Urban Environmental Health and Sensitive Populations: How Much are the Italians Willing to Pay to Reduce Their Risks?

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Summary

We use contingent valuation to elicit WTP for a reduction in the risk of dying for cardiovascular and respiratory causes, the most important causes of premature mortality associated with heat wave and air pollution, among the Italian public. The purpose of this study is three-fold. First, we obtain WTP and VSL figures that can be applied when estimating the benefits of heat advisories, other policies that reduce the mortality effects of extreme heat, and environmental policies that reduce the risk of dying for cardiovascular and respiratory causes. Second, our experimental study design allows us to examine the sensitivity of WTP to the size of the risk reduction. Third, we examine whether the WTP of populations that are especially sensitive to extreme heat and air pollution—such as the elderly, those in compromised health, and those living alone and/or physically impaired—is different from that of other individuals. We find that WTP, and hence the VSL, depends on the risk reduction, respondent age (via the baseline risk), and respondent health status. WTP increases with the size of the risk reduction, but is not strictly proportional to it. All else the same, older individuals are willing to pay less for a given risk reduction than younger individuals of comparable characteristics. Poor health, however, tends to raise WTP, so that the appropriate VSL of elderly individuals in poor health may be quite large. Our results support the notion that the VSL is "individuated."

Keywords: Contingent valuation, Willingness to pay, Mortality risk reductions, Value of a statistical life, Scope test, Cardiovascular and respiratory risks, Heat waves, Heat advisories, Adaptation to climate change, Air pollution, Premature mortality

JEL Classification: Q51, Q54

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I. Introduction and Background

The 2001 Intergovernmental Panel on Climate Change (IPPC) report warns that an increase in the frequency and/or intensity of heat waves will raise heat-related premature mortality, primarily among the elderly and the urban poor, with the largest increases in thermal stresses occurring in cities in temperate regions. Urban areas in Europe could, therefore, experience increases in mortality outcomes associated with extremely hot weather.

An unprecedented heat wave affected the European Region during Summer 2003. This heat wave was accompanied by an increase in mortality that started early, rose quickly, and affected primarily the elderly (75 years-old and older), but was also severe within the 45-74 year-old age group.[3] Most of the premature deaths were attributed to cardio- and peripheral vascular, cerebrovascular, and respiratory causes.

Historically, cardiovascular diseases have accounted for 13-90% of the increase in overall mortality during and following a heat wave, while cerebrovascular disease accounted for 6-52%, and respiratory diseases for 0-14% (Kilbourne, 1997). The adverse health effects of heat waves are compounded by the poor air quality that sometimes accompanies them.

[3] Higher than normal mortality rates were observed in France (20% to 130% increase in mortality rates, depending on the region), Portugal (26% percent increase in mortality in August 2003, compared to the average of the previous five years), Spain (6% increase in total mortality), and Italy (15% increase in mortality for all causes over the Summer mortality figures for 2001 and 2002) (Alberini and Menne, 2003). In Italy, the authorities estimate that 34,071 people over the age of 65 died during the period of July 16 to

Air pollution is, of course, another major concern for urban areas. A raft of epidemiological studies documents both short-term spikes in mortality during high pollution episodes and long-term effects of exposures to elevated levels of fine particular matter, ozone, nitrogen oxides, and sulfur dioxide. Kunzli et al. (2000), for example, estimate that for the combined population of France, Austria and Switzerland some 40,000 deaths per year are attributable to fine particulate matter, and Samet et al. (2000) estimate 20 to 200 lives lost each day in US cities because of polluted air.

Because air pollution has been linked to cardiovascular and respiratory effects, susceptible populations include children and fetuses, persons with cardiovascular illnesses, asthma, emphysema and chronic obstructive pulmonary disease, and the elderly (World Health Organization, 2002). Epidemiological evidence from the US (Pope et al., 1995) indicates that over 75% of the lives saved by the Clean Air Act are those of persons 65 years old and older.

The European Union and many European countries are currently adopting policies to reduce these mortality effects. Regarding extreme heat, a survey of European countries (cCASHh Research Team, 2005) reveals that while only the city of Lisbon had a heat advisory program in place by 2002, other countries began to implement similar programs in response to the 2003 heat wave. Other possible policies include the creation of green islands within urban areas, retrofitting buildings, establishing climate-controlled shelters for the population, and emergency response plans. Regarding air quality, the recent Clean Air for Europe (CAFE) initiative emphasizes reductions in emissions from stationary and mobile sources.

August 15. This is 4,175 more than during the same period in the previous year. See http://www.cbsnews.com/stories/2003/09/11/world/main572686.shtml.

Economists would recommend that, when setting these policies, at least some consideration be given to their costs and benefits. Ebi et al. (2004) do a complete benefit-cost analysis of the Philadelphia heat warning system. They use time-series mortality data to identify the reduction in mortality associated with the system (an estimated 117 lives saved over 3 years), and multiply this figure by an estimate of the Value of a Statistical Life (VSL). The resulting mortality benefits are then compared with the cost of the system, showing that the former greatly exceed the latter. The VSL figures prominently in the cost-benefit analysis of CAFE (Hurley et al., 2005), despite the considerable controversy surrounding the mortality effects.[4]

The VSL can be estimated through a variety of methods. One method is to observe the additional compensation that workers must be offered for them to accept riskier jobs (Viscusi, 1993). The VSL figures resulting from compensating wage studies are frequently transferred to the environmental policy context (US EPA, 2000), even though, without further documentation, there is no particular reason to believe that workers should exhibit the same preferences for income and risk as the beneficiaries of environmental and thermal stress adaptation policies (e.g., the elderly).

In principle, it is possible to estimate the VSL using hedonic regressions that relate housing prices and wages to climate (Moore, 1998; Maddison and Bigano, 2003) or air quality (Portney, 1981), but doing so requires rather restrictive assumptions. An alternative is to use contingent valuation, a survey-based approach that asks individuals to report directly their willingness to pay (WTP) for a specified reduction in their own risk of dying. The VSL is then approximated as $\text{WTP}/\Delta R$, where ΔR is the risk

[4] There is much disagreement over whether the impacts should be expressed in terms of counts of deaths attributable to pollution or loss of life years spread over the population. See Rabl (2004) for a critical

reduction. One advantage of using the contingent valuation (CV) method is that respondents can be informed about their mortality risks and be told exactly the extent of the risk reduction they are to value. In addition, a CV study can be tailored to the specific type of risk being considered, a feature that is especially attractive to us, given the dearth of VSL figures specific for the cardiovascular and respiratory risks typical of thermal stresses and the air pollution context.[5]

The goal of this paper is three-fold. First, we present the results of a contingent valuation survey that was administered in Italy for the purpose of obtaining the WTP for reductions in the risk of dying for cardiovascular and respiratory causes. This figure can, therefore, be used to estimate the benefits of policies that save lives that would be lost to thermal stresses, air pollution, and other environmental toxicants (e.g., certain heavy metals, such as lead; see US EPA, 1997). To our knowledge, this is the first such study conducted in Italy.[6]

Second, we examine the issue of scope in a contingent valuation survey about mortality risk reductions. We vary the risk reduction to the respondents, which allows us to test whether the WTP increases with the size of the risk reduction, and, if so, by how much. Economic theory predicts that WTP should be increasing in the size of the risk

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discussion of the inference from ecological studies of populations and prospective cohort studies.

[5] The method of contingent valuation can be and has been used to place a value on public goods, environmental quality, as well as private goods, including episodes of illness and private mortality risk reductions. A recent bibliography (Carson et al., 2002) documents over 5000 papers and articles studying or reporting on applications of the method of contingent valuation.

[6] A previous study by Alberini et al. (2004b) elicits WTP for mortality risk reductions, but does not focus specifically on the risk of dying for cardiovascular and respiratory causes. Due to the small sample size (less than 300 respondents for Italy), Alberini et al. pool data collected in Italy, France and the UK. The recent cost-benefit analysis of the Clean Air for Europe Program (Hurley et al., 2005) declined to produce VSL figures on a country-by-country basis on the grounds that original WTP data were not available and for political considerations. Yet, in the context of morbidity health endpoints commonly associated with air pollution exposures, Ready et al. (2004) show that there may be considerable differences in WTP across European countries that are not explained by mere differences in income or other sample demographics,

reduction. This relationship is dubbed the “scope” effect, and Carson (2000) underscores that credible WTP figures for mortality risk reductions elicited through contingent valuation surveys should satisfy the scope effect requirement. In practice many CV studies fail to detect a significant relationship between WTP and the size of the risk reduction (Hammitt and Graham, 1999), and Corso et al. (2001) explore the possibility that such failure might be due to poor risk communication.

