Journal of Risk and Uncertainty, 8:243–265 (1994)

Preferences for Life Saving Programs: How the Public Discounts Time and Age

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Key words: value of life, discounting, life-years saved

Abstract

In surveys of 3,000 households, we have found that people attach less importance to saving lives in the future than to saving lives today, and less importance to saving older persons than to saving younger persons. For the median respondent, saving six people in 25 years is equivalent to saving one person today, while for a horizon of 100 years, 45 persons must be saved for every person saved today. The age of those saved also matters; however, respondents do not weight lives saved by number of life-years remaining: For the median respondent, saving one 20-year-old is equivalent to saving seven 60-year-olds.

In a country that spends over 15% of its GNP on health and safety, the evaluation of programs that save lives is of paramount importance. Typically, health and safety programs are compared by computing the cost-per-life saved of each program—that is, the total cost of the program is divided by the number of premature deaths avoided. Two problems that arise in making such comparisons are (1) that programs may save lives at different times, and (2) that programs may prevent death at different ages, and thus save different numbers of life-years.

The first problem arises frequently in comparing environmental programs with other health and safety regulations. Most environmental programs save lives by reducing exposure to a pollutant, often a cancer-causing one, that would not have caused death until many years after exposure. Lives are thus saved in the future rather than today. The problem, however, is more general: Even a program such as mandatory air bags in automobiles, which will begin to save lives immediately, will save lives over a number of years. The question therefore arises: Should a life saved in the future be counted as equivalent to a life saved today?

The second problem—that programs save persons of different ages—occurs frequently when comparing health and safety programs. Programs to reduce deaths due to cancer clearly save fewer life-years per person than programs to reduce neonatal death rates or programs to reduce auto accidents. A typical method of controlling for differences in life-years saved is to divide program cost by the total number of life-years saved. This, however, implicitly values individuals in proportion to their life expectancies, a view that may not reflect society's preferences. Society may, for example, deem it more important to save the lives of persons raising young children than either the lives of the very old or the very young.

Our purpose in this article is to examine such preferences. Specifically, we report the results of asking over 3,000 members of the general public to choose between pairs of hypothetical life-saving programs. In some cases, the choices involved programs that would save persons at different points in time, while in others the choice was between programs that would save persons of different ages.

Our purpose in asking people to choose between programs that save different numbers of people at different points in time is to examine marginal rates of substitution for present versus future life saving.[1] We are interested in uncovering both implicit discount rates for future life saving and also the determinants of those rates. Concerning the latter, for example, what is the relationship—if any—between an individual's socioeconomic characteristics and the rate at which he is willing to trade off present for future life saving?

Another issue that we investigate is the relationship between people's discount rates for money and their discount rates for lives. Since it can be argued that lives saved in the future should be discounted at the same rate as costs (Keeler and Cretin, 1983), we are interested in finding out whether individuals' discount rates for money and lives saved are, on average, equal.

Our goal in asking people to choose between programs that save persons of different ages immediately is to infer rates of substitution between saving the lives of 60-year-olds and younger persons (specifically, 20-, 30- and 40-year-olds). There are two issues of interest here. One is whether the rate of substitution between saving persons of different ages is proportional to the ratio of life-years saved, the assumption made in comparisons of cost-per-life-year saved. The second is whether this rate of substitution varies systematically with the respondent's age: Is it primarily young people who feel that more weight should be given to saving the lives of the young than the lives of the old, or is this view held by all age groups?

With regard to discount rates for life saving, we find that individuals do, indeed, discount future lives saved. In fact, their discount rate for lives saved is almost as high as their real discount rate for money. The median respondent in our surveys requires that 2.3 lives be saved five years from now for every life saved today—a discount rate of 16.8%. (By contrast, the median rate at which respondents discount money over this period is 20%.) The median respondent requires that 44 lives be saved 100 years from today for every life saved today, implying a discount rate of 3.4% for a 100-year horizon.

