Fondazione Eni Enrico Mattei

NOTA DI LAVORO

86.2010

The Benefits of Contaminated Site Cleanup Revisited: The Case of Naples and Caserta, Italy

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SUSTAINABLE DEVELOPMENT Series
Editor: Carlo Carraro

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Summary

Guerriero and Cairns (2009) recently estimate that contaminated sites and improper waste management result in 848 excess deaths per year in the provinces of Naples and Caserta in Southern Italy, 403 of which are fatal cancers. In the absence of estimates of the Value of a Prevented Fatality (VPF) in Italy or specific to the hazardous waste context, they use figures recommended by DG-Environment. Contrary to their claims, estimates of the VPF *are* available for Italy that are specific to the hazardous waste context, and for causes of death that have been linked to contaminated site exposures. We review them in this paper. We also produce new estimates of the cancer VPF using data from a recent survey conducted in Milan, Italy, in late November to mid-December 2008. The evidence points to much higher VPF figures than the ones used by Guerriero and Cairns, and hence to much larger estimates of the reduced mortality benefits of remediating the hazardous waste in the Naples and Caserta areas. We also examine the importance of the discount rates, since the mortality benefits of remediation begin in 20 years and are assumed to continue over 30 years.

Keywords: Value of a Prevented Fatality, Stated Preferences, Hazardous Waste Sites, Contaminated Sites, Cancer, Mortality Benefits, Cost-Benefit Analysis

JEL Classification: I18, J17, K32, Q51, Q53

The 2008 survey in Italy was conducted as part of the VERHI-Children Research Program, funded by the European Commission, SSPE-CT-2005-6529, http://www.oecd.org/site/0,3407,en_21571361_36146795_1_1_1_1_1,00.html.

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June 2010

Abstract. Guerriero and Cairns (2009) recently estimate that contaminated sites and improper waste management result in 848 excess deaths per year in the provinces of Naples and Caserta in Southern Italy, 403 of which are fatal cancers. In the absence of estimates of the Value of a Prevented Fatality (VPF) in Italy or specific to the hazardous waste context, they use figures recommended by DG-Environment. Contrary to their claims, estimates of the VPF *are* available for Italy that are specific to the hazardous waste context, and for causes of death that have been linked to contaminated site exposures. We review them in this paper. We also produce new estimates of the cancer VPF using data from a recent survey conducted in Milan, Italy, in late November to mid-December 2008. The evidence points to much higher VPF figures than the ones used by Guerriero and Cairns, and hence to much larger estimates of the reduced mortality benefits of remediating the hazardous waste in the Naples and Caserta areas. We also examine the importance of the discount rates, since the mortality benefits of remediation begin in 20 years and are assumed to continue over 30 years.

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); Q53 (Air Pollution; Water Pollution; Noise; Hazardous Waste; Solid Waste; Recycling)

Keywords: Value of a Prevented Fatality, stated preferences, hazardous waste sites, contaminated sites, cancer, mortality benefits, cost-benefit analysis.

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1. Introduction and Motivation

A recent analysis by Guerriero and Cairns (2009) estimates the number of deaths, including the number of fatal cases of cancer, attributable to improper landfilling of municipal solid waste and illegal disposal of hazardous waste in the Provinces of Naples and Caserta in Southern Italy. To calculate the (avoided) mortality benefits of policies that address the uncontrolled disposal of wastes, Guerriero and Cairns apply a willingness-to-pay (WTP) based approach, using the Value of a Prevented Fatality (VPF) combined with assumptions about latency, the horizon over which the risk reductions delivered by the policy would take place, and the discount rate.

Guerriero and Cairns write that "the WTP approach has not been used to estimate the VPF in Italy, nor in the context of waste exposure," and so they use the VPF suggested by the European Commission-DG Environment for benefit-cost analysis purposes—both the "generic" VPF as well as the one specific for cancer deaths.

Contrary to the claims by Guerriero and Cairns, a number of original studies are available for Italy that estimate the VPF or related metrics using the WTP approach. One of these studies (Alberini et al., 2007) is specific to the hazardous wastes and contaminated sites context, focuses on fatal illnesses, and is based on a survey of residents of Naples and other cities in Italy. The VPF is estimated to be €5.6 million euro (2006 euro). In another study (Alberini and Chiabai, 2007a, 2007b) attention is restricted to cardiovascular disease, which has been linked with heavy metal exposures. Finally, Alberini and Scasny (2009, 2010) deploy stated preference methods to estimate the VPF when the cause of death is cancer.[1] We model the data from this most recent survey and estimate the cancer VPF to be €4.2 million (2008 euro).