Third, we examine whether the WTP for risk reductions is different for populations that are particularly sensitive to environmental and thermal stresses and are thus the primary beneficiaries of environmental or adaptation policies. We focus on the elderly, those with a compromised cardiovascular system and with serious respiratory conditions, and those that may be unable to cope with thermal stresses because they live alone and/or are physically impaired. We also examine whether persons who take care of an elderly and physically impaired family member are willing to pay more for a reduction in their *own* risks. In other words, does this experience change their preferences for risk and income?

Our findings support the notion that the VSL is “individuated” (Smith and Evans, 2004; Sunstein, 2004): We find that it varies with the size of the risk reduction, age (which we capture into baseline risk) and health status, income, and being a caregiver. For the risk reductions considered in this survey, the VSL ranges from €0.257 million to over €5.8 million, depending on the baseline risk/age of the beneficiary, size of the risk reduction, health status, and statistic used to compute the VSL (median or mean WTP).

which suggests that it is important that European Union-wide figures be corroborated with evidence from the individual countries.

The remainder of this paper is organized as follows. Section II introduces the concept of VSL and discusses its relationship with age, health status and other factors identifying sensitive populations. Section III presents the survey. Section IV presents our econometric models, Section V the data, and Section VI the estimation results. We offer a discussion of the results, two policy applications and our concluding remarks in section VII.

II. The Value of a Statistical Life and its Determinants

A. The Value of a Statistical Life

The VSL 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:

(1) $$VSL = \frac{\partial WTP}{\partial R} \ ,$$

where WTP signifies the willingness to pay for a change in the risk of dying, and R is the risk of dying. The VSL 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, 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 VSL implied by this WTP is €30/0.0001, or €300,000. The concept of VSL 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.

In our contingent valuation survey, we ask individuals to report directly their WTP to reduce their risk of dying for specified causes. The WTP for a given risk reduction ΔR is then converted into an approximation to the VSL: VSL ≈ WTP/ΔR.[7]

B. Sensitive Populations: The Elderly

Deaths linked with environmental exposures and extreme heat occur disproportionately among the elderly. This has led to the question whether the VSL should be adjusted for age. Proponents of such an adjustment argue that the VSL should be lower for older persons because they have a shorter remaining lifetime. To see how this claim compares with economic theory, consider the life cycle model, according to which an individual at age j receives expected utility V_j over the remainder of his lifetime:

(2) $$V_j = \sum_{t=j}^{T} q_{j,t}(1+\rho)^{j-t} U_t(C_t),$$

where V_j is the present value of the utility of consumption in each period, $U_t(C_t)$, times the probability that the individual survives to that period, $q_{j,t}$, discounted to the present at the subjective rate of time preference ρ. T is the maximum lifetime. The specific expression of the budget constraint of the individual depends on the assumptions about opportunities for borrowing and lending. If, for example, it is assumed that the individual

[7] Willingness to pay is defined as the maximum amount that can be subtracted from an individual's income to keep his or her expected utility unchanged. Individuals are assumed to derive well-being, or utility, from the consumption of goods. Let U(y) denote the utility function expressing the level of well-being produced by the level of consumption 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. Under these assumptions, it can be shown that the VSL is equal to U(y)/[(1-R)U'(y)].

can borrow and lend at the riskless rate *r*, but never be a net borrower, and that the individual's wealth constraint is binding only at T, the VSL at age j is equal to:

$$(3) \qquad VSL_j = (1 - D_j)^{-1} \sum_{t=j+1}^{T} q_{j,t} (1+\rho)^{j-t} \frac{U_t(C_t)}{U_t^{'}(C_t)} \ ,$$

where D_j is the probability of dying at age j.[8]

If the term $\frac{U_t(C_t)}{U_t^{'}(C_t)}$ is constant with respect to age, then it can be brought outside of the summation in (3), implying that WTP is proportional to the discounted remaining life years. If, in addition, the discount rate is zero, then WTP for a reduction in the risk of dying is indeed strictly proportional to remaining life years.

In sum, adjusting VSL for age to make it proportional to expected remaining life years relies on two restrictive assumptions: (i) that the utility divided by marginal utility does not vary with age, and (ii) that the discount rate is zero. There is no particular reason to believe that these assumptions should be true in practice. For example, if the marginal utility of consumption increases with age, then it is no longer appropriate to assume that the WTP is proportional to remaining life years.

Shepherd and Zeckhauser (1984) assume that the utility function is of the form C^{β}, and consider (i) the situation where the individual is completely self-sufficient and cannot borrow or lend, and (ii) the extreme opposite—perfect markets—in which individuals can borrow against future earnings and purchase actuarially fair annuities. For plausible values of β, in the former case the WTP for a risk reduction has an inverted-U shape that peaks when the individual is in his 40s, and in the latter it declines monotonically beginning at age 20.

Some empirical support has been found for both predicted relationships. Johannesson et al (1997) find that WTP for a given risk reduction peaks at age 40-50, and is lower among younger and older individuals. Krupnick et al (2002) find that WTP declines (by about 30%) only for the oldest age group in their sample of residents of Hamilton, Ontario, and report of a similar pattern for a national sample of US residents, although in the latter case the effect is not statistically significant. A subsequent application of the Alberini et al. survey instrument in the U.K., France and Italy, found a similar pattern, but once again the effect was not significant (Alberini et al., 2004b).

C. Sensitive Populations: Persons in Poor Health

Equation (3) can be used to examine the value placed on risk reductions by persons with chronic cardiovascular and respiratory illnesses. In equation (3), a person with a chronic illness has a higher probability of dying in his j-th year of age, D, and lower probabilities of surviving to future ages. However, it is not clear how the remaining terms in (3) depend on health status, implying that theory does not offer predictions about the effect of impaired health on the VSL.

Krupnick et al (2002) and Alberini et al. (2004a) find that, if anything, people with chronic cardiovascular and respiratory illnesses are willing to pay slightly *more*, rather than less, to reduce their own risk of dying. It remains to be seen whether this result is borne out in other studies as well.

We are aware of only one CV study that focused on a population who faces an elevated risk of dying for cardiovascular causes: Johannesson et al.'s 1991 survey of

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[8] VSL at age j is defined as the willingness to pay for a marginal change in D_j, the probability of dying at age j.

hypertensive patients.[9] Based on the results of the Johanesson et al.'s study, we would expect people to *be* prepared to pay to reduce their risk of dying for cardiovascular and respiratory causes, especially if they have already being diagnosed to have chronic cardiovascular and respiratory conditions.

D. Other Sensitive Populations

Many of the people that died prematurely in the Chicago 1995 heat wave were persons with mobility impairments, and elderly persons living alone.[10] Lacking air conditioning in their homes, and unable to get out and reach climate-controlled environments (Klinenberg, 2002), these individuals had been in some cases dead for days before worried neighbors called the police. During the heat wave in Europe in Summer 2003, the highest increase in the mortality rates was observed in nursing homes (Alberini and Menne, 2003).

Although our survey does not explicit mention heat waves and the reasons why old people living alone and persons with mobility impairments might be at higher risk during heat waves, we still wish to find out how these people value reducing their risk of dying for cardiovascular and respiratory causes. In addition, we wish to see whether *familiarity* with and being responsible for people that due to age or mobility impairments need assistance on a day-to-day basis influence our respondents' WTP to reduce their own risks.

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[9] Patients with high blood pressure were recruited at a clinic in Sweden. The survey questionnaire asked these persons to report their subjective baseline risk of dying from heart diseases and other complications associated with hypertension, and to estimate the risk reduction afforded by the medication they took on a regular basis. These persons were subsequently asked to report their WTP to continue taking the medication.

[10] For the week between July 14 and 20, 1995, epidemiologists attributed a total of 739 "excess" deaths to the heat wave. The City of Chicago reported 521 heat-related deaths, based on autopsies and police reports.