Discount rates increase with age, and are higher for blacks than for other races. For horizons of 25 years or more, they are also higher for persons with minor children. This is consistent with the view that people wish to protect their children when they are children, rather than when they are adults.

The most striking finding with regard to saving persons of different ages is that the median respondent in our surveys places more weight on saving young persons than he would if people were weighted strictly by life expectancy: Eight 60-year-olds are judged equivalent to saving one 20-year-old, and seven 60-year-olds are judged equivalent to saving one 40-year-old. By contrast, eleven 60-year-olds are judged equivalent to saving one 30-year-old, suggesting that the utility attached to saving an anonymous life is a hump-shaped function of the age of the person saved. This finding, it is important to note, is independent of the respondent's age. While the number of 60-year-olds who must be saved for each younger person is higher for male respondents and respondents with a college degree, it is unrelated to age.

These findings are substantiated in the remainder of the article. In section 1, we describe a series of surveys we have administered over the past two years to elicit individuals' views about hypothetical regulatory programs. Section 1 also presents the statistical techniques used to estimate both discount rates for life saving and their determinants. Section 2 presents our findings about discount rates for lives saved and contrasts these with discount rates for money. Results pertaining to tradeoffs between people of different ages are presented in section 3. We offer some concluding observations in section 4.

1. Estimating marginal rates of substitution for saving lives

1.1. Description of the surveys

To measure the number of lives saved in the future that are equivalent to saving one life today, we confronted people with questions such as the following:

Question 1

> Each year some people in the United States may die as a result of exposure to certain kinds of pollutants. Unless there are programs to control this pollution, 100 people will die this year from pollution, and 200 people will die 25 years from now. The government has to choose between two new programs to control this pollution. The two programs cost the same, but there is only enough money for one.
>
> Program A will save 100 lives now.
> Program B will save 200 lives 25 years from now.
> Which program would you choose?[2]

To obtain more information about the respondent's preferences, Question 1 was followed by a question in which Program B was made more attractive if Program A was chosen in Question 1, and less attractive if Program B was chosen in Question 1.

Question 2

> Suppose Program A stayed the same. It will save 100 lives now. Program B, however, will save [*fill in Y*] lives 25 years from now. Which of the programs would you prefer?

The value of Y chosen was varied at random among respondents.[3] Questions 1 and 2 were followed by a "debriefing" question, in which the respondent was asked to explain the reasons for his choice.

In our first survey, approximately 1,000 Maryland households were asked Questions 1 and 2 as part of a larger survey on public issues—the Maryland poll—conducted by the University of Maryland Survey Research Center in November and December of 1990. Because our interest, initially, was in intergenerational preferences, half of the households received a time horizon of 25 years ($T = 25$) in both questions, while the other half received a 100-year horizon ($T = 100$). All households who chose Program A in both questions were asked to choose the best reason for their answers from a list of possible explanations.[4]

In March and April of 1991, 564 households in the Washington, D.C. metropolitan area received Questions 1 and 2 as part of the Washington poll.[5] Here, the structure of the questions was slightly different. In Question 1 each household was assigned one of ten values for future lives saved. The time at which future lives were saved was set at 50 years ($T = 50$). In Question 2, the number of lives saved by each program was kept the same as in Question 1, but T was increased to 100 for respondents who chose Program B in Question 1 and reduced to 25 for respondents who chose Program A. After answering both questions, respondents who either always chose Program A or always chose Program B were asked to explain the reasons for their choices.

Our third survey was administered to a national random sample of 1,000 households in September through November of 1991. Following a series of general questions on environmental issues, 496 of the households were confronted with a series of discounting questions in which the horizon was five years; the remaining households were presented with discounting questions in which the horizon was ten years. In addition to making choices between life-saving programs, households were asked to make two other types of choices: They were asked to choose between receiving \$10,000 now and a larger amount in either five or ten years, to enable us to infer discount rates for money. They were also asked to choose between a program that would save the lives of 60-year-olds and a program that would save either 20-year-olds or 40-year-olds.

