Available online at www.sciencedirect.com
ScienceDirect
Journal of Health Economics 27 (2008) 739–752
JOURNAL OF HEALTH ECONOMICS
www.elsevier.com/locate/econbase

Are some lives more valuable? An ethical preferences approach

Olof Johansson-Stenman *, Peter Martinsson

Department of Economics, Göteborg University, Box 640, SE 405 30 Göteborg, Sweden

Received 30 October 2006; received in revised form 12 September 2007; accepted 18 October 2007
Available online 31 December 2007

Abstract

We develop a theoretical model of the ethical preferences of individuals, combining individual social welfare functions and random utility theory. The model is applied by conducting a choice experiment regarding safety-enhancing road investments that target different age groups and road user types. The relative value of a saved life is found to decrease with age, such that the present value of a saved life-year is almost independent of age at a pure rate of time preference of a few percent. Moreover, a saved pedestrian is consistently valued higher than a saved car driver of the same age.
© 2007 Elsevier B.V. All rights reserved.

JEL classification: D63; I18; J17

Keywords: Ethical preferences; Individual social welfare function; Relative value of life; Choice experiments; Random utility model

1. Introduction

As a very general principle, most people probably agree that all human lives have, or should have, the same value. However, the meaning of this principle becomes less clear when attempting to implement it into real life decisions. Does it mean that the same amount of resources should be spent on saving the life of an elderly person as on saving the life of a child, or does it mean that the same amount should be spent per expected saved life-year? Or should responsibility for one's own actions (e.g. use of illegal drugs), social responsibility (e.g. parenthood), time preferences and/or quality of life be considered? Consider two public projects: an information campaign expected to result in a decreased frequency of sudden infant death syndrome corresponding to 100 children per year, and buying more respirators that are expected to result in a 1-week life extension for 200 elderly people per year. With limited resources, how should these benefits be compared? It is clear from this example that the answer may have very large implications for public priorities.

In this paper we focus on estimating people's *ethical preferences*, by which we mean people's preferences with respect to the outcomes of *others*, where they themselves are unaffected both financially and in other ways. More specifically, we estimate people's ethical preferences with respect to the value of life as a function of age and perceived responsibility/vulnerability, by letting the respondents make pair-wise choices between alternatives characterized by

* Corresponding author. Tel.: +46 31 786 2538; fax: +46 31 786 1043.
E-mail address: olof.johansson@economics.gu.se (O. Johansson-Stenman).

0167-6296/$ – see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.jhealeco.2007.10.001

the saved number of people, their age, and whether they are drivers or pedestrians. We develop a general theoretical model of the ethical preferences of individuals, and test the model empirically by linking it with random utility theory.

Currently, policy practice is sometimes based on a constant value of life for all, whereas it may at other times be based on a constant value per gained life-year, or quality adjusted life-year (QALY); see e.g. Hammitt (2002, 2007). In applications such as risk regulations and infrastructure investment projects, one typically relies on a constant value of life for all, i.e. irrespective of age and other factors.[1] The health-care sector, on the other hand, commonly bases evaluations on QALYs, implicitly implying that the value per life decreases strongly with age.

In addition to the non-obvious ethical justification behind these practices, there are large methodological problems behind the quantification of the values of statistical lives and value of (quality-adjusted or not) life-years *per se*. Indeed, the existing estimated values for statistical lives (and life-years) from contingent valuation studies can vary greatly (by up to 100 times), although based on the same populations or comparable ones (e.g. Beattie et al., 1998). Furthermore, almost all of the studies show an inadequate sensitivity to the scale of risk reduction (Hammitt and Graham, 1999). There are at least two reasons for these somewhat discouraging results. First, as has been repeatedly documented in psychological research, it is difficult to communicate and perceive small probabilities (Kahneman et al., 1982; Kahneman and Tversky, 2000). Second, it is cognitively difficult to translate a small risk reduction into a monetary benefit (Kahneman and Knetsch, 1992; Kahneman et al., 1999). Moreover, our ability to value goods consistently in monetary units is very limited, even for goods with which we are experienced and for which we have perfect information. Ariely et al. (2003) demonstrated this phenomenon experimentally and denoted it, together with the observation that people in most cases are consistent when valuing goods in relation to other goods, “coherent arbitrariness”. In terms of risk evaluation, it would mean that it is less difficult for respondents to compare different risk reductions and outcomes than to equate these risk reductions and outcomes with monetary values; similar arguments are made by Carthy et al. (1999) who also provide supporting empirical evidence.

For these reasons, we will here focus on the valuation of *relative* values of life for different groups of people, and in particular with respect to age. Thus, we do not need to communicate small probabilities or to introduce monetary units. Moreover, in reality policy makers often work under specific budget constraints, such that x million dollars should be used in the best way to improve safety for example measured by lives saved in sector y (e.g. the health sector). In terms of such priority decisions, it is sufficient to know the relative values of the various safety improvements.

In our analytical approach we develop and link the notions of ethical preferences and underlying individual social welfare functions (ISWFs) (e.g. Arrow, 1963; Harsanyi, 1955) with random utility theory (McFadden, 1974) as applied when studying the revealed or stated behaviour of individuals. This allows us to calculate the relative value of a statistical life among different sub-groups in the population using different assumptions on what affects utility and on discount rates. The focus of our survey is on estimating people’s ethical preferences regarding saved lives based on a random sample of people in Sweden. Using a choice experiment, the respondents were asked to act as social planners and make repeated choices between pairs of road investment projects whose outcomes differed in terms of the number of people saved, the ages of those saved and whether they were drivers or pedestrians. This last distinction was introduced to test whether responsibility and/or volition influence the choices made. We exclusively asked about fatal accidents, thus we ignore injuries.

We find that the value of life consistently decreases as age increases, but not nearly as sharply as in the studies by Cropper et al. (1994) and Johannesson and Johansson (1997). We argue that methodological issues are the main reason behind these differences. The rest of the paper is organised as follows: Section 2 provides a brief literature review, Section 3 outlines the theoretical and empirical models, Section 4 presents the choice experiment, Section 5 presents the empirical results and Section 6 concludes the paper.

[1] Yet there are exceptions. For example, the European Commission (2001) recommends its member countries to apply age-decreasing monetary values in cost–benefit analysis.