III. The Survey

A. Cardiovascular and Respiratory Mortality Risk Questionnaire

As mentioned, many environmental and thermal stresses are linked with excess deaths for cardiovascular and respiratory causes. Our questionnaire elicits WTP for reductions in the risk of dying for these causes from a sample of Italian citizens. The risk reduction we ask people to value is of a private nature.[11] Our questionnaire is self-administered by the respondent using the computer. This allows us to tailor risks and scenarios to the respondent's individual circumstances (e.g., age, gender, and health status) and avoids interviewer bias.

B. Structure of the Questionnaire

The questionnaire is divided into seven sections. In section 1, after querying the respondent about gender and age, we ask the respondent if he or she has ever been diagnosed to have certain cardiovascular and respiratory conditions (including high blood pressure, high LDL cholesterol,[12] heart disease, chronic obstructive pulmonary disease, and emphysema) or diabetes. We also ask people to tell us about the health and longevity of other family members, their own current and expected future health, and to what age they expect to live.

In section 2, we ask questions assessing the respondent's health over the last four weeks, as well as any physical mobility limitations and psychological well-being. Our

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[11] By focusing on a private risk reduction, we avoid possible double-counting problems due to the difficulty of recognizing if individuals are motivated by altruistic concerns, and, if so, the specific nature of these altruistic concerns (e.g., paternalistic or non-paternalistic altruism).

[12] This type of cholesterol is commonly dubbed "bad" cholesterol because it can clog arteries, causing a heart attack or a stroke.

questions are adapted from the Short Form 36 (SF36) questionnaire, which is widely used in medical research to assess physical and emotional health.

Section 3 provides a simple probability tutorial, leading to the explanation of one's chance of dying, which is expressed as X in 1000 over 10 years, and is graphically depicted using a grid of 1000 squares.[13] White squares represent survival, while blue squares represent death. Respondents are then tested for probability comprehension. In crafting this section of the questionnaire, we kept in mind that because it is difficult for many people to grasp the concept of risk and to place a value on mortality risk reductions, it is important to communicate risks clearly to the respondents.

In section 4, we acquaint respondents with the concept that it *is* possible to reduce one's risk of dying, and that many people do so on a routine basis. For example, we tell respondents that a pap smear can reduce the risk of dying of cervical cancer (in women) and that blood pressure medication reduces the risk of dying of a heart attack. We then introduce cardiovascular and respiratory illnesses. Respondents can learn more about them by reading a glossary which is accessed by double-clicking a link on the screen. The respondents are then asked questions about any treatments or actions they are currently taking to prevent or cure cardiovascular and respiratory illnesses, and their cost.

In section 5, we present the chance of dying for all causes for a person of the respondent's age, gender, and health status. This is shown using blue squares in the grid

[13] Assuming that the risk reduction is spread evenly over the 10 years, this is equivalent to X in 10,000 a year. As in Alberini et al. (2004a), our initial focus groups revealed that people find the risk reductions more credible when they are presented using a 10-year frame. In addition, the visual aids based on the X in 1000 risk reduction are much clearer than those depicting an X in 10,000 risk.

of 1000 squares. We highlight the chance of dying for cardiovascular and respiratory illnesses using orange squares, emphasizing that these risks increase with age.[14] [15]

Section 6 presents the hypothetical risk reduction scenario. People were offered a risk reduction of X over the next 10 years, where X ranges from 1 to 22, depending on the respondent's age and gender. The extent of the risk reduction was shown visually by green squares on the grid. The experimental design for the baseline risk and risk reduction is displayed in table 1,[16] and an example of a screen presenting the risk reduction to the respondent is shown in Figure 1.[17]

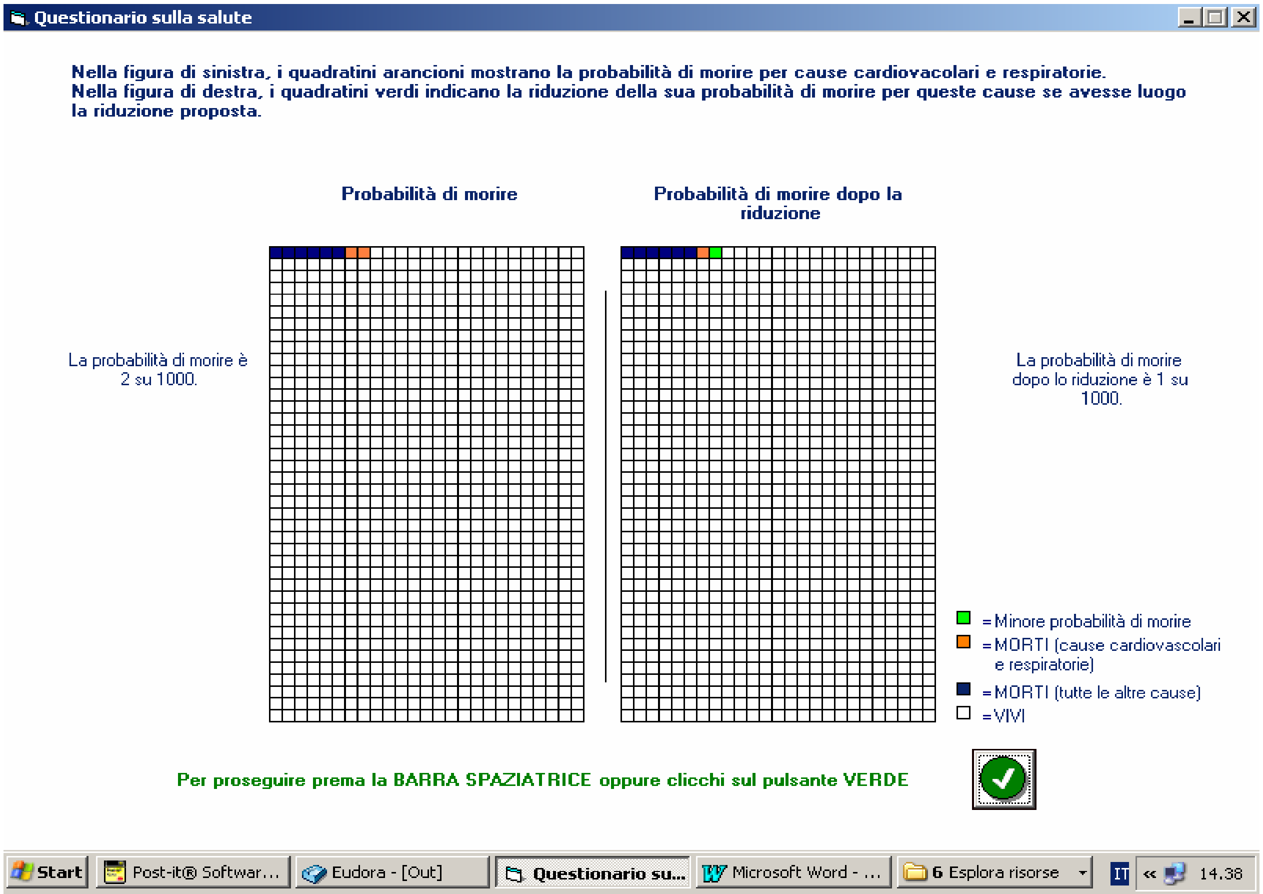
[14] We based our estimate of the respondent's risk of dying for cardiovascular and respiratory causes on age- and gender-specific population mortality. However, respondents were told that the risk was calculated for a person of their same age, gender, and health status undertaking their same preventive actions and/or treatments (if any). The purpose of doing this was to minimize the chance that respondents might think that the baseline risks stated in the questionnaire do not apply to them, which would create a problem of errors-in-variables in our econometric model (Greene, 2003).

[15] The purpose of showing both the risk of dying for all causes and that of dying for cardiovascular and respiratory causes is to make the respondent aware that the latter can be a very small, or a relatively large, share of the former, depending on his or her age and gender.

[16] Table 1 shows that after a certain age, people were randomly assigned to one of two possible risk reductions. Practical considerations dictated that the absolute risk reduction should be greater for older respondents because they have higher baseline risks, although this means that they are given smaller percentage risk reductions than younger people. There are a total of nine different risk reductions, which should allow us to identify the relationship between WTP and risk change. Our experimental design, however, does not allow us to separately identify any additional effect that age may have on WTP above and beyond that already captured into baseline risk.