Using the figures from these studies, we recalculate the benefits of addressing improper landfilling and uncontrolled hazardous waste disposal in the Provinces of Naples and Caserta, and show that the earlier Guerriero and Cairns analysis vastly underestimated the mortality benefits of remediation. The context- and cancer-specific VPF figures for Italy are at least twice as large as the figures recommended by DG-Environment, and are the reason why we obtain much higher mortality benefits. This questions the use of one-for-all European Union-wide VPF estimates.

Since the benefits of remediation are incurred several years into the future and continue over a relatively long time horizon, they depend crucially on the choice of the discount rate. The European Commission generally uses a discount rate of 4% in its policy analyses, but the Italy-based and context-specific studies we selected for the purposes of this paper were able to infer individual discount rates from the tradeoffs between immediate payments and future risk reductions made by survey respondents. These are generally low and very close to zero. The only exception is the Alberini et al. 2007 study, where the respondents' discount rate was 7.41%. Only in this scenario are our mortality benefits estimates and those in Guerriero and Cairns close, with a partial overlap between our 95% confidence interval and their low-to-high range.

The remainder of this paper is organized as follows. Section 2 presents the relevant concepts and metrics, discusses reasons for the existence of a "cancer premium," and reviews the relevant literature. Section 3 reviews the VPF estimates for Italy specific to hazardous waste

[1] Were it possible to estimate the number of cases of cancer (fatal *and* non-fatal) attributable to contaminated site exposures, we would avail ourselves of the results in Tonin et al. (2009), who elicit the value of a statistical case of cancer in a contaminated site/hazardous waste context, to estimate the benefits of eliminating uncontrolled carcinogenic wastes.

situations. Section 4 presents VPF estimates specific for cancer from a recent conjoint choice survey we did in Milan, Italy. Section 5 presents benefits calculations, and section 6 concludes.

2. Background: The VPF and the Cancer Premium

A. What is the VPF?

Willingness to Pay (WTP) is defined as the maximum amount that can be subtracted from an individual's income to keep his or her expected utility unchanged while obtaining a specified quantity of a good. To derive the WTP for a mortality risk reduction, let U(*y*) denote the utility from consumption of *y* when the individual is alive. Further let R denote the risk of dying in the current period, and V(*y*) the utility of consumption when dead. Expected utility is expressed as EU=(1-R)·U(*y*)+R·V(*y*). This expression is simplified to EU=(1-R)·U(*y*) if it is further assumed that the utility of income is zero when the individual is dead.

The VPF is a summary measure of the WTP for a mortality risk reduction, and a key input into the calculation of the benefits of policies that save lives.[2] The mortality benefits are computed as VPF×L, where L is the expected number of lives saved by the policy.

The VPF is the marginal value of a reduction in the risk of dying, and is therefore defined as the rate at which the people are prepared to trade off income for a risk reduction, holding utility constant:

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

where R is the risk of dying.[3] The VPF can equivalently be described as the total WTP by a group of N people experiencing a uniform reduction of 1/N in their risk of dying. To illustrate,

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[2] By "saving lives" we mean "reducing premature mortality."

consider a group of 10,000 individuals, and assume that each of them is willing to pay €30 to reduce his, or her, own risk of dying by 1 in 10,000. The VPF implied by this WTP is €30/0.0001, or €300,000.

The concept of VPF 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. As shown in the above example, in practice an approximation to the VPF is often computed by first estimating the WTP for a specified risk reduction ΔR, and then by dividing WTP by ΔR.

B. Estimates of the VPF

People do not trade mortality risks in marketplaces, and so it is necessary to use non-market methods to estimate the VPF. One approach is to observe the compensation required by workers for them to accept riskier jobs (Viscusi, 1993, Viscusi and Aldy, 2003; Aldy and Viscusi, 2007). Despite econometric difficulties and recent evidence questioning the interpretation of the results from compensating wage studies (Black and Kniesner, 2003; Hintermann et al., 2008), the VPF figures currently used by the US Environmental Protection Agency in its environmental policy analyses reflect primarily this approach (US EPA, 2000). Alternatively, it is possible to infer the VPF by observing the expenditures incurred by people to reduce their risks of dying in an accident (e.g. Jenkins et al., 2001) or the prices of vehicles with additional safety features (Andersson, 2005). Finally, in contingent valuation surveys and other types of stated-preference studies individuals are asked to report information about their WTP for a hypothetical risk reduction that is specified to them in the course of a survey.

