgeon, and Anne Spencer. (2002). “Public Perceptions of Risk and Preference-based Values of Safety,” *Journal of Risk and Uncertainty* 25(3), 211–232.
Cropper, Maureen L., Sema K. Aydede, and Paul R. Portney. (1991). “Discounting Human Lives,” *American Journal of Agricultural Economics* 73(5), 1410–1415.
Cropper, Maureen L., Sema K. Aydede, and Paul R. Portney. (1992). “Rates of Time Preference for Saving Lives,” *American Journal of Agricultural Economics* 82(2), 469–472.
Davidson, Debra J., and Wiluam R. Freudenburg. (1996). “Gender and Environmental Concerns: A Review and Analysis of Available Research,” *Environmental Behavior* 28, 302–339.
DeShazo, J.R., and Trudy A. Cameron. (2005). “The Effect of Health Status on Willingness to Pay for Morbidity and Mortality Risk Reductions,” *California Center for Population Research On-line Working Paper Series*, CCPR-050-05.
Eeckhoudt, Louis R., and James K. Hammitt. (2001). “Background Risks and the Value of a Statistical Life,” *Journal of Risk and Uncertainty* 23(3), 261–279.
Fischhoff, Baruch, Paul Slovic, Sarah Lichtenstein, Stephen Read and Barbara Combs. (1978). “How Safe is Safe Enough? A Psychometric Study of Attitudes towards Technological Risks and Benefits,” *Policy Sciences* 9, 127–152.
Gayer, Ted, James T. Hamilton, and W. Kip Viscusi. (2000). “Private Values of Risk Tradeoffs at Superfund Sites: Housing Market Evidence on Learning About Risks,” *Review of Economics and Statistics* 82(3), 439–451.
Gayer, Ted, James T. Hamilton, and W. Kip Viscusi. (2002). “The Market Value of Reducing Cancer Risk: Hedonic Housing Prices with Changing Information,” *Southern Economic Journal* 69(2), 266–289.
Gazzetta Ufficiale. (1997). “Decreto Legislativo 5 febbraio 1997, N. 22, Attuazione delle direttive 91/156/CEE sui rifiuti, 91/689/CEE sui rifiuti pericolosi e 94/62/CE sugli imballaggi e sui rifiuti di imballaggio,” *Supplemento Ordinario n. 33*, Rome, 15 February.
Gazzetta Ufficiale. (2006). “Decreto Legislativo 3 aprile 2006, n. 152, Norme in materia ambientale, N. 88,” *Supplemento Ordinario N. 96*, Rome, 14 April.
Gupta, Shreekant, George van Houtven, and Maureen Cropper. (1996). “Paying for Permanence: An Economic Analysis of EPA’s Cleanup Decisions at Superfund Sites,” *RAND Journal of Economics* 27(3), 563–582.
Hakes, Jahn Karl, and W. Kip Viscusi. (2004). “Dead Reckoning: Demographic Determinants of the Accuracy of Mortality Risk Perceptions,” *Risk Analysis* 24(3), 651–664.
Hammitt, James K., and Jin-Tan Liu. (2004). “Effects of Disease Type and Latency on the Value of Mortality Risk,” *The Journal of Risk and Uncertainty* 28(1), 73–95.
Hanley, Nick, Susana Mourato, and Robert E. Wright. (2001). “Choice Modelling Approaches: A Superior Alternative for Environmental Valuation?” *Journal of Economic Surveys* 15(3), 435–462.
Horowitz, John K., and Richard T. Carson. (1990). “Discounting Statistical Lives,” *Journal of Risk and Uncertainty* 3, 403–413.
Itaoka, Kenshi, Aya Saito, Alan Krupnick, Wiktor Adamowicz and Taketoshi Taniguchi. (2006). “The Effect of Risk Characteristics on the Willingness to Pay for Mortality Risk Reductions from Electric Power Generation,” *Environmental and Resource Economics* 33(3), 371–398.
Ladenburg, Jacob, and Søren Bøye Olsen. (2006). “Gender Specific Starting Point Bias in Choice Experiments: Evidence from an Empirical Study,” *Frederiksberg, Denmark: The Royal Veterinary and Agricultural University* (draft manuscript).
Legambiente. (2005). “La chimera delle bonifiche,” http://www.legambiente.com/documenti/2005/0510_dossier_bonifiche/La_chimera_delle_bonifiche.pdf (accessed January 31, 2006).
Martuzzi, Marco, Francesco Mitis, Aannibale Biggeri, Benedetto Terracini, and Roberto Bertollini. (2002). “Ambiente e stato di salute nella popolazione delle aree ad alto rischio di crisi ambientale in Italia,” *Epidemiologia e Prevenzione* 26(6), 1–56.

McDaniels, Timothy L., Mark S. Kamlet, and Gregory W. Fischer. (1992). "Risk Perception and the Value of Safety," *Risk Analysis* 12, 495–503.

Meyer, Peter B. (2000). "Looking at State Voluntary Cleanup Programs in Perspective: Liability Relief, Flexible Cleanup Standards and Institutional Controls as Forms of Economic Development Subsidies," *Working Paper*, Center for Environmental Policy and Management, University of Louisville.