1.2. Models used to analyze the data

In analyzing responses to our discounting questions, we assume that the respondent receives utility $U_A = aX$ from Program A and $U_B = bY$ from Program B, and chooses Program A if

$$aX > bY, \quad \text{which implies} \quad b/a \equiv z < X/Y.^{6} \tag{1}$$

z is the fraction of a person saved today, which is equivalent to saving one person at time T, or the marginal rate of substitution between lives saved today and time T.

We assume that there is a distribution of z values in the population, $F(z)$, and wish to estimate it. If z is a random variable, the probability that a randomly chosen person prefers Program A to Program B is

$$P(z < X/Y) = F(X/Y). \tag{2}$$

The functional form of F depends on the distributional assumptions made about z. Suppose that z has a lognormal distribution with mean μ_1 and variance σ_1^2 when the time horizon is T_1 years. Then

$$P(z < X/Y) = \Phi[(\ln[X/Y] - \mu_1)/\sigma_1], \tag{3}$$

where Φ denotes the standard normal cumulative distribution function. The parameters μ_1 and σ_1 can be estimated by maximum likelihood methods, since X/Y is varied across respondents in the survey.[7]

If one wants to avoid making an assumption about the distribution of z, one can estimate $F(\ )$ using sample proportions. A simple way to estimate the distribution of marginal rates of substitution is to face n_i people with a given ratio of X/Y, $(X/Y)_i$, and to record the number of persons in cell i who favor Program A. The proportion of persons in the cell who favor Program A, p_i, is an estimate of the value of the cumulative distribution of z, at $(X/Y)_i$, $F[(X/Y)_i]$. A nonparametric estimate of the distribution of (z) is obtained by plotting p_i against $(X/Y)_i$ for various $(X/Y)_i$ ratios.[8]

1.3. Testing discounting hypotheses

In addition to examining the distribution of marginal rates of substitution for a given horizon, we are interested in seeing how these change as the horizon changes. Because the number of persons who must be saved in the future (T) to equal one life saved today presumably increases with T, the distribution of z should shift to the left as T increases. One hypothesis which we are interested in testing is whether the distribution shifts in a manner consistent with constant exponential discounting. If people discount future lives saved at a constant exponential rate, the marginal rate of substitution between lives saved now and at T may be written

$$z = \exp(-\delta T). \tag{4}$$

Hence there is a one-to-one correspondence between the marginal rate of substitution z and the discount rate δ. The hypothesis that persons discount at a constant exponential rate can be tested by seeing whether the distribution of δ shifts with T.

Constant exponential discounting implies that the discount factor applied to a life saved at $T = 100$ to discount it to $T = 50$ is the same one applied to a life saved at $T = 50$ to discount it to the present ($T = 0$). The hypothesis that these two discount factors are equal has repeatedly been refuted in experiments involving the discounting of monetary payoffs (Horowitz, 1991; Lowenstein and Thaler, 1989; Thaler, 1981; Winston and Woodbury, 1991). In terms of the present example, this literature has found that the discount factor used to discount lives from $T = 50$ to $T = 0$ is greater than the discount factor used to discount lives saved at $T = 100$ to $T = 50$, suggesting that the discount rate falls over time.

We therefore examine the possibility that people discount lives saved at a non-constant exponential rate, i.e., that

$$z = \exp - \left\{ \int_{T_1}^{T_2} \delta(t) dt \right\}. \tag{5}$$

One possibility which we consider is that the discount rate declines linearly with time,

$$\delta(t) = \alpha - \beta t, \qquad \alpha, \beta > 0. \tag{6}$$

An alternative hypothesis is that the discount rate follows a rectangular hyperbola,

$$\delta(t) = \gamma. \tag{7}$$

To capture heterogeneity in preferences, we assume that α in equation (6) and γ in equation (7) are random variables that are independently and identically normally distributed in the population, with mean μ_α (μ_γ) and variance σ_α^2 (σ_γ^2). In the linear case, β, the slope of the discount rate function, is assumed to be identical for all persons.