[3] In an expected utility framework with expected utility $EU=(1-R)\cdot U(y)$, the VPF can be expressed as $VPF=U(y)/[(1-R)\cdot U'(y)]$.

Many observers question whether the VPF in an accidental death context should be applied when the cause of death is cancer, especially when cancer is caused by environmental exposures. Cancer is usually delayed with respect to environmental exposures, is associated with suffering and pain, and is highly dreaded (see Starr, 1969; Fischhoff et al., 1978, Slovic, 1987; and Chilton et al., 2006), which is often taken to imply that the VPF should be greater when the cause of death is cancer (e.g., Jones-Lee et al., 1985; McDaniels et al., 1992, and Savage, 1993).

In policy practice, the ExternE project considered the use of a cancer premium for fatal outcomes due to heavy metals and radionuclides; the 2005 update of the methodology (European Commission, 2005) suggested a 50% premium for fatal cancer. A similar cancer premium was adopted by DG-Environment (2001).

What empirical evidence is there that people are prepared to pay more to reduce the risk of dying of cancer than the risk of dying for other causes? Surprisingly little, Magat et al. (1996) find that the median survey participant was indifferent between reducing the risk of terminal lymph cancer and reducing the risk of automobile death, implying that the VPF for the former is the same as that for the latter. Hammitt and Liu (2004) elicit WTP for reductions in the risks of acute and latent cancer and non-cancer illnesses affecting the lung or the liver. WTP to reduce cancer risks is about 40% larger than WTP to reduce a risk of a similar chronic, degenerative disease (with a VPF of around $2.1 million for acute lung cancer, or of $1.5 million for acute lung non-cancer). However, the coefficient for the cancer dummy was significant only at the 10 percent level. More recently, Tsuge et al. (2005) conduct conjoint choice experiments and conclude that it is unnecessary to adjust the VSL according to the differences in the type of risk, if the VSL is calculated by using an “adequate approach.”

3. Earlier Estimates of the VPF for Italy

In this section, we review a number of studies that match closely the context studied by Guerriero and Cairns in at least two of the following four criteria: they i) estimate the VPF directly from the potential beneficiaries of mortality risk reductions using surveys, ii) were conducted in Italy, iii) present scenarios that entail hazardous waste sites, or iv) value reductions in the risk of dying from causes that have been linked with hazardous waste exposures.

Alberini et al. (2006) conduct a contingent valuation survey in several Italian cities that elicits the WTP for a reduction in the risk of dying of either 1 or 5 in 1000 over 10 years. The risk reduction covers any cause of death, and is delivered by an unspecified "product" and an abstract scenario (see Krupnick et al., 2002; and Alberini et al., 2004). The VPF is €1.022 million or €2.264 million (2002 euro), depending on whether median or mean WTP is used.[4]

Alberini and Chiabai (2007a, 2007b) survey individuals in five cities in Italy (Venice, Milan, Genoa, Rome and Bari) in late May 2004. Their survey instrument is similar to that in Alberini et al. (2006), but focuses on the risk of dying for cardiovascular causes, and a greater range of risk reductions is used (up to 12 in 1000 over 10 years). Independent samples of respondents consider either a hypothetical preventive medical intervention (or diagnostic test) or a completely abstract risk reduction. For a risk reduction of 1 in 10000 a year—which is close to the annual mortality risks attributable to uncontrolled wastes by Guerriero and Cairns for the Naples and Caserta areas—the VPF for cardiovascular disease for persons aged 30-49 is €2.282 million (if median WTP is used) or €4.865 million (if mean WTP is used).[5] Alberini and Chiabai further ask people to report information about their WTP now for a future risk reduction, and

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[4] The VPF is computed as median (or mean) WTP divided by the size of the risk reduction.
[5] For comparison, for persons aged 60-69 the VPF is €1.160 million or €2.475 million. For persons in this age group who already have a cardiovascular condition, the VPF is €1.625 million or €3.465 million, depending on whether median or mean WTP is used, respectively.

estimate the discount rate implicit in people's responses, which is 0.3-1.7%, depending on whether different WTP responses within the same individuals are allowed to be correlated or modeled as statistically independent.