2. Literature review

By now there is an extensive body of theoretical literature on health and safety priorities in economics as well as in philosophy (for overviews see e.g. Broome, 1999, 2004; Dolan and Olsen, 2001; Dolan et al., 2005; Hausman and McPherson, 1993; Williams and Cookson, 2000), but these studies rarely suggest quantifications that can be applied by policy makers. Results from surveys on health care priorities suggest that children should be given higher priority, while people responsible for their own bad health, such as smokers and users of illicit drugs, should be given lower priority (e.g. Anand and Wailoo, 2000; Cookson and Dolan, 2000). On choices among life-saving programmes, people prefer to reduce involuntary risks (e.g. Slovic et al., 1985; Mandeloff and Kaplan, 1989) and risks that are difficult to avoid (e.g. Subramanian and Cropper, 2000).

To our knowledge, the only studies that quantify preferences towards saving the lives of *other* people at different ages are Cropper et al. (1994) and Johannesson and Johansson (1997). In both of these innovative studies, the respondents were asked to choose between different projects targeting certain (unspecified) accidents and diseases, which would result in different numbers of saved people of different ages. Both studies found that the value of life decreases sharply with increased age. There are also other studies that have looked at people's attitudes with respect to priorities and age without quantifying the results in terms of relative values; see e.g. Dolan and Tsuchiya (2005). In summary, previous studies imply that both age and responsibility are factors that people think should affect the relative value of lives.

However, recent contingent valuation results by Krupnick et al. (2002) and Alberini et al. (2004) indicate that people's willingness to pay (WTP) for risk reductions *for themselves* (and hence the statistical value of life) is fairly constant, which implies that the value per remaining year of life increases with age, and that WTP is only reduced a little as age increases. Others have found stronger but non-monotonic relationships. For example, Philips et al. (1989) observed an inverted U-shape between the WTP and age with a maximum close to the age of 40. Viscusi and Aldy (2003), on the other hand, surveyed various kinds of revealed-preference studies and found in most studies that the WTP-based value of a statistical life decreases with age, although the degree of the reduction varies largely. Conventional economic theory in itself is sufficiently general to encompass many different patterns between WTP and age (Johansson, 2002), although most studies seem to conclude either that WTP should decrease monotonically with age, or that it has an inverted U-shape.

It is debated whether WTP measures based on potential risks for people themselves should guide public priorities with respect to saving lives of different ages (Hammitt, 2002). Studies such as Krupnick et al. (2002) and Alberini et al. (2004) take this as the implicit starting point, without even discussing alternatives. Sunstein (2004), on the other hand, argues that irrespective of the empirical results from WTP studies, and irrespective of theoretical results of how individual WTP should vary with age, it is the social welfare that matters intrinsically. The social welfare gain, he continues, in terms of saved total well-being, is higher when saving a young individual than when saving an old one. Consequently, he argues that the focus for public policy should be on saving life-years rather than lives. Still, he provides no empirical support in terms of people's ethical preferences. The main task of this paper is to investigate and quantify these ethical preferences. The methodology used here of letting people choose between different projects described by different numbers of people saved with different characteristics corresponds to the 'person trade-off' recommended on ethical grounds by Nord (1994, 1999).

3. Modelling approach

This section first presents various versions of our theoretical model based on consequentialist ethics and welfare economic theory. An empirical model that constitutes the base for the econometric analysis is then presented, which in turn makes it possible to test whether the different versions of our theoretical model are consistent with our observed survey data.

3.1. The theoretical model

The model is based on the assumption that each individual has consequentialist ethical (or social) preferences over different states of the world described by ISWFs, where the outcome for each individual remains fixed. A reference case, to which the empirical findings can be compared, is a discounted utilitarian ISWF based on the current population,[2]

$$W = \int_0^{\tau_{\max}} \int_0^{T(\tilde{\tau})-\tau} \int_{y_{\min}(\tilde{t},\tilde{\tau})}^{y_{\max}(\tilde{t},\tilde{\tau})} \int_{z_{\min}(\tilde{y},\tilde{t},\tilde{\tau})}^{z_{\max}(\tilde{y},\tilde{t},\tilde{\tau})} \Psi(u(\tilde{\tau}+\tilde{t},\tilde{y}),\tilde{z}) f(\tilde{y},\tilde{\tau},\tilde{t},\tilde{z}) \mathrm{e}^{-\delta\tilde{t}}\, \mathrm{d}\tilde{z}\, \mathrm{d}\tilde{y}\, \mathrm{d}\tilde{t}\, \mathrm{d}\tilde{\tau}, \tag{1}$$

where $u(\tau + t, y)$ is the utility for an individual who is $\tau + t$ years old at calendar time t (from now, i.e. from $t = 0$) with income y, and where z is a vector that reflects personal and contextual characteristics. Ψ is the individual social-preference function, which thus depends on u and z. $f(y, \tau, t, z)$ is the population size of people with income y, who are τ years old today, and hence $\tau + t$ years old at calendar time t. $T(\tau) - \tau$ is the expected remaining lifetime for a person aged τ today, and δ is the (constant) utility discount rate. In other words, W is the present value of the sum of $\Psi(\cdot)$ for all living people today aggregated over each individual's expected remaining lifetime. The social-preference function Ψ can at this stage be interpreted quite broadly to include anything that an individual considers to be of moral significance, including perceived individual responsibility, and does not need to be limited to individual well-being u (cf. Hammond and Fleurbaey, 2004). Moreover, one may believe that Ψ is an increasing but strictly concave function of u, so that it is *ceteris paribus* better to save two people with a well-being of u* each than one individual with a well-being of 2u*; cf. Dolan (1998). W may of course vary among individuals, but to avoid clutter we suppress individual indices throughout the paper. In order to estimate the relative value of saving the life of a person belonging to group j compared to a person belonging to group k, we can calculate the corresponding *individual social marginal rate of substitution* (*SMRS*) from Eq. (1):

$$\mathrm{SMRS}^{jk} = \frac{\partial W/\partial f(y^j,\tau^j,z^j)}{\partial W/\partial f(y^k,\tau^k,z^k)} = \frac{\int_0^{T(\tau^j)-\tau^j} \Psi(u(\tau^j+t,y^j),z^j)\mathrm{e}^{-\delta t}\,\mathrm{d}t}{\int_0^{T(\tau^k)-\tau^k} \Psi(u(\tau^k+t,y^k),z^k)\mathrm{e}^{-\delta t}\,\mathrm{d}t}. \tag{2}$$