[17] Respondents were randomly assigned to one of two versions of the questionnaire. In Version 1, they were asked to imagine that a new medical test is available that is safe and without side effects, and delivers the stated risk reduction, but must be done and be paid for every year to be effective. In this variant of the questionnaire, the payment mechanism is a co-pay modeled after the fee for medical tests charged by the Italian national health care system. Version 2 the questionnaire is similar in all respects, except that people are simply asked to imagine that it is possible to reduce their risk by a certain amount, without mentioning any other specifics. Our focus groups indicated that people accepted such an abstract risk reduction, and that with this approach they tended to focus more sharply on the size of the risk reduction, without being distracted by other details. We compare the groups of respondents that received these two "treatments" elsewhere (Alberini, Chiabai and Scasny, 2005).

Figure 1. Presentation of risk reduction in the questionnaire.



(Translation)

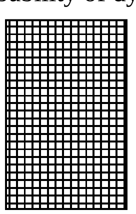
Health Questionnaire.

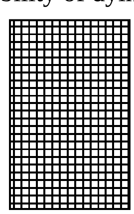
In the grid on the left, the orange squares show your probability of dying for cardiovascular and respiratory causes. In the grid on the right, the green squares show the reduction in your probability of dying for these causes.

Probability of dying

Probability of dying after the risk reduction

The probability of dying (for cardiovascular and respiratory causes) is 2 in 1000





After the risk reduction, the probability of dying (for cardiovascular and respiratory causes) is 1 in 1000

□ = reduction in the probability of dying
□ = dead (for cardiovascular and respiratory causes)
□ = dead (for all other causes)
□ = alive

To continue, press the space bar or click on the green button.

The payment question is in a dichotomous choice format with one or two follow-ups.[18] The bid amounts are shown in table 2. Respondents were randomly assigned to one of these four bid sets.

Table 1. Baseline risks and risk reductions assigned to respondents in the survey.

Males				Females			
Age	Baseline risk (all causes of death)	Baseline risk (cardiovasc and respiratory)	Risk reduction (cardiovasc and respiratory)	Age	Baseline risk (all causes of death)	Baseline risk (cardiovasc and respiratory)	Risk reduction (cardiovasc and respiratory)
30-34	12	2	1	30-34	5	2	1
35-39	15	4	2	35-39	8	2	1
40-44	23	6	3	40-44	13	4	2
45-49	37	11	5	45-49	20	5	2
50-54	62	18	3 or 6	50-54	38	7	3
55-59	105	34	5 or 8	55-59	49	13	4
60-64	177	64	5 or 10	60-64	80	25	4 or 5
65-69	297	122	5 or 12	65-69	138	54	5 or 8
70-74	478	225	12 or 22	70-74	247	118	8 or 12

Table 2. Bid amounts.

initial bid (euro per year)	if yes	if no
110	250	70
250	500	110
500	950	250
950	1200	500

In section 7 of the questionnaire we describe, and elicit WTP for, a risk reduction that takes place X years from now (where X varies with the respondent's age), when the

[18] Respondents who answered "yes" to the first payment question were queried about a higher amount, while respondents who answered "no" to the first payment question were asked whether or not they would purchase the proposed risk reduction for a lower price. When a respondent answered "no" to both the initial payment question and the follow-up question, he or she was asked whether he would pay anything at all to obtain the risk reduction, and, if so, exactly how much.

respondent is older. To make this question meaningful to the respondents, we show them that the chance of dying for any cause and for cardiovascular causes increases as one gets older. This future risk reduction question is reserved for respondents of ages up to 60.

In section 8, we ask questions that investigate the intertemporal rate of preference of the respondent, and his or her aversion to financial risk. Section 9 concludes the survey with the usual socio-demographic questions, and with debriefing questions about the respondent's interpretation of the questions.

We wish to emphasize that climate change or pollution was never mentioned to the respondent in this survey. We chose to do so for two reasons. First, we wished to keep the risk reduction a private good, because it is difficult to identify the altruistic components of WTP, and to account for them appropriately to avoid double-counting. Second, linking risk changes to emissions reductions or adaptation to climate change would require that we educate respondents about them, quantify effects, and address the uncertainty associated with them. In our opinion, doing so would have resulted in an excessively heavy cognitive burden, which prompted us to choose a context-free risk reduction.

C. Sampling Plan and Survey Administration

In addition to extensive one-on-one testing during the questionnaire development work, we pre-tested the final questionnaire in a small pilot study with 20 respondents. The final survey was administered at centralized facilities in five cities in Italy—Venice, Milan, Genoa, Rome and Bari—on 31 May-9 June 2004, resulting in 801 completed questionnaires.

Respondents were recruited from the general population of the residents of those cities aged 30-75. The sample is stratified by age, with an equal number of respondents in each of three broad age groups (30-44, 45-59, and 60-75), and is comprised of a roughly equal number of men and women. We did not tell prospective participants what the exact topic of the survey would be.

IV. Econometric Models

A. Models of Willingness to Pay

In this paper, attention is restricted to the willingness to pay for the risk reduction that begins immediately. Let $V(y, R)$ denote the individual's indirect utility, which depends on income and the risk of dying R. Willingness to pay, WTP^*, is defined as the maximum amount of money that can be taken away from an individual at lower level of risk to keep his utility unchanged. Formally,

(4) $$V(y - WTP^*, R_1 \mid \mathbf{X}) = V(y, R_0 \mid \mathbf{X}),$$

where y is income, R_0 is the baseline risk, R_1 is the risk after the reduction ($R_0 > R_1$, where $R_1 = R_0 - \Delta R$), and $\mathbf{X}$ is a vector of individual characteristics. Willingness to pay should, therefore, depend on the baseline and final risk, income, and individual characteristics:

(5) $$WTP^* = WTP^*(R_0, \Delta R, y, \mathbf{X}).$$

We assume that:

(6) $$WTP_i^* = \exp(\mathbf{x}_i \beta_1) \cdot (R_{0i})^{\beta_2} \cdot (\Delta R_i)^{\beta_3} \cdot \exp(\varepsilon_i)$$

where **x** is a 1×k vector of individual characteristics thought to influence WTP (including income: $\mathbf{x}_i = [\mathbf{X}' \;\vdots\; y]'$), ΔR is the absolute risk change, ε is an error term, and the subscript *i* denotes the respondent. On taking logs, we obtain:

$$\log WTP_i^* = \mathbf{x}_i \boldsymbol{\beta}_1 + \beta_2 \log R_{0i} + \beta_3 \log \Delta R_i + \varepsilon_i \,. \quad (7)$$

In other words, the logarithmic transformation of WTP depends on log baseline risk, log risk change, and other individual characteristics. Since the baseline risk and the risk reduction vary across respondents, their coefficients can be identified in regression equation (7).[19]

We expect β_3 to be positive. The magnitude of this coefficient determines the sensitivity of willingness to pay to scope, i.e., to the size of the risk reduction. If $\beta_3 = 1$, willingness to pay is strictly proportional to the size of the risk reduction (Hammitt and Graham, 1999). All else the same, theory suggests that β_2 should be positive, at least when the baseline risk is large (the "dead anyway" effect; Pratt and Zeckhauser, 1996). In our case, however, due to our experimental design, the effect of baseline risk may be confounded by competing risks (see Eeckhoudt and Hammitt, 2001),[20, 21] and/or offset by the effect of age.

[19] Implicit in this model is the assumption that the elasticity of WTP with respect to the risk change is constant with respect to the baseline risk and to individual characteristics of the respondent. We experimented with including interactions between the risk reduction and individual characteristics of the respondents (e.g., age) but these models gave unreliable results, which we attribute to the experimental design. To keep the risk figures realistic and acceptable to the respondents, we had no choice but to offer larger risk reductions to older people (who also have higher baseline risks). The "ideal" design would have considered all possible combinations of baseline risks and risk reductions, but this was simply not feasible.

[20] Baron (1997) proposes ways of testing whether individuals are affected by the baseline risk and pay attention to relative, in addition to the absolute, risk changes. Also see McDaniel (1992).