The VPFs described above may apply to many of the deaths associated with toxic wastes (e.g., because of exposure to heavy metals), but we feel that the study that is closest to the needs of the Guerriero and Cairns analysis is Alberini et al. (2007). Alberini et el. use conjoint choice experiments, where respondents selected from the general public are asked to indicate which out of K (K≥2) hypothetical risk reduction programs they prefer.

The alternatives are stylized public programs that would address uncontrolled hazardous waste sites (including poorly managed landfills, industrial plants, etc.) and are described by five attributes. These are i) the annual risk reduction, expressed as the number of lives saved in a million, ii) the size of the population that would benefit from this risk reduction (0.5, 1 and 2 million), iii) the latency period until the risk reductions begin (2 or 10 years), iv) the years over which the risk reductions would be experienced (T=20, 30, 40 and 45), and v) the cost of the policy to the respondent's household, which would be incurred immediately and paid one time only.

In the first choice task, the respondent must indicate which he prefers out of two hypothetical programs that differ in the level of two or more attributes, so K=2. The respondent is then asked to choose between the same two programs and the option to do nothing (=pay nothing, get no risk reduction), in which case K=3. This sequence is repeated for total of 5 times, with different pairs of hypothetical government programs.

Alberini et al. estimate the VPF to be €5.580 million (standard error around the VPF €0.771 million) for an immediate risk reduction. Since the discount rate implicit in the respondents' choices is estimated to be 7.41%, it follows that the VPF would be only €2.660 million if the latency period is 10 years, €1.260 million if the latency period is 20 years, and €0.604 million if the latency period is 30 years. The survey respondents were residents of the cities of Venice, Milan, Naples and Bari, all of which have several contaminated sites, some of which are severe enough to be on the Italian National Priorities List for publicly funded cleanup. No differences in the taste for risk reduction and income were detected across these cities, which suggests that the estimate of the VPF from this study can be applied to the Guerriero and Cairns analysis.

Tonin et al. (2009) estimate the Value of a Statistical Case of Cancer (VSCC) or Value of Preventing a Case of Cancer, namely the willingness to pay for a marginal change in the risk of developing cancer (which may or may not be fatal). They deploy conjoint choice experiments, and the sample of respondents is selected among the residents living within specified distances of a major Superfund site in Italy, the Marghera chemical complex, which is on the mainland side of Venice. The VSCC is €2.612 million (standard error €0.274 million), is highest among those respondents who live closest to the contaminated sites, and increases with income. This figure could be combined with cancer risk assessment studies or estimates of the excess cancer risks in the exposed population from epidemiological studies, but these are in short supply for the locales studied in Guerriero and Cairns.

4. A New Survey about the Value of a Prevented Cancer Fatality

In late November to mid-December 2008, we conducted a survey of residents of Milan, Italy (see Alberini and Scasny, 2009) and asked them to engage in several conjoint choice tasks. Half of the respondents were to assume that the alternatives in these choice tasks would apply to them, and the other half that they would apply to one of their children (selected at random from the respondent's children). The attributes we used to describe the hypothetical alternatives were i) the size of the mortality risk reduction, ii) the cause of death to which the risk reduction applies (cancer, respiratory illnesses, road traffic accidents), iii) whether the risk reduction would be delivered by a public program or would be privately undertaken, iv) latency (0, 2, 5 and 10 years), and v) a one-time cost to the respondent, to be incurred now. The questionnaire was self-administered by the respondents using the computer, and resulted in a total of 1906 completed questionnaires.

In what follows, attention is restricted to the subsample of respondents who valued cancer risk reductions in the first two screens of the conjoint choice portion of the interview. To model the responses to the choice questions in these first two screens, we rely on a random utility framework, which posits that the respondent's indirect utility is:

(2) $$\overline{V_{ij}} = \alpha \cdot DR_{ij} + \beta \cdot (y_i - C_{ij}),$$

where DR is the discounted risk reduction (see below), α is the marginal utility of a unit of risk reduction, β is the marginal utility of income, (y-C) is residual income since C is the cost of alternative j, and subscripts i and j denote the individual and the alternative, respectively.