The linear discount rate function is, of course, satisfactory only as an approximation to $\delta(t)$ over some range, since it eventually implies negative discount rates. The assumption that the discount rate follows a rectangular hyperbola, on the other hand, restricts discount rates always to be positive. The assumption that the discount rate follows a rectangular hyperbola is formally equivalent to Harvey's (1986) hypothesis that people discount the future at a constant relative rate (see also Ainslie, 1991). According to Harvey's hypothesis, the discount factor applied to lives at T_2 to discount them back to T_1 is

$$z = (T_1/T_2)^\gamma, \tag{8}$$

implying that the discount factor used to discount lives saved from $T = 100$ to $T = 50$ will be identical to the discount factor used to discount lives saved from $T = 2$ to $T = 1$.

In addition to testing hypotheses about the discount rate, we wish to see how the mean of the discount rate function varies with respondent characteristics. Discount rates may increase with age if individuals consider benefits to themselves in choosing among life-saving programs. Individuals with small children may be more future-oriented (have lower discount rates) than those without, although people with children may consider it more important to protect their children when they are young than when they are old. Accordingly, we allow μ_α and μ_γ to depend on respondent characteristics.

2. Public preferences for saving lives

Before testing discounting hypotheses, it is important to establish that the responses to our questions are reasonable: that people understood the questions they were asked and that they answered in a rational manner. Evidence that this occurred comes from two sources: a comparison of the responses of individuals faced with different time horizons and numbers of lives saved, and an analysis of people's stated reasons for their answers.[9]

2.1. Distribution of responses

If individuals are focusing on the number of lives saved, then one would expect the percentage of respondents choosing the present-oriented program to increase as the ratio of lives saved by that program (X), to lives saved in the future (Y), increases. An examination of figures 1 and 2 reveals that this is the case. Each curve in figures 1 and 2 shows, for a given time horizon, the proportion of persons who favored the present-oriented program at various X/Y ratios. We emphasize that, because different groups of people were confronted with different X/Y ratios, there is nothing to guarantee that the percentage of persons choosing the present-oriented program will increase as one moves along the horizontal axis. The fact that all four curves increase monotonically suggests that individuals in fact paid attention to the number of lives saved.

Figures 1 and 2 also suggest that individuals have considered carefully the time at which lives are saved. If one compares two groups of respondents who were confronted with the same X/Y ratio but different horizons, one would expect a larger percentage of the group with the more distant horizon to choose the present-oriented program. This is in fact the case: Curves for more distant horizons lie above and to the left of curves for shorter horizons.[10]

A further check on the reliability of responses lies in people's stated reasons for their answers. At the end of the Washington poll and the national survey, we asked people who always chose the present-oriented program or who always chose the future-oriented

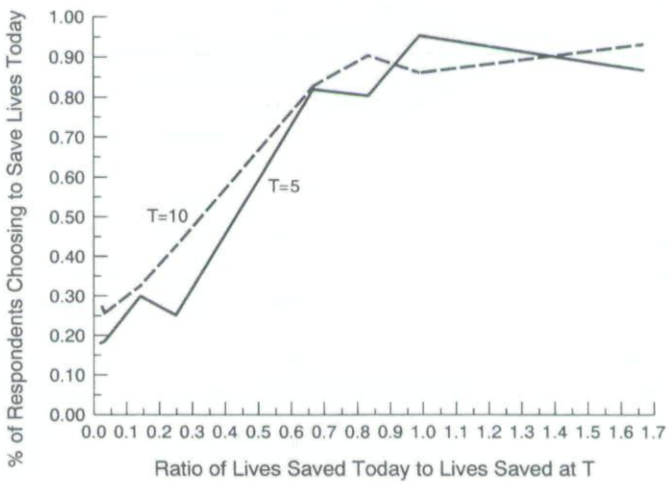

Figure 1. Percent of respondents choosing to save lives today rather than in Five Years or Ten Years