[21] Eeckhoudt and Hammitt (2001) examine the effect of competing risks, asking how WTP to reduce a specific cause of death, and the implied VSL, change as the risk of dying for a competing cause changes. They describe the "why bother" effect, whereby an old and chronically ill individual with a large risk of dying for, say, cardiovascular causes would be willing to pay very little, or nothing at all, to reduce his or

B. Estimation Strategy

To estimate equation (7), where WTP^* is the respondent's unobserved willingness to pay, we begin by recognizing that our sample contains a mix of continuous and interval-data observations on willingness to pay. Observations on a continuous scale are contributed by those respondents who answered "no" to both the initial and follow-up payment question, and finally reported an exact WTP amount. All other respondents contribute interval-data observations. For example, suppose that an individual was offered an initial "price" of €250 for risk reduction ΔR_i, which he declined to pay. He was then queried about €110, which he was willing to pay. We interpret this to mean that his true willingness to pay for ΔR_i lies between €110 and €250.

Assuming that WTP^* is a random variate with cdf F(WTP;λ) and pdf f(WTP;λ), where λ is the vector of parameters that index the distribution, the log likelihood function is thus:

$$(8) \qquad \sum_{i=1}^{n} I_i \cdot \log f(WTP_i^*;\lambda) + (1-I_i)\cdot \log\left[F(WTP_{Hi};\lambda) - F(WTP_{Li};\lambda)\right]$$

where I_i is a dummy indicator that takes on a value of one if the respondent reported his WTP amount on a continuous scale, and zero otherwise. WTP_L and WTP_H denote the lower and upper bound of the interval around the respondent's (unobserved) WTP amount. The parameters λ are estimated by the method of maximum likelihood.

We assume that WTP follows the Weibull distribution with shape θ and scale σ_i, where $\sigma_i = \exp(\mathbf{x}_i \boldsymbol{\beta}_1 + \beta_2 \log R_{0i} + \beta_3 \log \Delta R_i)$, which means that ε_i follows the type I

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her risk of dying associated with, say, air pollution exposure. The predictions of their model rest crucially extreme value distribution with scale θ, and that equation (7) is an accelerated-life model. Here, λ is comprised of $\boldsymbol{\beta}_1$, β_2 and β_3. Mean WTP for individual *i* is computed as $\hat{\sigma}_i \cdot \Gamma(1/\hat{\theta}+1)$, where $\Gamma(\bullet)$ is the gamma function, while median WTP is equal to $\hat{\sigma}_i \cdot [-\ln(0.5)]^{1/\hat{\theta}}$, the hats denoting the maximum likelihood estimates. The VSL is estimated as mean (median) WTP, divided by the size of the risk reduction.

C. The Choice of the Independent Variables

In this study, as a result of our experimental design, the effect of age on willingness to pay is captured by the baseline risk, which increases with the respondent's age. To test whether health status influences willingness to pay, we include in the model a dummy (ATRISK) equal to one if the respondent suffers from chronic cardiovascular and respiratory illnesses, is diabetic, has high blood pressure, or has high cholesterol.

Willingness to pay should, all else the same, increase with the respondent's income. We divide household income by the number of family members (PCAPPINC), and enter this variable in the model along with a companion missing income dummy (MISSINC).[22]

Other individual characteristics thought to influence WTP are whether the respondent is married (MARRIED), a dummy denoting whether the respondent has dependent children of ages 12 and younger (CHILDREN12), and a college education dummy (COLLEGE).

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on whether the marginal utility of income when one is dead is zero or positive.

[22] Specifically, we created a dummy, MISSINC, that takes on a value of one if the respondent did not answer the income question. If so, PCAPPINC is recoded to zero. The recoded PCAPPINC and MISSINC must be included in the regression equation together. The coefficient of MISSINC, if significant, captures any systematic differences in VSL among those respondents who do and do not report household income.

Finally, we examine the effect on WTP of physical mobility limitations by using the dummy IMPEDITO and that of being elderly and living alone using the dummy (OLDALONE). The questionnaire asks people whether they take care of a family member or other person who, due to age or physical limitation, needs day-to-day assistance, whether in the respondent's home or elsewhere. For those who do, the dummy HELP takes on a value of one. We include this dummy to check the effect of familiarity with old age, physical limitations and experience as a caregiver. City dummies are included to account for possible differences in the cost of living.

V. The Data

A. Individual Characteristics of the Respondents

Descriptive statistics of our survey respondents are displayed in table 3. As shown in table 3, the sample is relatively well-balanced in terms of gender, with only a slight prevalence of women. The average respondent is 50 years old. Persons aged 65 and older account for 18% of the sample.

Almost 70% of the respondents are married, and 16% have children younger than 12 years of age. Eleven percent of the respondent has a college degree, although only 3.44% of our respondents of ages 65 and older do. Regarding household income, 84% of the respondents answered the income question. The average income among those respondents who did report income information is 21,368 euro a year, which corresponds to an average per household member of €8,513 a year.

The coefficient of PCAPPINC must be interpreted as the effect of income, conditional on knowing what the respondent income is.

We did not find major differences across cities in terms of respondent socio-demographics, with two exceptions. One is income, which is, as expected, highest in Milan and lowest in Bari (the differences across cities being statistically insignificant). The other is college-degree education: The rate is highest in Rome (almost 21%) and lowest in Bari (7.41%).

Table 3. Descriptive statistics of the respondents.

Variable	Valid obs.	Mean	Stand. Devn.	Minimum	Maximum
Male (dummy)	801	0.48	0.50	0	1
Age (years)	801	50.50	13.52	30	77
OLDER65 (dummy)	801	0.18	0.38	0	1
Married (dummy)	801	0.70	0.46	0	1
CHILDREN12 (dummy)	801	0.16	0.37	0	1
College degree (dummy)	801	0.11	0.45	0	1
Household size	801	2.89	1.22	1	7
Household income (euro/yr)	677	21,368	8,624	6,000	60,000

Table 4 reports descriptive statistics about the health status of the sample. About a quarter of the respondents has high blood pressure, 16% has high low-density cholesterol, and serious cardiovascular illnesses are reported by 3-6% of the sample. Emphysema, chronic bronchitis and asthma affect 1 to 9 percent of the sample.

This means that 49% of the sample has been diagnosed to have at least one chronic cardiovascular or respiratory illness (“at risk”). Indeed, 11% of the respondents have been admitted to a hospital in the last 5 years for a cardiovascular or respiratory illness, and 17% have had to go to the emergency room within this time frame for the same reasons. As expected, chronic cardiovascular or respiratory illnesses are more frequently reported by the elderly: 71% of the respondents of age 65 and older have at least one such condition. We found some variation in illness rates across the cities. For example, our Rome-based respondents reported slightly higher rates of chronic illness (measured using the dummy “at risk”) (56% versus 45-47% in the other cities).

Table 4. Health status of the respondents.

Illness or activity	**Percent of the sample**
high blood pressure	25.72
high "bad" cholesterol	16.23
Angina	3.25
heart attack	4.87
Diabetes	7.49
other cardiovascular illness	6.24
Stroke	1.5
Emphysema	1.37
Chronic bronchitis	6.74
Asthma	8.74
At risk for cardiovascular and respiratory causes	49.0
Cancer	2.62
Admitted to hospital in the last 5 years for cardiovascular and respiratory illness	11.24
Went to emergency room in the last 5 years for cardiovascular and respiratory illness	17.24

The sample is comparable to the Italian population at large in terms of composition by gender (males account for 47% of the Italian population) and educational attainment (10.2% of the Italians have a college degree). Because of our age restrictions and quotas, the proportion of married people in the sample is higher than in the population (the latter being about 49%). In terms of health status, this sample reports rates of illness that are very similar to those observed in an earlier study in almost all of the same cities (Alberini et al., 2004b).

Our respondents tend to come from slightly larger households than the population: In the latter, the average household size is 2.69 (Banca d’Italia, 2002), while in our sample it is 2.89. Finally, our sample respondents’ income is somewhat lower than that of the Italian population: In 2002, the average household income among the latter was €27,868, and the average income per household member was roughly €10,000. (This is to be expected, since respondents were asked to take the questionnaire at a centralized facility. Presumably, the likelihood of participating in such a study is higher for persons with lower incomes, more free time, and lower opportunity cost of time.)

The difference with respect to the income population statistics is particularly stark among our respondents of ages 65 and older. For these persons, the average household income in our sample is €14,385, and the income per household member is €7,443, whereas the corresponding statistics for the population in the same age group in 2002 were €20,000 and €12,000, respectively.