The relative value in Eq. (2) equals the ratio between the present values of the expected remaining value of the sub-social-preference function Ψ. Given that people's ethical preferences are welfaristic, i.e. they depend solely on utility information (Sen, 1979), we can simplify Eq. (2) to

$$\mathrm{SMRS}^{jk} = \frac{\int_0^{T(\tau^j)-\tau^j} \Psi(u(\tau^j+t,y^j))\mathrm{e}^{-\delta t}\,\mathrm{d}t}{\int_0^{T(\tau^k)-\tau^k} \Psi(u(\tau^k+t,y^k))\mathrm{e}^{-\delta t}\,\mathrm{d}t}. \tag{3}$$

If moreover Ψ is linear in u so that $\Psi = ku$, where k is a constant, we have:

$$\mathrm{SMRS}^{jk} = \frac{\int_0^{T(\tau^j)-\tau^j} u(\tau^j+t,y^j)\mathrm{e}^{-\delta t}\,\mathrm{d}t}{\int_0^{T(\tau^k)-\tau^k} u(\tau^k+t,y^k)\mathrm{e}^{-\delta t}\,\mathrm{d}t}, \tag{4}$$

which is equal to the ratio of the present values of the remaining expected utilities. However, one can question whether people will value saving a rich person more than a poor person,[3] or whether they will consider the fact that the length of expected life increases in more recently born generations. If they do not, Eq. (4) can be simplified as follows:

$$\mathrm{SMRS}^{jk} = \frac{\int_0^{T(\tau^j)-\tau^j} u(\tau^j+t)\mathrm{e}^{-\delta t}\,\mathrm{d}t}{\int_0^{T(\tau^k)-\tau^k} u(\tau^k+t)\mathrm{e}^{-\delta t}\,\mathrm{d}t}. \tag{5}$$

Moreover, many economists and philosophers have argued against using a positive utility discount rate (pure rate of time preference) (e.g. Ramsey, 1928; Harrod, 1948). It is also possible that some individuals find it ethically dubious

[2] This formulation of course implies that individuals can make interpersonal comparisons of utility, and that utility is measurable in a strong cardinal form where the levels can be compared. Moreover, the formulation is deterministic in the sense that it is assumed that a person with a certain age will live until a specified expected age *with certainty*. An alternative formulation would be to introduce a survival function and hence introduce a distribution of life lengths for each cohort. The extent to which the present formulation approximates the expected present value of Ψ then depends on how well Ψ can be approximated by a linear (affine) function with respect to age, in the uncertainty interval considered with respect to the length of life. In the following calculations we assume for analytic simplicity that Ψ is approximately linear in the interval considered. The alternative formulation would have clear advantages if one were to consider the relative value of present and (in particular) future risk *reductions*.

[3] In addition, some researchers (e.g. Easterlin, 1995, 2001) find that subjective well-being or happiness appears to depend only on relative income. Others, such as Johansson-Stenman et al. (2002) and Solnick and Hemenway (1998), find that both absolute and relative income appear to matter.

to correct for a varying quality of life (utility) as a function of age. If so, we can simplify Eq. (5) further and re-write the relative value of life as

$$\mathrm{SMRS}^{jk} = \frac{T(\tau^j) - \tau^j}{T(\tau^k) - \tau^k}, \tag{6}$$

i.e. SMRS depends only on the ratio between the expected remaining lifetimes.

However, it is also possible that some individuals believe that lives *per se* should have a value, at least to some degree, irrespective of the circumstances such as how many life-years are gained; cf. Chilton et al. (2002). A simple way to allow for this possibility is to modify Eq. (6) as follows:

$$\mathrm{SMRS}^{jk} = \frac{T(\tau^j) - \tau^j + \alpha}{T(\tau^k) - \tau^k + \alpha}, \tag{7}$$

where α can be interpreted as the value of a saved life, *ceteris paribus*, in terms of saved life-years. This means that saving two individuals who are both expected to live x more years generates the same social welfare increase as saving one individual who is expected to live $(2x+\alpha)$ more years. Trivially, if $\alpha = 0$, then lives have no value *per se*, and thus only the number of saved life-years matters, i.e. Eq. (7) reduces to Eq. (6). The other extreme is that only saved lives matter, i.e. where $\alpha \to \infty$, irrespective of the number of life-years saved, in which case Eq. (7) reduces to

$$\mathrm{SMRS}^{jk} = 1. \tag{8}$$

3.2. The empirical model

To test whether any of the Eqs. (2)–(8) provide good descriptions of the ethical preferences of the respondents, we start with a general ISWF as follows:

$$W = w(S^1, \ldots, S^n, \Omega) + \phi, \tag{9}$$

where S^k is the number of people alive in group k (characterized by personal characteristics including age), Ω is a vector describing other aspects of the state of the world, and where ϕ is an error term reflecting unobservable characteristics and noise (e.g. due to cognitive limitations). We can then write the ISWF as a function of changes in the number of people alive in each group. As long as the changes are small, it follows that

$$W = \hat{W} + \frac{\partial w}{\partial S^1} s^1 + \ldots + \frac{\partial w}{\partial S^n} s^n + \phi \equiv \hat{W} + b^1 s^1 + \ldots + b^n s^n + \phi, \tag{10}$$

where $\hat{W}$ is social welfare at status quo, b is a vector of coefficients and s^j is the saved number of people in group j. We assume that the true ISWF is not perfectly observable, which is analogous to the random utility approach, and thus that the ISWF consists of a systematic observable part and a stochastic non-observable part. An ISWF-maximising respondent prefers alternative (project) A to alternative (project) B if $W(A) > W(B)$. Based on the observable information, we can then model the *probability* that alternative A will be chosen over alternative B as follows:

$$\Pr(\text{A is chosen}) = \Pr(W(A) > W(B)) = \Pr(b^1 \Delta s^1 + \ldots + b^n \Delta s^n > \varepsilon), \tag{11}$$

where $\Delta s^k = s^k(A) - s^k(B)$ and $\varepsilon = \phi(A) - \phi(B)$. Given that ε has a standard normal distribution, an estimation of Eq. (11) can be made with a standard probit regression (without an intercept since the constants $\hat{W}$ cancel out). The estimated relative value of saving a life from group j compared with one from group k is then given by $\mathrm{SMRS}^{jk} = b^j/b^k$, which can be compared with the different theoretical predictions of SMRS from Eqs. (2)–(8). To further test for differences in ethical preferences among the groups of respondents, the same approach as the one used to estimate preferences for the relative value of lives for different sub-samples can be applied separately.