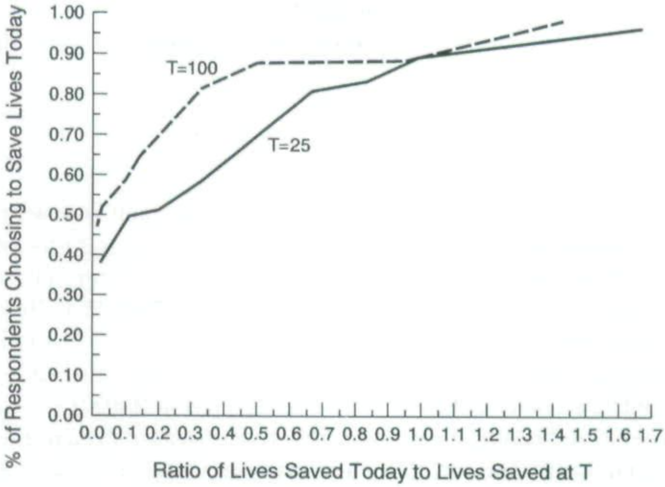

Figure 2. Percent of respondents choosing to save lives today rather than in 25 Years or 100 Years

program to state, in their own words, the reasons for their answers.[11] These are summarized in tables 1 and 2. Among the chief reasons for always preferring to save lives today are (1) that it is better to live for today, to solve today's problems; (2) that improvements in technology will allow future lives to be saved more cheaply than lives today; and (3) that the future is uncertain. Of these three reasons, only the second could possibly be challenged as a legitimate reason for preferring to save lives today. Since the goal of the

Table 1. Reasons for always choosing to save lives today

Reason	T = 5 and 10 Years Percent (National Survey)	T = 50 and 25 Years Percent (Washington Poll)
Technological progress provides means to save people in the future	22.8	31.3
One should live day by day	21.2	31.7
Future is uncertain	10.8	15.4
The life I save may be my own (or my Family is living now)	7.3	6.5
Present-oriented program saves more lives	1.2	1.6
Saving lives now means more lives in the future	5.4	2.8
Solve the problem now	9.7	—
Other	15.1	7.7
Do not know	6.5	2.9

Table 2. Reasons for always choosing to save lives in the future

Reason	T = 5 and 10 Years Percent (National Survey)	T = 50 and 25 Years Percent (Washington Poll)
Make the future better	34.4	50.0
Future-oriented program saves more lives	23.2	28.8
Other	21.6	17.6
Do not know	20.8	3.5

survey is to elicit people's preferences for saving lives, independently of cost considerations, people who cited technological progress as a reason for choosing the present-oriented program may not be answering the question that we intended them to answer. On the other hand, one could interpret references to technological progress as a reason for feeling that future generations should take care of themselves.

2.2. *Discount rates for life-saving*

What do the responses in figures 1 and 2 imply about discount rates for life saving?[12] If one translates the z distributions in figures 1 and 2 into distributions of discount rates for life saving, two results are apparent: (1) a significant fraction of our respondents have very high discount rates—18% have discount rates in excess of 72% for a horizon of five years, and 38% have discount rates in excess of 15% for a horizon of 25 years; and (2) approximately 10% of respondents have negative discount rates, i.e., they choose the future-oriented program even when it saves *fewer* lives.