Finally, we did a city-by-city comparison between the sample and the population (see table A.1 in the Appendix). This comparison suggests that (i) persons with college-degree education are overrepresented in our Rome sample and underrepresented in Milan and Bari, (ii) only in Genoa does the sample match the population in terms of household size, and (iii) the average household income in the sample is lower than its population counterpart in each city. These findings imply that it is important to control for sociodemographics in our WTP regressions and to use population values for the covariates when making predictions for the population's WTP.

B. Risk Comprehension and Acceptance of Risk

Our questionnaire included two quizzes intended to check whether the respondents had grasped the concept of probability explained in the probability tutorial. The first quiz asks people to indicate which of two people has the higher risk of dying—the person with a 5 in 1000 risk of dying, or the person with the 10 in 1000 risk of dying.

About a quarter of the respondents failed this quiz, but almost eighty percent of those who did promptly corrected their answer when offered the opportunity to do so.

The second quiz asks people which of those two persons they would rather be. About two-thirds of the sample selected the person with the lower risk, 16% chose the person with the higher risk, and the remainder said that they were indifferent. When queried again, less than 5% of the sample (38 people) confirmed that they wished to be the person with the higher risk of dying.

Since our questionnaire presents respondents with the baseline risk of dying for a person like them, it is important to check whether they accepted the baseline risks stated to them in the survey. The responses to a debriefing question at the end of the questionnaire indicate that 27.84% of our respondents felt that the baseline risks stated to them were roughly what they expected, 15.23% thought that they were higher than expected, 11.36% judged them to be lower than expected, and the remainder (45.57%) had no idea what to expect.

C. Responses to the Payment Questions

Our first order of business is to check that the percentage of “yes” responses to the initial payment question declines with the bid amount. As shown in table 5, this is indeed the case, implying that the responses to the payment questions are reasonable and consistent with economic theory. The percentage of “yes” responses is about 66% at the lowest bid amount included in the study, and about 41.3% at the highest. (It should be kept in mind that in this survey people value risk reductions of different sizes, but that the risk reductions were the same across the four groups assigned to the different bid sets.)

Table 5. Percentage “yes” responses to the initial payment question (immediate risk reduction).

Initial bid	% yes
110	65.89
250	52.26
500	42.76
950	41.3

Next, we consider the sequences of responses to the initial and follow-up payment questions. As is often the case in contingent valuation surveys, the most frequently observed pair of responses is “no”-“no” (NN) (40.07%), followed by “yes”-“yes” (28.71%). YN and NY combinations account for 19.75% and 11.24% of the sample, respectively.

VI. Model Results

We begin with reporting the estimation results for equation (7) in table 6. For good measure, our regressions are based on a “clean” sample that excludes those respondents who failed both probability quizzes on the first attempt (26 respondents). In addition, we exclude from the sample those respondents who were assigned a risk reduction greater than 12 in 1000. This decision is motivated by two reasons. First, we wish to be consistent with a companion survey in the Czech Republic, where ΔR ranged from 1 to 12 in 1000 over 10 years. Second, ΔR greater than 12 in 1000 over 10 years is outside of the range appropriate for the policy applications of this paper.[23]

We initially included in the regressions city dummies to control for differences in the cost of living and other locale-specific factors that could influence WTP, but since the

[23] Including observations with large risk changes does not change the results appreciably. The coefficient on base risk is similar, and the coefficient on the log risk change is slightly smaller (0.40) and significant at

coefficients on these dummies were jointly insignificant, we omit them from the specification reported in table 6.

Table 6. WTP for risk reduction, equation (7). Weibull WTP, continuous/interval-data model. Cleaned sample (deleted FLAG1=1). N=775. Log Likelihood = -1086.24.

Variable	**Coefficient**	**Standard error**	**T statistic**
Intercept	7.7677	1.164	6.672
Log base risk (β_2)	-0.2465	0.124	-1.993
Log risk reduction (β_3)	0.4508	0.223	2.022
ATRISK dummy	0.3701	0.136	2.725
Income per household member (000 euro)	0.0255	0.014	1.783
Missing income dummy	0.0617	0.216	0.286
Male dummy	-0.0933	0.129	-0.724
Married dummy	0.2672	0.146	1.833
Children of ages 12 and younger dummy	0.068	0.181	0.376
College degree dummy	0.1207	0.213	0.566
Weibull shape parameter	0.7084	0.034	20.959

As shown in table 6, holding the risk reduction the same, willingness to pay does depend on the (log) baseline risk. The coefficient on this variable is *negative*, which means that older individuals—who have larger baseline risks—are willing to pay less than younger individuals for any given risk reduction. By contrast, the coefficient β_3 on the log risk change is positive, as expected, and significant at the 5% level, indicating that—holding baseline risk and all else the same—WTP does increase with the size of the risk reduction. However, this coefficient is significantly less than 1, implying that WTP is less than proportional to the size of the risk reduction. This result is in line with earlier studies (e.g., Alberini et al., 2004a; Alberini, forthcoming, using data from Persson et al., 2001).

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the 10% level, but not at the 5% level. Income exhibits a somewhat stronger association with WTP, Our regression results also indicate that persons with cardiovascular problems are willing to pay, all else the same, about 50% more than persons in better health. This effect goes against the conventional wisdom implicit, for example, in the use of quality-adjusted life years (QALY) measures, which discount programs or interventions that save the lives (or extend the lifetimes) of persons in poor health.

Finally, willingness to pay increases with income, an effect that is significant at the 10% level.[24] Males have a lower WTP, but this effect is not statistically significant, and married people have WTP values that are about one-third larger than those of single, divorced, or widowed individuals. Having young children, however, does not have a statistically discernible effect on WTP, perhaps because any such effect is already subsumed into income per household member. Likewise, a higher educational attainment, like having a college degree, does not influence WTP.

We added regressors—one at the time—to the base specification of table 6 to test whether WTP is different for other sensitive subpopulations. In these runs, we found that people with mobility impairments (who account for 13.2% of the sample) were willing to pay slightly more for the risk reduction, but this effect is not significant at the conventional levels.

Those respondents who are 65 or older and live alone are prepared to pay less for the risk reduction (coefficient -0.679, t statistic 1.81). This result, however, should be interpreted with caution, because these individuals make up a tiny share of the sample (3.37%), and because we suspect that the coefficient on the OLDALONE dummy picks up restricted income. (Income is no longer significant when this dummy is included in the

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approaching significance at the 5% level. All other coefficients are virtually the same as those of table 6.

regression.) Finally, caregivers (16.85% of the sample) are willing to pay 49% more for any given risk reduction. Perhaps taking care of people with limitations due to age and impaired mobility raises the salience of the risk reduction valued in this questionnaire to the respondents, and this in turn increases willingness to pay.

To illustrate the scope effect, and the effect of age, we computed annual mean and median WTP for various risk reductions using the base regression of table 6 for two males of ages 45 and 65, respectively.[25] Both of these individuals are assumed to be healthy, married without children, and to have income per household member equal to the Italian average (€10,000). Our calculations—displayed for median WTP in figure 2—confirm that WTP grows with the risk reduction, but at a decreasing rate.

As shown in figure 2, it is also clear that the older individual's WTP is lower than that of the younger individual for all risk reductions, income and other characteristics being the same. The 45-year-old's median WTP ranges from €182 a year (for the risk reduction of 1 in 10,000 a year) to €559 (for the risk reduction of 12 in 10,000 a year). By contrast, the 65-year-old's annual median WTP ranges from €101 to €309.