	Project A	*Project B*
The total number of saved lives	*4*	*6*
The age of the saved individuals	*5-15 years old*	*25-35 years old*
Type of road user who is saved	*Pedestrians*	*Car drivers*
Your choice		

Fig. 1. Scenario used in the choice experiment.

4. The choice experiment

Choice experiments are increasingly used in health economics (Ryan and Gerard, 2003).[4] Designing a choice experiment includes creating a scenario and identifying the attributes to be used (see e.g. Alpizar et al., 2003; Louviere et al., 2000), which, in our case, are the factors that will be affected by the chosen road investment project. In order to create a credible scenario that in a short and understandable way describes the task that the respondents are required to perform, we pre-tested the questionnaire in focus groups before testing it in a pilot study on a small random sample of Swedes. It was revealed that, in addition to the number of individuals saved, the age of the saved individuals and the type of saved road users were important for respondents when making choices between projects. This was not the case for other personal characteristics that were tested, such as income, gender and social class. To explain how a certain road investment can target a specific group of recipients, we used the examples of building a pedestrian bridge near a school, which would primarily save the lives of children, and special crash barriers to reduce the risk for car drivers. The reason we used these road user types is that they seem to imply different degrees of accident responsibility and vulnerability.[5] We also stated that it is possible, based on accident and population statistics, to express the effects of different investments in terms of the number of saved individuals of a given age. In order to make the scenario more realistic and credible we chose to present saved lives in groups that spanned a range of ages, rather than in groups of individuals who were all the same age.

The respondents were asked to choose which one out of two road investment projects they would prefer in seven different pair-wise choices. Each project was described in terms of the number of saved individuals (an integer between 1 and 10), their age groups (5–15, 25–35, 45–55 or 65–75 years) and whether they were car drivers or pedestrians. Of course, the youngest age group (ranging from 5 to 15 years old) only contains pedestrians. In order to reduce the number of combinations of attributes to a manageable level, we followed the optimal design approach by Zwerina et al. (1996) and generated nine different blocks, each consisting of seven choice sets. Individuals were randomly assigned to one of the nine blocks, but we ensured a geographic spread of the choice sets based on postal codes. In order to reduce the potential problems of learning and order effects, the respondents were encouraged to go back and change earlier choices if they wished to do so. Fig. 1 shows the scenario presented to the respondents.

Following these instructions, seven choice sets of the type shown above were presented to each respondent. The survey was mailed to 2500 randomly selected individuals aged 18–65 in Sweden and a 62% response rate was obtained. After omitting those who did not fully complete the choice experiment, we included 1444 respondents in the analysis, i.e. 58% of the total selected sample. Moreover, there are only small differences between our sample and the targeted background population with respect to measurable characteristics. A disadvantage with mail surveys is the lack of opportunity to ask questions if something is perceived as unclear. An advantage, compared to for example telephone interviews, is that the respondents have sufficient time to think. This is particularly important in terms of questions that the respondents rarely face in everyday life.

5. Results

We are interested in estimating how people on average value, in relative terms, saved lives of different ages, as well as with respect to perceived responsibility or vulnerability. Moreover, we also want to find out the extent to which

[4] See e.g. Ryan et al. (2006) for an interesting application where the relative importance of different aspects of quality of life in addition to health was quantified.

[5] Although, as pointed out by a referee, the difference in responsibility may not always be in this direction, such as if a pedestrian rushes out to cross a busy street.

Table 1
Probit regressions for the total sample as well as for five sub-samples

	All ($n = 1444$)		Over 57 years old, no children ($n = 190$)		57 years old or below, no children ($n = 663$)		57 years old or below with children ($n = 584$)		Male ($n = 739$)		Female ($n = 705$)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
10-year-old pedestrian	0.366***	0.012	0.300***	0.030	0.378***	0.018	0.398***	0.022	0.381***	0.018	0.352***	0.017
30-year-old pedestrian	0.239***	0.009	0.219***	0.023	0.265***	0.013	0.225***	0.014	0.256***	0.013	0.223***	0.012
30-year-old driver	0.196***	0.007	0.199***	0.021	0.213***	0.012	0.183***	0.012	0.214***	0.011	0.178***	0.010
50-year-old pedestrian	0.189***	0.007	0.193***	0.021	0.208***	0.011	0.172***	0.011	0.200***	0.010	0.177***	0.011
50-year-old driver	0.170***	0.007	0.190***	0.018	0.185***	0.010	0.151***	0.010	0.181***	0.010	0.159***	0.009
70-year-old pedestrian	0.112***	0.007	0.119***	0.021	0.136***	0.010	0.089***	0.011	0.122***	0.010	0.103***	0.010
70-year-old driver	0.079***	0.006	0.087***	0.017	0.090***	0.009	0.067***	0.009	0.089***	0.008	0.069***	0.009
Number of statistical observations	10108		1330		4641		4088		5173		4935	

Note: standard errors are adjusted for clustering on individuals. *, **, ***Significance at a 5%, 1% and 0.1% level, respectively. Seven respondents fall into the category over 57 years old with children.

these relative values differ between various groups of respondents. Our rich data set and large sample enable us to run separate probit regressions for these different sub-populations. This approach facilitates straightforward comparisons and, more importantly, is less restrictive compared to an approach based on a single regression with several interaction effects.

5.1. Probit results

Table 1 presents the results of the probit regressions for the whole sample of respondents as well as for the following five sub-samples of respondents: (i) aged 57 and older with no children,[6] (ii) age 57 or below with no children, (iii) age 57 or below with children, (iv) males and (v) females. Since each respondent made seven choices, the observations should not be treated as independent, and ignoring this would imply underestimated standard errors. In order to deal with this we used the cluster subcommand in the STATA software, where each respondent is associated with a separate cluster.

As expected, all parameters are positive indicating that the value of saving a life is always positive irrespective of age and whether it is a driver or pedestrian. Moreover, we can immediately see that the size of each parameter decreases monotonically with age in each sub-sample, indicating that the relative value of life decreases with age.

5.2. Relative value of saved lives

Table 2 presents the estimated relative value of life figures, based on the probit regressions in Table 1. Note that the relative values are simply the ratios between the probit coefficients. The SMRS figures thus express how many saved 70-year-old drivers would be equivalent to saving one individual of a certain age and type of road user for each of the six samples. For example, the figure of 4.646 in the top left corner of Table 2 should be interpreted as respondents being indifferent between saving 4.646 70-year-old car drivers and saving one 10-year-old pedestrian. We test whether the obtained relative values of statistical life are statistically different from one, i.e. the null hypothesis of no difference in relative values between saving one 70-year-old car driver and one individual of a certain age and type of road user, by using a Wald test.[7] As can be seen, in all cases we can reject the null hypothesis at a significance level of 5%, and at 0.1% in all cases except two.