That many people have high discount rates is apparent from the fact that, in both figures, a significant fraction of respondents continues to choose the present-oriented program as the ratio of X/Y approaches zero. In figure 2, when T = 100, 47% of our respondents prefer saving 100 lives today to 7,000 lives in the future. Similarly, 38% of respondents prefer saving 100 persons today to saving 4,000 persons 25 years from today. This implies that 47% of our respondents have a discount rate greater than 4.3% when the horizon is 100 years and that 38% have a discount rate greater than 14.8% when the horizon is 25 years. In figure 1, 28% of respondents have discount rates in excess of 39% when T = 10, and 18% have discount rates in excess of 72% when T = 5.[13]

At the other end of the spectrum, however, are respondents with negative discount rates, i.e., persons who prefer to save fewer lives in the future than are saved today. For each of the horizons in figures 1 and 2, approximately 10% of respondents have negative discount rates. People's stated reasons for preferring to save fewer lives in the future include a feeling of responsibility toward persons in future generations; however, we cannot rule out the importance of baseline risks in explaining these results. It may be the case that respondents, feeling that too little is currently being done to help future generations, chose the future-oriented program for that reason.

2.3. Do people discount lives saved at a constant exponential rate?

An interesting question is whether the distributions of discount rates corresponding to the z distributions in figures 1 and 2 are consistent with respondents discounting the future at a constant exponential rate. Table 3 presents the median discount rate for each horizon in our surveys, assuming that the future is discounted at a constant exponential rate over that horizon. Also presented are the mean and standard deviation of δ, assuming, for each horizon, that δ is normally distributed.[14] A glance at the table suggests that respondents do not, in fact, discount future lives saved at a constant exponential rate.[15] Median discount rates range from 17% for a five-year horizon to 3.7% for a horizon of 100 years. As has been found in the monetary discounting literature, the constant exponential discount rate declines with the length of the horizon.[16]

Two alternatives to constant exponential discounting that allow the discount rate $\delta(t)$ to decline over time are the linear discount rate function and a discount rate function that is a rectangular hyperbola. Table 4 indicates that fitting a linear discount rate function to horizons of five and ten years yields very different results than fitting a linear function to horizons of 25 to 100 years. The former is much steeper, with a mean discount rate of 34% at $T = 0$, and a mean discount rate of zero at $T = 11.65$. The function estimated using data from horizons of 25 to 100 years is much flatter, with a discount rate that does not reach zero until 122 years.

Table 3. Parameters of discount rate distributions assuming constant exponential discounting

		Raw Data	δ Normally Distributed	
Horizon	N	Median δ	μ_δ	σ_δ
$T = 5$	475	.168	.274	.314
			(16.6)	(22.8)
$T = 10$	480	.112	.179	.183
			(19.2)	(20.0)
$T = 25$	462	.074	.086	.083
			(19.0)	(15.3)
$T = 50$	528	.048	.068	.092
			(11.4)	(6.51)
$T = 100$	442	.038	.034	.026
			(21.5)	(13.7)

Note: $|t\text{-statistics}|$ appear in parentheses

Source: Data for $T = 5, 10$ come from the national survey; data for $T = 50$ from the Washington poll, and data for $T = 25, 100$ from the Maryland poll.

Table 4. Estimates of the linear discount rate function for saving lives, $\delta(t) = \alpha - \beta t$

	$T = 5$ and 10 Years (National Survey)	$T = 25$ and 100 Years (Maryland Poll)
Mean of α	0.3391	0.0866
	(12.1)	(21.0)
β	0.0291	7.12E–4
	(3.82)	(5.24)
Standard deviation of α	0.2568	0.0616
	(33.4)	(23.3)
N	955	904
Intercept	0.2923	0.0385
	(6.47)	(3.51)
Age in years	1.03E–3	6.86E–4
	(1.77)	(3.73)
Male	−0.0285	3.93E–4
	(1.49)	(0.08)
Married	−1.49E−3	5.65E−3
	(0.07)	(1.01)
Children ≤ 18 at home	0.0249	0.0145
	(1.13)	(2.54)
Black	0.0648	0.0303
	(2.42)	(4.49)
College degree	−4.36E−3	3.62E−3
	(0.19)	(0.62)
Income ≤ \$30,000	−3.87E−3	−1.85E−3
	(0.19)	(0.30)
β	0.0306	6.76E−4
	(3.93)	(4.71)
Standard deviation of α	0.2504	0.0608
	(32.7)	(22.4)
N	887	794

Note: Figures in parentheses are $|t$-statistics$|$.