Mitis, Francesco, Marco Martuzzi, Annibale Biggeri, Roberto Bertollini, and Benedetto Terracini. (2005). "Industrial Activities in Sites at High Environmental Risk and Their Impact on the Health of the Population," *International Journal of Occupational and Environmental Health* 11, 88–95.

Moore, Michael J., and W. Kip Viscusi. (1990). "Models for Estimating Discount Rates for Long-term Health Risks Using Labor Market Data," *Journal of Risk and Uncertainty* 3, 381–401.

Patassini, Domenico, Paola Cossettini, Enrico De Polignol, Markus Hedorfer, and Enrico Rinaldi. (2003). "El.Gi.R.A. Una procedura di aiuto alla conoscenza nelle aree di bonifica di Porto Marghera (Venezia)." Paper presented at a FEEM seminar, http://www.iuav.it/Didattica1/pagine-web/facolt–di2/Domenico-P/ricerca/Bonifiche-/slide_ELGIRA.pdf (accessed July 31, 2006).

Patassini, Domenico, Paola Cossettini, Enrico De Polignol, Markus Hedorfer, and Enrico Rinaldi. (2005). "ELGIRA: Support System for Knowledge Building and Evaluation in Brownfield Redevelopment." In CORILA (ed.), *Scientific Research and Safeguarding of Venice*, Research Programme 2001–2003, Volume III, CORILA, Venice, 5–20.

Regione del Veneto and Comune di Venezia. (2004). "Master Plan per la bonifica dei siti inquinati di Porto Marghera," http://www.regione.veneto.it/NR/rdonlyres/408958E0-542A-4227-9CF9-46025D51DBDF/0/134.pdf (accessed August 2, 2006).

Revesz, Richard L., and Richard B. Stewart. (1995). "The Superfund Debate," In Richard L. Revesz and Richard B. Stewart (eds.), Analyzing Superfund: Economics, Science, and Law. Washington, DC: Resources for the Future.

Savage, Ian. (1993). "Demographic Influences on Risk Perceptions," *Risk Analysis* 13(4), 413–420.

Sunstein, Cass R. (2004). "Are Poor People Worth Less than Rich People? Disaggregating the Value of a Statistical Life," *AEI-Brookings Joint Center for Regulatory Studies Working paper 04-05*, Washington, DC, January.

Tsuge, Takahiro, Atsuo Kishimoto, and Kenji Tekeuchi. (2005). "A Choice Experiment to the Valuation of Mortality," *Journal of Risk and Uncertainty* 31(1), 73–95.

U.S. Environmental Protection Agency. (1989). *Risk Assessment Guidance for Superfund*, Washington, DC: Office of Solid Waste and Emergency Response 9285.701A.

U.S. Environmental Protection Agency. (1991). *Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions*, Washington, DC: Office of Solid Waste and Emergency Response 9355.30.

U.S. Environmental Protection Agency. (2000). *Guidelines for Preparing Economic Analyses*, EPA 240-R-00-003, Washington, DC: September.

U.S. Environmental Protection Agency. (2003). *Arsenic in Drinking Water: Cessation Lag Model*, EPA 815-R-03-008, Office of Water, Washington, DC: January.

U.S. General Accounting Office. (1997). *Superfund: State Voluntary Programs Provide Incentives to Encourage Cleanups*, GAO/RCED-97-66, Washington, DC: April.

Vassanadumrongdee, Sujitra, and Shunji Matsuoka. (2005). "Risk Perceptions and Value of a Statistical Life for Air Pollution and Traffic Accidents: Evidence from Bangkok, Thailand," *Journal of Risk and Uncertainty* 30(3), 261–287.

Verdecchia, Arduino, Angela Mariotto, Riccardo Capocaccia, Gemma Gatta, Andrea Micheli, Milena Sant, and Franco Berrino. (2001). "Incidence and Prevalence of all Cancerous Diseases in Italy: Trends and Implications," *European Journal of Cancer* 37, 1149–1157.

Viscusi, W. Kip. (1993). "The Value of Risks to Life and Health," *Journal of Economic Literature* 31(4), 1912–1946.

Viscusi, W. Kip, and Joseph E. Aldy. (2003). "The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World," *Journal of Risk and Uncertainty* 27(1), 5–76.

Viscusi, W. Kip, and James T. Hamilton. (1999). "Are Risk Regulators Rational? Evidence from Hazardous Waste Cleanup Decisions," *American Economic Review* 89(4), 1010–1027.

Viscusi, W. Kip, Wesley A. Magat, and Joel Huber. (1991). "Pricing Environmental Health Risks: Survey Assessments of Risk–risk and Risk–dollar Tradeoffs for Chronic Bronchitis," *Journal of Environmental Economics and Management* 21, 32–51.

Walker, Katherine D., March Sadowitz, and John D. Graham. (1995). "Confronting Superfund Mythology: The Case of Risk Assessment and Management." In Richard L. Revesz and Richard B. Stewart (eds.), *Analyzing Superfund: Economics, Science and Law*. Washington, DC: Resources for the Future.