[6] We define ‘with children’ as having at least one person aged 18 or under living in the household.

[7] We apply the subcommand for a Wald test in STATA. The delta method is applied to obtain the Wald statistics, which is then compared to a chi-square distribution.

Table 2
Social marginal rate of substitution (SMRS) in the total sample and in sub-samples. Saved 70-year-old drivers constitute the base case

	All ($n = 1444$)		Over 57 years old, no children ($n = 190$)		57 years old or below, no children ($n = 663$)		57 years old or below with children ($n = 584$)		Male ($n = 739$)		Female ($n = 705$)	
	SMRS	S.E.	SMRS	S.E.	SMRS	S.E.	SMRS	S.E.	SMRS	S.E.	SMRS	S.E.
10-year-old pedestrian	4.646***	0.306	3.470***	0.567	4.213***	0.365	5.909***	0.705	4.281***	0.354	5.133***	0.549
30-year-old pedestrian	3.030***	0.185	2.529***	0.387	2.960***	0.239	3.336***	0.366	2.867***	0.219	3.249***	0.324
30-year-old driver	2.489***	0.142	2.304***	0.345	2.373***	0.174	2.713***	0.283	2.406***	0.170	2.603***	0.246
50-year-old pedestrian	2.394***	0.140	2.226***	0.327	2.316***	0.176	2.549***	0.273	2.246***	0.163	2.589***	0.248
50-year-old driver	2.159***	0.123	2.191***	0.322	2.065***	0.153	2.244***	0.234	2.035***	0.144	2.315***	0.218
70-year-old pedestrian	1.428***	0.082	1.369*	0.187	1.513***	0.114	1.326*	0.148	1.369***	0.098	1.504***	0.142
70-year-old driver (base case)	1		1		1		1		1		1	
Number of statistical observations	10108		1330		4641		4088		5173		4935	

Note: the *P*-value refers to the null hypothesis that the SMRS is the same for a specific age group with a certain type of road user as it is for 70-year-old drivers, i.e. if SMRS is equal to one. This hypothesis is tested by applying a Wald test. *, **, ***Significance at a 5%, 1% and 0.1% level, respectively. Seven respondents fall into the category over 57 years old with children.

The overall findings in the whole sample, as well as in all sub-samples, are clearly that saved lives of younger individuals are consistently given higher values than older lives, and that saved pedestrians are valued higher than saved drivers of the same age. However, the difference expressed in the relative value between young and old individuals is much smaller than that obtained by Cropper et al. (1994) and Johannesson and Johansson (1997). For example, the latter found that saving forty-one 70-year-olds is equivalent to saving one 30-year-old. Moreover, we find that older respondents value saved older lives higher than younger respondents do, which is contrary to the findings by Cropper et al. (1994) and Johannesson and Johansson (1997) (although the differences are relatively small). For example, respondents aged above 57 value saving 2.529 lives of 70-year-old car drivers the same as saving one 30-year-old pedestrian, whereas the corresponding number for respondents aged 57 or below without children is 2.96. Furthermore, people with children value saving children more highly than those without. Although fairly small, these differences point in the expected direction of self-interest, i.e. that the responses do not solely reflect the respondents ISWFs but also to a certain degree their own expected utility. An alternative explanation is self-serving bias (see e.g. Babcock and Loewenstein, 1997), i.e. that individuals try to be objective, but still unconsciously tend to favour themselves. It can also be noted that women value children relative to others higher than men do.

In Table 3, we show the relative value between car drivers and pedestrians. For example, 1.218 in the top left corner implies that the respondents are indifferent between saving 1.218 lives of 30-year-old car drivers and saving one 30-year-old pedestrian. When using both the full sample and the sub-samples in the estimations, we find that car drivers are consistently given lower values than pedestrians. These effects are statistically significant at the 5% level for all comparisons based on Wald tests, except for comparisons with the sub-group containing respondents aged above 57. In this case, there is no statistical difference for ages between 30 and 50. The differences between the sub-samples are relatively minor, although it is noteworthy that women consistently value pedestrians, in relative terms, higher than men do.

Table 3
Social marginal rate of substitution (SMRS) in the total sample and in sub-samples between saved drivers and saved pedestrians for different ages groups

	All		Over 57 years old, no children		57 years old or below, no children		57 years old or below with children		Male		Female	
	SMRS	S.E.	SMRS	S.E.	SMRS	S.E.	SMRS	S.E.	SMRS	S.E.	SMRS	S.E.
30-year-old	1.218***	0.033	1.098	0.090	1.247***	0.046	1.230***	0.053	1.192***	0.043	1.248***	0.051
50-year-old	1.109**	0.036	1.016	0.083	1.122**	0.048	1.136*	0.066	1.104*	0.048	1.119*	0.053
70-year-old	1.428***	0.082	1.369*	0.187	1.513***	0.114	1.326*	0.148	1.369***	0.098	1.504***	0.142

Note: we test the null hypothesis that SMRS is the same for drivers and pedestrians of a specific age, i.e. that SMRS is equal to one, by applying a Wald test. *, **, ***Significance at a 5%, 1% and 0.1% level, respectively. Seven respondents fall into the category over 57 years old with children.

5.3. Relative value per saved life-year and QALY

The results obtained can also be interpreted in terms of relative value per expected remaining life-*year*. The second column of Table 4 reflects the expected remaining number of life-years at different ages, whereas the third column reflects the same thing but in relative terms compared to the ones at the age of 70. The fourth column reflects the relative value of a statistical life for pedestrians elicited from Table 2 based on the full sample with all respondents; for example, the top value of 3.25 is given by 4.646/1.428, i.e. the relative value of 10-year-old pedestrians in terms of 70-year-old drivers, divided by the relative value of 70-year-old pedestrians in terms of 70-year-old drivers. (The reason why we here focus on pedestrians is of course that there are no drivers at the youngest age.) The relative value per saved life-year, reported in Column 5, is then simply obtained by dividing the values in Column 4 by the ones in Column 3. The results imply that the value per remaining life-year is highest for saved 70-year-olds, and that the results hence deviate to a non-negligible degree from the undiscounted utilitarian model corresponding to Eq. (6), from which we would expect the relative value per remaining life-year to be independent of age.