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

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

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. Evidence reported in Alberini and Scasny (2009, 2010) shows that in this study the respondents held a discount rate virtually equal to zero, so the indirect utility in (2) is simplified to

(4) $$\overline{V}_{ij} = \alpha \cdot \Delta R_{ij} + \beta \cdot (y_i - C_{ij}) \, .$$

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:

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

In each conjoint choice experiment question, the respondent is asked to examine K≥2 alternatives and to indicate the most preferred option.[6] We assume that the respondent will choose the one with the highest indirect utility. If we further posit that the error terms in (5) are i.i.d. and follow a standard type I extreme value distribution, the probability that the respondent chooses alternative k is:

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

Expression (6), where we have omitted the subscript i to avoid notational clutter, is the contribution to the likelihood of a conditional logit model (see Train, 2003).

Once maximum likelihood estimates of parameters α, β, and δ are obtained, we can use them to compute the VPF. Specifically, the VPF is estimated as $VPF = (\hat{\alpha} / \hat{\beta}) \times 10{,}000$. In other words, the VPF is the marginal utility of a unit of mortality risk reduction, converted into euro through division by the marginal utility of income.[7] Equations (2)-(6) assume that the VPF is

[6] Half of the sample was assigned to a variant of the questionnaire such that the respondent first had to choose between alternative A and alternative B (a "forced choice" question), followed by another choice question where he had to indicate whether he preferred A, B or the status quo (no risk reduction, no payment). The other half of the sample received a "one shot" question—A, B or the status quo? As a consequence, 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.

[7] Multiplication by 10,000 is necessary because in our computer programs we express the risk reduction as, say, 3 or 4 (in 10,000) instead of 0.0003 or 0.0004.

constant for all individuals in the sample, but the model is easily amended by entering interactions between the risk reduction and individual characteristics of the respondent, so that we can check whether respondent characteristics, perceptions of risk and attitudes affect the VPF. We also allow for random coefficients (see the Appendix).

Estimation results are presented in table 1. Columns (A) and (B) mirror equation (4), but differ in that (A) uses the entire sample, whereas (B) uses the responses from those individuals who were to value their own risk reductions (as opposed to risk reductions for one of their children). Column (C) enters an interaction between risk reduction and a "public program" dummy to see if that changes the VPF, and column (D) enters interactions between risk reduction and individual characteristics, risk perceptions and attitudes. The econometric model is a conditional logit in columns (A)-(D), and a mixed logit in column (E) where we allow for selected coefficients to be random variables in an effort to capture heterogeneity in taste among our respondents.

Table 1. Estimation results. Conditional logit and mixed logit models of the responses to the conjoint choice questions.

VARIABLES	VARIABLE DEFINITION	(A)	(B)	(C)	(D)	(E)
reduction	reduction in mortality risk	0.2116*** (0.016)	0.2047*** (0.022)	0.1989*** (0.016)	0.1325*** (0.034)	0.1321*** (0.043)
rpublic	risk reduction × public initiative			0.0476*** (0.013)	-0.1524*** (0.044)	-0.2867*** (0.089)
rgenetic	risk reduction × predisposition to developing cancer				0.0269 (0.030)	0.0371 (0.040)
rfamily	risk reduction × a family member has or has had cancer				0.0167 (0.025)	0.0128 (0.032)
rchild	risk reduction × reduction is for the respondent's child				0.0025 (0.022)	0.0015 (0.028)
rsalience	risk reduction × respondent has cancer				0.0908* (0.049)	0.1258** (0.063)
rfriends	risk reduction × someone close to you has cancer				0.0269 (0.023)	0.0491 (0.030)
rallfamilies	risk reduction × someone in most families gets cancer				0.0008 (0.024)	-0.0127 (0.031)
rsmoker	risk reduction × smoker				-0.0113 (0.028)	0.0727 (0.062)
rsmokcanc	risk reduction × smoking causes cancer				0.0459 (0.029)	0.0719* (0.038)
rpubleff	risk reduction × public initiative × public program effective (1=not effective, 5=very effective)				0.0556*** (0.012)	0.1063*** (0.027)
cost	One-time cost to household	-0.0005*** (0.000)	-0.0005*** (0.000)	-0.0005*** (0.000)	-0.0005*** (0.000)	-0.0007*** (0.000)
Std Dev rpubleff	Standard deviation of the coefficient on rpubeff					0.1494*** (0.018)
Std Dev rsmoker	Standard deviation of the coefficient on rsmoker					0.4192*** (0.081)
Observations		5102	2565	5102	5060	5060

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Col. (B): Subsample of respondents who value an own risk reduction.