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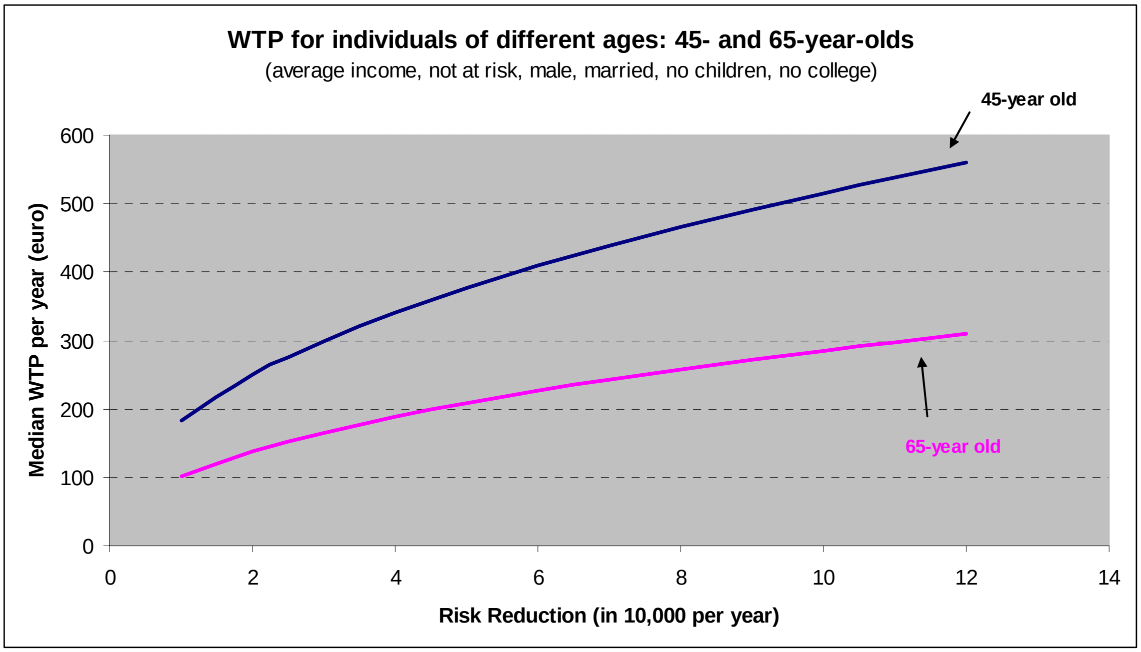
[24] It is comforting that the missing income dummy is not significant. This means that on average the WTP figures of those persons who did not report their income are not different from those of those respondents who did.

[25] We remind the reader that by our experimental design, a 45-year-old and a 65-year-old are both asked to value a risk reduction of 5 in 1000 over ten years.

Figure 2.



In Figure 3, attention is restricted to the 5 in 1000 risk reduction (5 in 10,000 in a year). We plot median WTP per year against age, which influences WTP via the baseline risk. It is clear that, as follows from the regression of table 5, WTP for the same risk reduction—and hence the VSL—*declines* with age. Holding the risk reduction the same, the WTP of the oldest people in our sample is less than half that of the youngest people in the sample.

Figure 3.

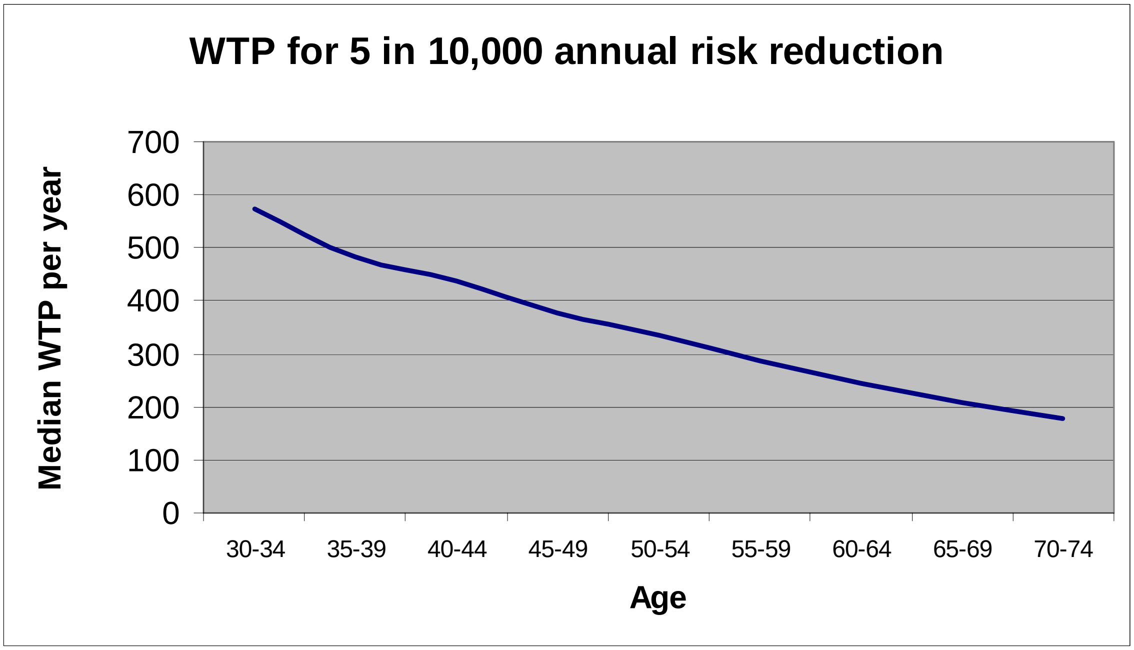
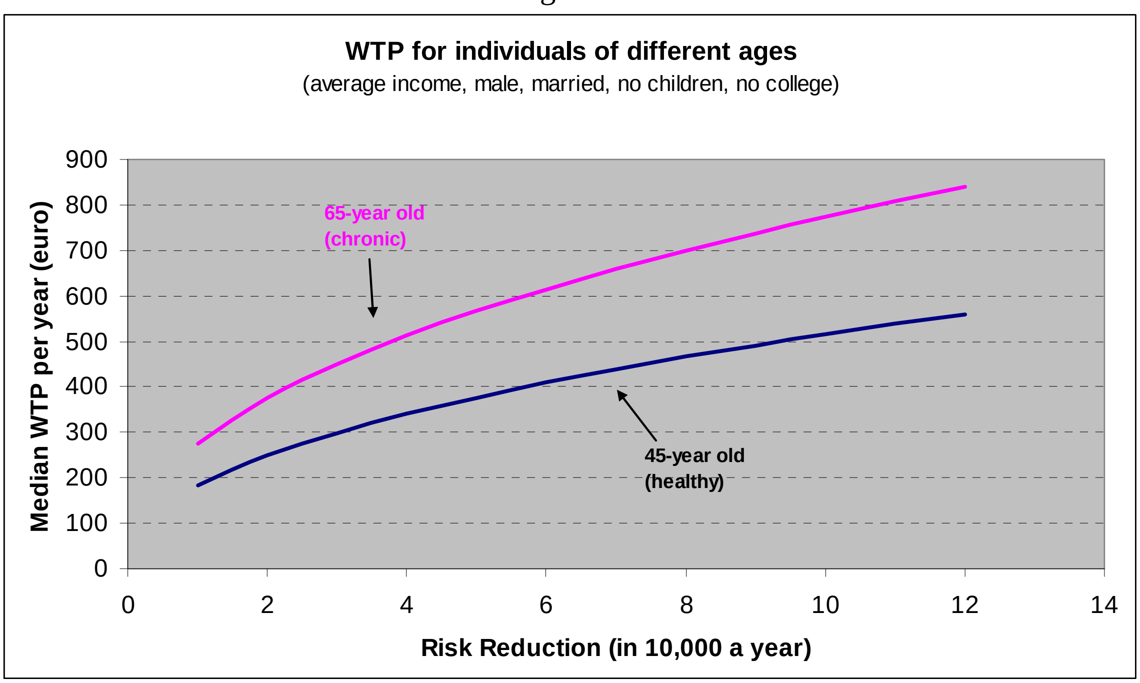


Figure 4.



In figure 4, we examine the issue of health status. In this figure, we plot the median WTP of the 45-year-old and the 65-year-old of the preceding examples, except that the 65-year-old is assumed to be suffering from a chronic cardiovascular or respiratory condition (or is at elevated risk because he is a diabetic). Clearly, the WTP of the elderly person now exceeds that of his younger and healthier counterpart.

As shown in table 7, the VSL of 45-year old is €1.824 million or €3.875 million (based on median and mean WTP, respectively) when referred to a 1 in 1000 risk reduction over 10 years, and €0.754 million or €1.601 million when referred to a 5 in 1000 risk reduction. For the healthy 65-year-old, the VSL is €1 million or €2.141 million (1 in 1000 risk reduction, median and mean WTP, respectively) and €0.417 million or €0.885 million (5 in 1000 risk reduction, median and mean WTP). When this 65-year-old is assumed to be in compromised health, however, the VSL is considerably higher, ranging from $1 million to €5.8 million, depending on the size of the risk reduction and the welfare statistic used.

Table 7. VSL in million Euro.