The linear discount function results suggest that the discount rate declines at a decreasing rate, a fact consistent with the hyperbolic discount rate function. Results of fitting our data to the hyperbolic function are given in table 5. They indicate that the mean discount rate is 0.80 at one year and 0.08 at 100 years—rates far higher than those implied by the two linear functions.

It is, however, difficult to compare the fit of the two discount rate functions formally, since one function is not nested in the other. An informal comparison of the fit of the two functions is made in table 6, which compares the median number of lives that must be saved at various T, as predicted by the linear and hyperbolic discount rate functions, with the sample medians computed from raw survey data. The comparisons suggest that,

Table 5. Estimates of the rectangular-hyperbolic discount rate function for saving lives, $\delta(t) = \gamma/t$

	T = 5, 10, 25 and 100 years
Mean of γ	0.7965
	(37.6)
Standard deviation of γ	0.8040
	(41.4)
N	1,859
Intercept	0.4506
	(5.14)
Age in years	5.24E−3
	(3.65)
Male	−0.0497
	(1.11)
Married	0.0370
	(0.77)
Children ≤ 18 at home	0.1201
	(2.36)
Black	0.2801
	(4.57)
College degree	0.0277
	(0.54)
Income ≤ $30,000	1.33E−3
	(0.03)
Standard deviation of γ	0.7906
	(40.0)
N	1,681

Note: Figures in parentheses are $|t\text{-statistics}|$.
Source: Maryland poll (T = 25 and 100 years)
National Survey (T = 5 and 10 years)

Table 6. Median number of lives saved at T that are equivalent to saving one life today

T	Raw data	Linear $\delta(t)$	Rectangular-Hyperbolic $\delta(t)$
5	2	4	4
10	3	7	6
25	6	7	13
50	11	31	23
100	44	165	30

while the piecewise linear discounting function does a better job of predicting the median value of z^{-1} for horizons less than or equal to 25 years, the hyperbolic discount rate function fits the data better for horizons greater than 25 years.

2.4. *Factors affecting discount rates*

An issue that arises in interpreting discount rate results is whether the discount rate reflects pure altruism or also incorporates selfish concerns. Do individuals discount future lives saved because they or their families are unlikely to benefit from future life-saving programs or because they do not feel as close a kinship with future anonymous lives as with present anonymous lives?

One way of investigating this issue is to ask respondents whether, in answering our questions, they considered how the programs would affect them personally. At the end of the national survey, we asked respondents whether, in making their choices, they had considered the effect programs would have on them or their families. Forty percent of respondents said that they had; however, the probability that the respondent chose Program A was not significantly higher if he considered how the programs would affect him personally than if he did not.

An indirect way of investing whether responses reflect selfish concerns is to see if variation in responses can be explained by the respondent's age or by whether or not he has children. If older people are less likely to benefit from future programs, and responses are partly selfish, then older people should have higher discount rates than younger people. This should also be true of people with young children. A person with small children who is faced with a choice between a program that saves lives today and one that saves lives in 25 years is more likely to choose the former program—all else equal—if he is more concerned about protecting his children when they are children than when they are adults.

The lower portions of tables 4 and 5 present the effect of covariates on the discount rate for both linear and hyperbolic discount rate functions. In all cases, an increase in the age of the respondent significantly raises the discount rate. When the discount rate function is linear, an increase in age of ten years raises the discount rate by 69 basis points for horizons of 25 years or more and by 100 basis points for horizons of ten years or less. Having children under 18 at home raises the discount rate by 145 basis points for horizons of 25 years or more, but has no statistically significant effect for horizons of five or ten years. This is consistent with the hypothesis above: Five years from now one's children will still be children, and just as deserving of protection as they are now; 25 years from now they will be adults, and able to take care of themselves.