The results generally indicate that the responses to the conjoint choice questions are internally valid. As shown in table 1, the coefficient on the risk reduction is always positive and significant, and that on the cost of the program negative and significant, as expected.[8] The estimates in column (A), which are based on the entire sample, imply that the cancer VPF is €4.164 million, with a standard error of €0.276 million (2008 euro). Since the risk reductions in this sample are for children and adults, in column (B) we present estimation results when the sample is restricted to those who valued own (adult) risk reductions only. The VPF is virtually the same (€4.252 million, standard error of €0.420 million).[9]

As shown in column (C), people value cancer risk reductions more when they are delivered by a public program. The cancer VPF is about €0.950 million higher when the risk reduction comes from a public program. In columns (D) and (E), however, we show that people value public risk reductions more *only* when they believe that public programs are "effective" at reducing cancer (where by "effective" we mean at least 4 on a scale from 1 to 5, where 1=not effective at all and 5=very effective).

Turning to individual circumstances that might affect the perceived risk of developing cancer, columns (D) and (E) show that thinking that cancer runs in the family, having a family member (parent, grandparent, sibling) who has or has had cancer, and valuing risk reductions for one's child does not influence the VPF.

We measure salience as i) whether the respondent has or has had cancer, and/or ii) has been hospitalized or taken to the emergency room for it. An interaction between risk reduction and the salience dummy suggest that persons who have first-hand experience with cancer hold a much higher VPF than the others (by almost €2 million), but the coefficient on this interaction is estimated imprecisely and is significant only at the 10% level. Another possible measure of

[8] The coefficient on cost is the negative of the marginal utility of income, which of course is positive.

[9] This result is confirmed by a run (not reported) in which we entered an interaction between the risk reduction and a dummy indicating whether the respondent valued the risk reduction for himself. The coefficient on the latter was virtually zero and insignificant at the conventional levels.

experience and familiarity with cancer is whether a spouse or a close friend has had cancer, and this is likewise associated with a higher VPF (about €0.400 million more) but this effect is insignificant at the conventional levels. Smokers also are not statistically different from non-smokers, but it is interesting that the coefficient on the interaction between risk reduction and being a smoker is negative (in other words, smokers appear to be more tolerant of cancer risks).

We also wished to check if agreement with the statement that "there will be a case of cancer in almost all families" (i.e., that cancer is very widespread) influences the VPF, but we find no evidence of such an association. Agreement with the statement that "Smoking is one of the major causes of cancer" tends to be associated with a higher VPF (about €0.800 million), although the effect is not significant.

We experimented with letting different coefficients be random variates, and in the end we settled for treating as such that on [risk reduction × effectiveness rating of public programs] and that on [risk reduction × being a smoker]. We posited that these coefficients follow independent normal distributions. The results in column (E) of table 1 show that there is indeed heterogeneity across respondents in the marginal utilities of these interactions, since the estimated standard deviations of these marginal utilities are significant. All other coefficients, however, are treated as fixed and their estimates are similar to their counterparts in column (D).

5. Benefits in the Naples and Caserta Provinces

Guerriero and Cairns (2009) estimate a total of 848 lives lost every year in the Provinces of Naples and Caserta because of exposure to uncontrolled hazardous wastes. Out of these, 403 are cancer deaths. Table 2 reports their estimates of the benefits that would be incurred if these excess risks were eliminated (through cleanup and better waste disposal practices in the future).

Their VPF figures are taken straight out of DG-Environment (2001) and simply updated to 2007 euro. For any fatal illness, they use a central VPF of €1.4 million, and low and high values of €0.95 million and €3.7 million, respectively (2007 euro). For fatal cancer, they apply a 50% premium, which results in VPF figures equal to €2.1 million (central estimate), €1.42 (low) and €5.55 million (high), respectively. They further assume a latency period of 20 years, that the risk reductions would occur for 30 years thereafter, and that the discount rate is 0.04, the official discount rate used by the European Commission in its policy analyses.

Table 2. Mortality benefits of eliminating exposures to uncontrolled wastes in the provinces of Naples and Caserta. Source: Guerriero and Cairns (2009). 2007 euro.