Size of the risk reduction	45-year-old (healthy)		65-year-old (healthy)		65-year-old (at risk)	
	Based on median WTP	based on mean WTP	Based on median WTP	Based on mean WTP	Based on median WTP	Based on mean WTP
1 in 1000 over 10 years (1 in 10,000 a year)	1.824	3.875	1.008	2.141	2.740	5.821
5 in 1000 over 10 years (5 in 10,000 a year)	0.754	1.601	0.417	0.885	1.132	2.405

Calculations assume average income per household member in Italy, male, married, no children, no college degree.

These figures encompass those obtained for a 5 in 1000 risk reduction over 10 years by Alberini et al. (2004a) in the US and Alberini et al. (2004b) in the UK, France and Italy, although neither set of authors focuses specifically on cardiovascular and respiratory causes.

In sum, our results show that the VSL figure is not a fixed constant: The VSL varies with the baseline risk and with the size of the risk reduction valued by the respondent. The VSL would be a constant if β_2 was zero, β_3 was equal to one, and none of the covariates were found to be significantly associated with WTP.

VII. Discussion and Conclusions.

We have presented the results of an original contingent valuation study that elicits the value of a reduction in the risk of dying for cardiovascular and respiratory causes from a sample of Italians living in large Italian cities. We ask people to value private risk reductions, without mentioning climate change and adaptation policies or air pollution, to avoid possible double-counting of the benefits and to avoid imposing an excessive cognitive burden on the respondents. The VSL figures elicited from this study can be used for estimating the mortality benefits of adaptation policies that save lives during heat waves and of other environmental policies that limit exposure to pollutants that cause or worsen cardiovascular and respiratory illnesses.

The responses to the WTP questions in our survey are broadly consistent with the economic paradigm and suggest that people understood the commodity being valued. We find that WTP does increase with the size of the risk reduction, but in a less than proportional fashion, a result that confirms earlier findings in Alberini et al. (2004a), Alberini (2005), and Hammitt and Graham (1999).

The VSL is *not* a fixed constant for all risk reductions. For the risk reductions studied in this paper (1 to 12 in 10,000 a year, or 1 to 12 in 1,000 over 10 years), the VSL ranges from €0.257 million to over €5.8 million, depending on the baseline risk (age of the beneficiary), size of the risk reduction, health status, and statistic used to compute the VSL (median or mean WTP). We paid special attention to (sub-) populations that are regarded as especially sensitive to the environmental health risks in urban areas. We found that indeed the WTP for a given risk reduction, and hence the VSL, is lower among the elderly[26] and higher among subjects at elevated risk because of existing cardiovascular and respiratory conditions. Elderly persons living alone—a population of concern during heat waves—report a lower WTP, but this finding should be interpreted with caution, because we only have few such persons in our sample and because we suspect this effect may overlap with that of their low incomes.

We also found that respondents were willing to pay more when they are caregivers for impaired or elderly family members. Perhaps familiarity with physical impairments and old age increases the salience of the risk reductions valued in this questionnaire to the respondents. Taken together, our regression analyses support the claim that the VSL is "individuated" (i.e., individual-specific).[27]

How do these figures compare with estimates of the VSL from other studies? In Maddison and Bigano (2003) the amenity effects of climate are captured in two markets: The housing market and the labor market. The amenity effect of climate is its effect on wages ($\partial w / \partial C$) minus its effect on housing prices ($\partial h / \partial C$), and is estimated using data from Italy. Their regressions indicate that, absent any changes in the precipitation

[26] For comparison, while US government agencies no longer discount the VSL for age in policy analyses (Skrzycki, 2003), the Directorate-General Environment of the European Commission does apply an age adjustment to its VSL figure.
See http://europa.eu.int/comm/environment/enveco/others/recommended_interim_values.pdf.
[27] See, for example, Smith et al., 2004. Whether or not government agencies should account for individuated VSLs is, of course, another matter. Sunstein (2004) acknowledges the informational burden

patterns, Italians would be prepared to pay about €325-370 per household per year to *avoid* a one-degree increase in July temperatures. Combining these results with the excess deaths recorded in Rome in Summer 2003, and assuming that the value of the disamenity reflects entirely the excess deaths due to the heat wave, we obtain a VSL of €3.345 million.[28] This figure falls within the range of VSL values estimated directly in our study.

How can we apply our VSL figures to the mortality risks of thermal stresses? We use calculations by Kovats (2003), who estimates the mortality risks associated with changes in mean temperature in Italy, allowing for physiological adaptation to hotter weather (but no public adaptation programs). Her calculations imply that from 2000 to 2020 the risk of dying for cardiovascular and respiratory causes during heat waves would increase from 0.71 in 10,000 to 0.91 in 10,000 for persons of ages up to 65, and from 9.19 in 10,000 to 11.70 in 10,000 for the elderly (ages 65 and older).[29] When these rates are applied to the relevant age groups of the population of Rome, for example, they predict a total of 165 and 211 deaths for the younger group, and 440 and 561 for the older group. (For simplicity, in these calculations we hold the population the same as now.)

We compute two conservative estimates of VSL based on median WTP for individuals at risk and for the appropriate size of the risk reduction (about 1 in 10,000 a year, and 2.5 in 10,000 a year, respectively, for a 45-year-old and for a 65-year-old). These two VSL figures are equal to €1.784 million and €1.657 million. Assuming no

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required of agencies, should they pursue full individuation, but also points out that in some cases, as in the case of clean air, individuation is not desirable, because people cannot be excluded from clean air.

[28] See Alberini et al. (forthcoming) for details on these calculations. We wish to point out that these figures should be regarded as an upper bound, because they assume that housing price and wage differentials reflect solely differences in mortality risks across locales with different climate, and that amenity effects and aesthetics do not matter.

[29] These risks are expressed on an annual basis. They were calculated for Milan and Rome.

discounting for the sake of simplicity, the monetized mortality damages in the absence of adaptation programs are thus €281 million for the year 2020 (2004 euro) for the city of Rome alone. Policies that were able to avoid some of these deaths would be credited for the corresponding benefits, which would have to be compared with the costs of the program for a complete benefit-cost analysis.

To illustrate the potential use of our VSL figures in the air pollution context, WHO (2002) estimates that 3473 deaths would be avoided among the population of age 30 and older if it were possible to reduce particulate matter of diameter less than 10 micron (PM10) from the current average (52.6 $\mu g/m^3$) in the eight largest Italian cities (Rome, Milan, Naples, Turin, Palermo, Genoa and Bologna) to 30 $\mu g/m^3$. These calculations do not distinguish for the ages and susceptibility of the persons exposed to outdoor air pollution and assume only long-term mortality effects. This implies that we must use the VSL of a person of average age (the average age in Italy is 40.6 years) for a risk reduction of about 6 in 10,000 annually (the risk reduction implied by WHO's calculations). At the average income per household member in the population, the relevant VSL figures are €0.730 million (based on median WTP) or €1.533 million (based on mean WTP). This target level of particulate matter would, therefore, bring reductions in mortality worth €2,535 million to €5,323 million per year.

Our estimates provide independent support for the EU-wide figures recommended in the cost-benefit analysis of the Clean Air for Europe program, which are equal to €0.980 million and €2.0 million, respectively (2000 euro). Our VSL figures bracket those used by the European Commission, whose baseline central VSL is €1.4 million, but are below that used by the US Environmental Protection Agency (1999, 2000) ($6.1 million 1999 dollars).

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Appendix.

Table A.1. City-by-city comparison between sample and population.

	College degree (percent)		Household size		Annual household income (euro)	
City	**population***	**sample**	**population***	**sample**	**population* (2002 euro)**	**Sample (2004 euro)**
Milano	15.6%	8.46	2.58 (Northern Italy)	2.73	32,774 (Northern Italy)	24,277
Venezia	9.4%	11.32	2.58 (Northern Italy)	2.82	32,774 (Northern Italy)	19,038
Genova	10.1%	9.88	2.58 (Northern Italy)	2.58	32,774 (Northern Italy)	17,889
Roma	13.9%	20.89	2.61 (Central Italy)	3.06	29,355 (Central Italy)	20,620
Bari	11.5%	7.41	2.89 (Southern Italy)	2.99	20,172 (Southern Italy)	13,667

*** = Source: Banca d'Italia (2002). Regional statistics are used when city-level statistics are not available.**

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(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003

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