A similar pattern holds when we undertake a corresponding exercise and instead calculate the relative value per saved *quality-adjusted* life-year. These results are shown in the fifth column of Table 5, where the adjustments for varying quality of life are based on the results from a Swedish survey by Brooks et al. (1991). The results here are overall in sharp contrast to both Cropper et al. (1994) and Johannesson and Johansson (1997), whose results imply that the value per life-*year*, quality adjusted or not, decreases sharply as age increases.

5.4. Implicit discount rates

Assume now instead that people's ethical preferences are consistent with the particular version of the discounted utilitarian model described by Eq. (5). We can then calculate the implicit utility discount rates in order for this model to hold. For example, if the present value per saved life-year would be the same for saving a 10-year-old and a 70-year-old, we would need a positive utility discount rate since we have from Table 3 that the undiscounted value per saved life-year of the former is only 65% of the latter, and since most of the saved life-years of the 10-year-old will occur further into the future. Using a standard numerical method we can solve for the implicit utility discount rate in Eq. (5); in this case it turns out to be 1.7% per year.

Similarly, we calculate the discount rate at which the respondents would be indifferent between saving an additional quality-adjusted life-year in 70-year-olds and in each of the different age groups. Overall, the implicit discount rates vary between 1.7 and 4.8% per year, which is similar to implicit discount rates found in other studies; see for example Table 11 in the comprehensive survey of revealed-preference valuation studies by Viscusi and Aldy (2003). Moreover, the European Commission (2001) recommends a 4% real interest rate, and that 2% should be used as sensitivity analysis. It can also be observed that the implicit discount rates found here are lowest for the children, which may be interpreted as an additional 'child-premium' due to the perception that children have less responsibility as well as less ability to protect themselves.

5.5. Intrinsic value of life

However, as mentioned it is possible that not only life-years matter but also lives *per se*. The results are indeed also quite consistent with the model where people partly care about saved lives and partly about saved life-years, as in Eq. (7), with no discounting. Tables 4 and 5 therefore also present α for each age group, i.e. the value of a saved life *ceteris paribus* in terms of saved life-years, according to our empirical results. The results show that the value of one saved life *ceteris paribus* corresponds to between 10 and 20 life-years. For example, if $\alpha = 15$ and if an individual who can be expected to live 15 more years is saved, then the value of saving that person depends on two terms of equal weight: saving a life *per se* and saving 15 life-years. It also, for example, implies that saving two individuals with 30 years left to live each is equal to saving three individuals with 15 years left to live each.

Our chosen survey methodology offers a possible explanation for the large differences between our results and those of Cropper et al. (1994) and Johannesson and Johansson (1997). We used a choice experiment in which the respondents were asked to make seven pair-wise choices, whereas both the other studies asked just one closed-ended question. Kahneman et al. (1999) argue that the choices made under some circumstances may indicate attitudes or

Table 4
Calculations of the relative value per expected remaining life-year, implicit discount rates, and a parameter α that reflects the value of life, *ceteris paribus*

Age	Expected remaining years of life[a]	Expected remaining years of life relative to the ones at the age of 70	Relative value of life (from Table 2)	Relative value per remaining year of life[b]	Implicit discount rate for a constant present value of a life-year independent of age[c] (%)	Implicit α (assuming zero discount rate)[d]
10	72.3	4.98	3.25	0.65	1.7	11.1
30	52.4	3.61	2.12	0.59	3.5	19.3
50	32.9	2.27	1.68	0.74	4.1	12.6
70	14.5	1	1	1		

The calculations are based on pedestrians and the full sample ($n = 1444$).

[a] Obtained from SCB (2000).

[b] The implicit relative value of saving a life-year of an individual of a certain age compared to the value of saving a life-year of a 70-year-old pedestrian, assuming zero discount rate.

[c] Calculated so that the present value of a saved life-year is the same as for saving a life-year for a 70-year-old pedestrian.

[d] The value of a saved life, *ceteris paribus,* in terms of the number of saved life-years, assuming zero discount rate.

Table 5
Calculations of the relative value per expected remaining QALY, implicit discount rates, and a parameter α that reflects the value of life, *ceteris paribus*

Age	Expected remaining QALYs[a]	Expected remaining QALYs relative to the ones at the age of 70	Relative value of life (from Table 2)	Relative value per remaining QALY[b]	Implicit discount rate for a constant present value of a QALY independent of age[c] (%)	Implicit quality-adjusted α (assuming zero discount rate)[d]
10	61.8	5.43	3.25	0.60	2.3	11.0
30	43.4	3.82	2.12	0.56	4.4	17.2
50	27.7	2.43	1.68	0.69	4.8	12.8
70	11.4	1	1	1		

The calculations are based on pedestrians and the full sample ($n = 1444$).

[a] The quality adjustments of life-years used in the calculations are from Brooks et al. (1991) as follows: 10–30 years, 0.92; 30–45 years, 0.875; 45–60 years, 0.835; 60–75 years, 0.805; 75-, 0.735. The values are averages for men and women.

[b] The implicit relative value of saving a quality-adjusted life-year of an individual of a certain age compared to the value of saving a quality-adjusted life-year of a 70-year-old pedestrian, assuming zero discount rate.

[c] Calculated so that the present value of a saved quality-adjusted life-year is the same as for saving a quality-adjusted life-year for a 70-year-old pedestrian.

[d] The value of a saved life, *ceteris paribus,* in terms of the number of saved quality-adjusted life-years, assuming zero discount rate.

value expressions rather than actual tradeoffs between the projects presented. For example, if respondents strongly believe that younger individuals should be given a higher priority, the opportunity to express this view in the survey should be provided. If respondents are asked only one question, for example whether ten 70-year-old individuals or one 30-year-old individual should be saved, they may choose the latter even if their 'true' ISWF corresponds to a lower ratio. A related issue is that a single-question approach is more sensitive to the tradeoffs included in the experiment from a purely statistical point of view (compare the literature on the design of closed-ended contingent valuation surveys in e.g. Alberini, 1995). It is also possible that very general descriptions of 'life-saving projects' such as those in Cropper et al. (1994) and Johannesson and Johansson (1997) may have induced some respondents to assume different diseases and/or accidents (and associated suffering) for different age groups. Although both of these studies are very innovative, our overall conjecture based on methodological reasons, as well as intuitive common sense reasoning and introspection, is that our results reflect people's underlying ethical preferences better than the previous studies.