	Lives lost attributed to waste per year	benefits (billion euro) (central estimate of the VSL)	benefits (billion euro) (lower bound)	benefits (billion euro) (upper bound)
all causes mortality	848	9.4	6.3	25
all fatal cancers	403	6.7	4.5	17
all cause mortality adjusted for cancer premium	848	11.6	7.8	30.4

We begin our re-calculation of the mortality benefits of cleanup and proper waste management in the provinces of Naples and Caserta by selecting the appropriate Italy-based and context-appropriate VPF figures, which we display in table 3. Specifically, we select the VPF for a 30-39-year old from the Alberini-Chiabai studies because this would seem the age group that would be most likely to be affected if the (physical) risk reduction benefits begin in 20 year and continue for 30 years thereafter. Since this VPF is for cardiovascular illness, we will use it only in the calculations that do not distinguish for cancer deaths. We also select the Alberini et al.

(2007) estimates, which are well suited for all fatal illnesses associated with contaminated sites, including cancer. Our final VPF selection, which is specific for cancer deaths, is the one from the new study described in this paper.

Table 3. Italy- and cancer/waste-specific VPF figures for computing the mortality benefits of cleanup and improved waste management.

Reference	context and cause of death	VPF (mill. euro)	s.e. around VPF (mill. euro)	95% lower bound	95% upper bound	euro year	discount rate
A. Alberini and Chiabai (2007a,2007b)	cardiovascular illness, 30-49 year old now	2.282	Not avail.	Not avail.	Not avail.	2004	0.003
B. Alberini et al. (2007)	all fatal illnesses associated with contaminated site exposures	5.580	0.771	4.069	7.091	2006	0.074
C. This paper	VPF for cancer, no specific context	4.164	0.276	3.623	4.704	2008	0.000

Table 4. Mortality benefits of cleanup and waste management (billion euro).

	Mortality Benefits (central value)						
latency=20 years, duration=30 years	Guerriero and Cairns (2007 euro)	A. Alberini and Chiabai (2004 euro)		B. Alberini et al. (2006 euro)		C. This paper (2008 euro)	
	d=0.04	d=0.04	d=0.003	d=0.04	d=0.0741	d=0.04	d=0
all causes mortality (N=848)	9.4	15.191	52.285	37.144	12.936	n/a	n/a
all fatal cancers (N=403)	6.7	n/a	n/a	n/a	n/a	13.171	50.337
all cause mortality adjusted for cancer premium	11.6	n/a	n/a	37.144	12.936	n/a	n/a

n/a = not applicable.

Table 4 reports the mortality benefits of cleanup and improved waste management based on the Italy- and waste/cancer-specific values listed in table 3. The benefits are based on the formula:

(7) $$B = N \cdot VPF \cdot e^{-\delta \cdot L} \cdot \frac{1-e^{-\delta \cdot T}}{\delta},$$

where N is the number of deaths avoided, L is latency (here set to 20 years), T is the duration of the risk reduction in years (here, T=30 years). If δ=0, the benefits are simplified to $B = N \cdot VPF \cdot T$.

To avoid clutter, we only report central values in table 4. Regarding the discount rate, we use both the discount rate used by the European Commission (4%) as well as the respondents' discount rates as estimated in the three studies listed in table 3.

The results of this exercise show clearly that when Italy- and waste- or cancer-specific VPF figures are used, the benefits are generally larger than those computed by Guerriero and Cairns, because the VPFs we use are all greater than the €1.4 million (all fatal illnesses) or €2.1 million (cancer) recommended by DG-Environment and adopted by those authors. This highlights the importance of using estimates of the VPF that match the area and the context closely.

The only case in table 4 where the benefits are close to the Guerriero and Cairns figures is when we use the Alberini et al. (2007) study, and we use the discount rate exhibited by respondents in that study, which is about 7%. Indeed, the 95% confidence interval around this estimate of the benefits overlaps with the low-to-high range of benefits in Guerriero and Cairns.[10]

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[10] Since calculating the value of (7) from the Alberini et al. (2007) study requires the marginal utilities of risk reduction and income, and the discount rate estimated from that study, and these estimates are correlated, we used the original maximum likelihood estimation routine, and a simulation procedure based on 20000 replications to compute the standard errors around (7). The standard error around (6) is €1.480 billion (2006 euro), which means that the 95% confidence interval around the point estimate of the benefits lies between €10.03 billion and €15.84 billion.

6. Conclusions

We have reviewed recent studies that estimate the VPF for cancer or other causes of death that have been linked with exposures to waste or contaminated sites in Italy. We also presented new estimates based on the data collected in a recent study that focused on the effect of cause of death on the VPF (including cancer) (Alberini and Scasny, 2009; Alberini and Scasny, 2010) and was conducted in Italy. The evidence points to higher VPFs than the ones suggested for fatal illnesses and fatal cancers by DG-Environment (2001). When we use these Italy- and context-specific VPFs to re-calculate the mortality benefits of cleanup and better waste management in the provinces of Naples and Caserta (previously quantified by Guerriero and Cairns), we obtain much higher benefits figures.

We recognize that this exercise does not change the conclusions in Guerriero and Cairns that the mortality benefits in that area greatly exceed the costs of remediation. However, it is important to realize that the VPF figures recommended by DG-Environment are usually 50% or less than the estimates of the VPF for chronic conditions (e.g. cardiovascular illnesses), cancer and for all (chronic) causes of death associated with exposures to hazardous wastes that were estimated using survey-based approaches in Italy. At other locales in Italy where the cost of remediation is higher than in the Naples and Caserta areas, using the locale- and context-appropriate VPF figures might entirely change the outcome of the cost-benefit analysis.

Since the benefits of remediation of contaminated sites begin in the future, even if cleanup is done now, and continues over a long time horizon, the mortality benefits depend crucially on the choice of the discount rate. The European Commission uses a discount rate of 4%. The previous studies we reviewed in this paper and the new survey we use to obtain a cancer VPF all were able to infer the beneficiaries' own discount rate by observing the tradeoffs between immediate payments and future risk reductions. These respondent-based estimates of the discount rate range from 0% to 7.41%, and have a potentially important effect on the estimates of the mortality benefits of remediation.

In this paper, we applied the estimates of the VPF from recent, context-relevant studies in Italy to estimate the benefits of remediation and treatment of hazardous waste sites in the Provinces of Naples and Caserta. These very same VPF figures could also be used to estimate the monetized benefits of regulations that reduce the risk of industrial accidents where carcinogens are released into the environment (Pesatori et al., 2009) or that impose higher emission standards on hazardous or solid waste incinerators (Zambon et al., 2007).

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Appendix. Mixed logit models.

Let $\boldsymbol{\theta}$ denote the vector of the coefficients in equation (4) (or the coefficients in an augmented version of this model that includes interactions between risk reduction and public program indicators or respondent characteristics). To introduce the mixed logit model, we replace $\boldsymbol{\theta}$ in equation (4) with $\boldsymbol{\theta}_i$ where $\boldsymbol{\theta}_i$ is respondent *i*'s vector of coefficients. If the distribution of each $\boldsymbol{\theta}_i$ is described by a common multivariate density function $f(\boldsymbol{\theta})$, the unconditional probability of observing the sequence of responses exhibited by respondent i is P_i, where P_i is

(A.1) $$P_i = \int \ldots \int \prod_t \left[\frac{\exp(\mathbf{w}_{it}\boldsymbol{\theta}_i)}{\sum_{j=1}^{K_m} \exp(\mathbf{w}_{ij}\boldsymbol{\theta}_i)} \right] f(\boldsymbol{\theta}_i) d\boldsymbol{\theta}_i ,$$

and $\mathbf{w}_{it}$ denotes the attributes of the alternative that was selected by the respondent in choice occasion *t*. The log likelihood function is now:

(A.2) $$\log L = \sum_{i=1}^{n} \log P_i .$$

Density $f(\boldsymbol{\theta})$ can be specified so that only some, but not all, of the marginal utilities are treated as random variables. For example, we posit that the marginal utility of income as a fixed (but unknown) constant. In specification (E) of table 1 in the paper only two coefficients are treated as random variables, and the remainder are regarded as fixed. Mixed logit does not impose a restrictive substitution pattern, and caters to situations where some people view an attribute as desirable and others regard it as unattractive (see Henscher and Greene, 2003).

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(lxxxvi) *This paper was presented at the Conference on "Urban and Regional Economics" organised by the Centre for Economic Policy Research (CEPR) and FEEM, held in Milan on 12-13 October 2009.*

(lxxxvii) *This paper was presented at the Conference on "Economics of Culture, Institutions and Crime" organised by SUS.DIV, FEEM, University of Padua and CEPR, held in Milan on 20-22 January 2010.*

(lxxxviii) *This paper was presented at the International Workshop on "The Social Dimension of Adaptation to Climate Change", jointly organized by the International Center for Climate Governance, Centro Euro-Mediterraneo per i Cambiamenti Climatici and Fondazione Eni Enrico Mattei, held in Venice, 18-19 February 2010.*