6. Conclusions

This study has developed what could possibly be called a *Random Ethics Model*; a modification of the Random Utility Model that assumes that individuals maximise their subjective perception of social welfare, instead of their own utility. The model is applied by analysing life-saving road investment projects, where the main result is that the relative value of a saved life decreases with age in a pattern that is consistent with a discounted utilitarian model, with a pure rate of time preference of a few percent. An alternative interpretation discussed is that people may value saved lives *per se* to a certain degree in addition to saved life-years.

The observed pattern is quite consistent across groups of people, and does not differ much with respect to age, gender and whether or not children are part of the household. We believe that the estimates obtained here are quite reasonable as reflections of people's ethical preferences, and that the differences compared to the earlier mentioned more extreme results can largely be explained by methodological and design issues. That said, one should of course bear in mind that the results here too are based on people's stated responses. Even though we generally agree with Sen (1973, p. 258) that 'we have been too prone, on the one hand, to overstate the difficulties of introspection and communication and, on the other, to underestimate the problems of studying preferences revealed by observed behaviour,' there are still non-negligible potential problems with the former that may influence the results; cf. e.g. Bertrand and Mullainathan (2001). Still, we find it striking that the ethical preference patterns are very similar across sub-samples. For example, respondents of all ages, with or without children, responded in a way that is consistent with a monotonically decreasing value of a saved life with respect to age.

The results seem to give some implicit support for basing health care priorities on the benefits in terms of saved QALYs or life-years. Consequently, the results may also seem to imply an implicit criticism of basing life-saving benefits on the number of saved lives alone, which is a common practice in many countries e.g. when evaluating safety regulations. The result can also be interpreted as support for the European Commission (2001), which recommends its member countries to apply age-decreasing monetary values in cost–benefit analysis. Moreover, we also find that pedestrians are higher valued, which suggests that responsibility and/or vulnerability seem to matter in the valuation to a non-negligible extent (cf. Slovic et al., 1985; Mandeloff and Kaplan, 1989; Subramanian and Cropper, 2000).

However, even when disregarding scientific uncertainty, it is not obvious that these results should be applied in actual policy making, since one cannot readily derive a normative 'ought' from a positive 'is'. Indeed, some moral philosophers and politicians would disagree with the consequentialist ethics underlying the analysis in the first place. And to determine whether, and under what conditions, public policy should be based on individual WTPs or ethical preferences of the kind obtained here is clearly a non-trivial issue involving ethics, distributional effects and second-best considerations. Even though it is beyond the scope of this paper, this issue remains important for future research, since the priorities found can be quite different depending on the adopted approach.

Nevertheless, in either case we believe that the type of information obtained here is vital for policy makers, who may be interested in people's preferences for political economy reasons as well. Finally, and most importantly, we believe that the need for enlightened and rational decision-making is just as great, if not greater, in areas involving life and death, and where many of us may have strong ethical convictions.

Acknowledgements

We wish to thank Fredrik Carlsson, Thomas Sterner, seminar participants at Göteborg University and conference participants at Transport Forum, Linköping for valuable comments. Financial support from the Swedish Research Council is gratefully acknowledged.

References

Alberini, A., 1995. Optimal designs for discrete choice contingent valuation surveys: single-bound, double-bound and bivariate models. Journal of Environmental Economics and Management 28, 287–306.

Alberini, A., Cropper, M.L., Krupnick, A., Simon, N., 2004. Does the value of a statistical life vary with age and health status? Evidence from the U.S. and Canada. Journal of Environmental Economics and Management 48, 769–792.

Alpizar, F., Carlsson, F., Martinsson, P., 2003. Using choice experiments for non-market valuation. Economic Issues 8, 83–110.

Anand, P., Wailoo, A., 2000. Utilities versus rights to publicly provided goods: arguments and evidence from health care rationing. Economica 6, 543–577.

Ariely, D., Loewenstein, G., Prelec, D., 2003. Coherent arbitrariness: stable demand curves without stable preferences. Quarterly Journal of Economics 118, 73–105.

Arrow, K., 1963. Social Choice and Individual Values. Wiley, New York.

Babcock, L., Loewenstein, G., 1997. Explaining bargaining impasse: the role of self-serving biases. Journal of Economic Perspectives 11, 109–126.

Beattie, J., Covey, J., Dolan, P., Hopkins, L., Jones-Lee, M., Loomes, G., Pidgeon, N., Robinson, A., Spencer, A., 1998. On the contingent valuation of safety and the safety of contingent valuation. Part 1. Caveat investigator. Journal of Risk and Uncertainty 17, 5–25.

Bertrand, M., Mullainathan, S., 2001. Do people mean what they say? Implications for subjective survey data. In: American Economic Review, Papers and Proceedings, vol. 91, pp. 67–72.

Brooks, R.G., Jendteg, S., Lindgren, B., Persson, U., Björk, S., 1991. EuroQol, health-related quality of life measurement. Results of the Swedish questionnaire exercise. Health Policy 18, 37–48.

Broome, J., 1999. Ethics Out of Economics. Cambridge University Press, New York and Melbourne.

Broome, J., 2004. Weighing Lives. Oxford University Press, Oxford.

Carthy, T., Chilton, S., Covet, J., Hopkins, L., Jones-Lee, M., Loomes, G., Pidgeon, N., Spencer, A., 1999. On the contingent valuation of safety and the safety of contingent valuation. Part 2. The CV/SG "chained" approach. Journal of Risk and Uncertainty 17, 187–213.

Chilton, S., Covey, J., Hopkins, L., Jones-Lee, M., Loomes, G., Pidgeon, N., Spencer, A., 2002. Public perceptions of risk and preference-based values of safety. Journal of Risk and Uncertainty 25, 211–232.

Cookson, R., Dolan, P., 2000. Principles of justice in health care rationing. Journal of Medical Ethics 26, 323–329.

Cropper, M.L., Aydede, S.K., Portney, P.R., 1994. Preferences for life savings programmes: how the public discounts time and age. Journal of Risk and Uncertainty 8, 243–265.

Dolan, P., 1998. The measurement of individual utility and social welfare. Journal of Health Economic 17, 39–52.

Dolan, P., Olsen, J.A., 2001. Equity in health: the importance of different health streams. Journal of Health Economics 20, 823–834.

Dolan, P., Tsuchiya, A., 2005. Health priorities and public preferences: the relative importance of past health experience and future health prospects. Journal of Health Economics 24, 703–714.

Dolan, P., Shaw, R., Tsuchiya, A., Williams, A., 2005. QALY maximisation and people's preferences: a methodological review of literature. Health Economics 14, 197–208.

Easterlin, R.A., 1995. Will raising the incomes of all increase the happiness of all? Journal of Economic Behavior and Organization 27, 35–47.

Easterlin, R.A., 2001. Income and happiness: towards a unified theory. Economic Journal 111, 465–484.

European Commission, 2001. Recommended interim values for the value of preventing a fatality in DG Environment cost benefit analysis. Available on the Internet at: http://europa.eu.int/comm/environment/enveco/others/recommended_interim_values.pdf.

Hammitt, J.K., 2002. QALYs versus WTP. Risk Analysis 22, 985–1001.

Hammitt, J.K., 2007. Valuing changes in mortality risk: lives saved vs. life years saved. Review of Environmental Economics and Policy 1, 228–240.

Hammitt, J.K., Graham, J.D., 1999. Willingness to pay for health protection: inadequate sensitivity to probability. Journal of Risk and Uncertainty 18, 33–62.

Hammond, P.J., Fleurbaey, M., 2004. Interpersonally comparable utility. In: Barberá, S., Hammond, P.J., Seidl, C. (Eds.), Handbook of Utility Theory, vol. 2. Kluwer, pp. 1181–1285.

Harrod, R.F., 1948. Towards a Dynamic Economics. St. Martins Press, London.

Harsanyi, J.C., 1955. Cardinal welfare, individualistic ethics, and interpersonal comparisons of utility. Journal of Political Economy 63, 309–321.

Hausman, D.M., McPherson, M.S., 1993. Taking ethics seriously: economics and contemporary moral philosophy. Journal of Economic Literature 31, 671–731.

Johannesson, M., Johansson, P.-O., 1997. Is the valuation of a QALY gained independent of age? Some empirical evidence. Journal of Health Economics 16, 589–599.

Johansson, P.-O., 2002. On the definition and age-dependency of the value of a statistical life. Journal of Risk and Uncertainty 25, 251–263.

Johansson-Stenman, O., Carlsson, F., Daruvala, D., 2002. Measuring future grandparents preferences for equality and relative standing. Economic Journal 112, 362–383.

Kahneman, D., Knetsch, J.L., 1992. Valuing public goods: the purchase of moral satisfaction. Journal of Environmental Economics and Management 22, 57–70.

Kahneman, D., Tversky, A., 2000. Choices, Values and Frames. Cambridge University Press, Cambridge.

Kahneman, D., Slovic, P., Tversky, A., 1982. Judgement under Uncertainty: Heuristics and Biases. Cambridge University Press, Cambridge.

Kahneman, D., Ritov, I., Schkade, D., 1999. Economic preferences or attitude expressions?: an analysis of dollar responses to public issues. Journal of Risk and Uncertainty 19, 203–235.

Krupnick, A., Alberini, A., Cropper, M., Simon, N., O'Brien, B., Goeree, R., Heintzelman, M., 2002. Age, health and the willingness to pay for mortality risk reductions: a contingent valuation survey of Ontario residents. Journal of Risk and Uncertainty 24, 161–186.

Louviere, J.J., Hensher, D.A., Swait, J.U.D., 2000. Stated Choice Methods: Analysis and Applications. Cambridge University Press, Cambridge.

Mandeloff, J.M., Kaplan, R., 1989. Are large differences in lifesaving costs justified? A psychometric study of the relative value placed on preventing deaths. Risk Analysis 9, 349–363.

McFadden, D., 1974. Conditional logit analysis of qualitative choice behavior. In: Zarembka, P. (Ed.), Frontiers in Econometrics. Academic Press, New York.

Nord, E., 1994. The QALY—a measure of social value rather than individual utility? Health Economics 3, 89–93.

Nord, E., 1999. Cost–Value Analysis in Health Care: Making Sense Out of QALYs. Cambridge University Press, Cambridge.

Philips, P.R., Russell, I.T., Jones-Lee, M.W., 1989. The empirical estimation of individual valuation of safety: results of a national sample survey. In: Jones-Lee, M.W. (Ed.), The Economics of Safety and Physical Risk. Blackwell, Oxford.

Ramsey, F., 1928. A mathematical theory of savings. Economic Journal 38, 543–559.

Ryan, M., Gerard, K., 2003. Using discrete choice experiments to value health care programmes: current practice and future reflections. Applied Health Economics and Health Policy 2, 55–64.

Ryan, M., Netten, A., Skåtun, D., Smith, P., 2006. Using discrete choice experiments to estimate a preference-based measure of outcome—an application to social care for older people. Journal of Health Economics 25, 927–944.

SCB, 2000. Befolkningsstatistik 2000 (Population Statistics). SCB-Tryck, Örebro.

Sen, A.K., 1973. Behavior and the concept of preference. Economica 40, 241–259.

Sen, A.K., 1979. Personal utilities and public judgements: or what's wrong with welfare economics? Economic Journal 89, 537–558.

Slovic, P., Fischhoff, B., Lichtenstein, S., 1985. Regulation of risk: a psychological perspective. In: Noll, R. (Ed.), Regulatory Policy and the Social Sciences, California Series on Social Choice and Political Economy Berkeley. University of California Press, London, pp. 241–278.

Solnick, S., Hemenway, D., 1998. Is more always better?: a survey on positional concerns. Journal of Economic Behavior and Organization 37, 373–383.

Subramanian, U., Cropper, M., 2000. Public choices between life saving programs: the tradeoff between qualitative factors and lives saved. Journal of Risk and Uncertainty 21, 117–149.

Sunstein, C.R., 2004. Lives, life years and willingness to pay. Columbia Law Review 104, 205–252.

Viscusi, W.K., Aldy, J.E., 2003. The value of a statistical life: a critical review of market estimates throughout the world. Journal of Risk and Uncertainty 27, 5–76.

Williams, A., Cookson, R., 2000. Equity in health. In: Culyer, A.J., Newhouse, J.P. (Eds.), Handbook of Health Economics. Elsevier, Cambridge, pp. 1863–1910.

Zwerina, K., Huber, J., Kuhfeld, W.K.A., 1996. General method for constructing efficient choice designs, Working Paper, Fuqua School of Business, Duke University.