The only other demographic variable that consistently affects the mean of the discount rate distribution is race. Blacks have significantly higher discount rates than other races, a result that has also been found when it is money, rather than lives, that is discounted (Lawrence, 1991; Leigh, 1986). Because we have controlled for education (whether respondent has a college degree) and income (whether income is above or below

$30,000),[17] the race variable may reflect cultural factors or the fact that blacks have shorter life expectancies than whites.

What is perhaps surprising is that income and education have no effect on the discount rate. Further reflection, however, suggests that there is no reason why low-income persons, who have been found to discount monetary rewards more heavily than high-income persons, should discount lives at a higher rate.

2.5. Discounting lives versus discounting money

An individual's rate of substitution between lives saved now and in the future presumably reflects his ethical values and need not equal his discount rate for money. It is, nonetheless, of interest to see whether the two are correlated. An additional reason for comparing discount rates for lives and money is that, from a normative viewpoint, one can argue that a social planner should discount lives saved in the future at the same rate as he discounts the costs of life-saving programs (Keeler and Cretin, 1983). It is therefore of interest to see whether individuals' discount rates for life-saving are, on average, equal to their discount rates for money over the same horizon.

In our national survey, we asked respondents to imagine that they had won a lottery and confronted them with a choice between receiving a prize of $10,000 today or $30,000 in T years. The value of T chosen (either five or ten years) was the same value used in questions on life-saving programs. A follow-up question was asked, in which the future amount received was either raised or lowered based on the answer to the first question.

When the responses to the monetary discounting questions are used to estimate discount rate distributions, the similarity between the discount rate functions for money and for life-saving is striking. Under the assumption that the discount rate declines linearly over time, the discount rate function for money is given in table 7. The slope of this function and mean of its intercept are quite similar to those for discounting human lives. The one notable difference is that the standard deviation of the intercept of the monetary discounting function is much smaller than that of the discount rate function for human lives, suggesting that there is less variation in discount rates for money than in discount rates for human lives.

While the monetary discount rates in table 7 may seem high, they are not out of line with estimates imputed from individuals' purchases of energy-saving appliances (Hausman, 1979). They also agree with discount rates estimated from studies of reenlistment bonuses paid to military personnel (Cylke, Goldberg, Hogan, and Mairs, 1982).[18] Further evidence of the plausibility of our results comes from the relationship between discount rates and respondent characteristics.

Regarding the relationship between discount rates for money and lives, it appears to be the case that people with high monetary discount rates have high discount rates for life-saving. To test this hypothesis, dummy variables indicating the interval in which each respondent's monetary discount rate lies were added to the discount rate distribution in column 2 of table 4.[19] Respondents who always chose to receive $10,000 today have significantly higher discount rates for life-saving respondents in other categories.

Table 7. Estimates of the linear discount rate function for money, $\delta(t) = \alpha - \beta t$

	T = 5 and 10 years
Mean of α	0.3021
	(21.7)
β	0.0198
	(5.10)
Standard deviation of α	0.1285
	(23.0)
N	988
Intercept	0.1703
	(7.42)
Age in years	2.89E−3
	(8.72)
Male	6.82E−3
	(0.72)
Married	−2.34E−3
	(0.22)
Children ≤ 18 at home	0.0101
	(0.96)
Black	0.0515
	(3.76)
College degree	−6.44E−3
	(0.62)
Income ≤ $30,000	0.0142
	(1.37)
β	0.0225
	(5.94)
Standard deviation of α	0.1183
	(23.1)
N	912

Note: Figures in parentheses are $|t\text{-statistics}|$.
Source: National survey

3. Preferences for saving respondents of different ages

In the public health literature, life-saving programs are typically expressed in terms of the number of life-years saved: Each statistical life saved is weighted by the number of years of life remaining. One goal of our research is to see whether people implicitly use this weighting scheme in choosing between life-saving programs.

Letting X_i be the number of persons saved by program i and A_i the age of the persons saved, a possible form for the utility received from program i is

$$U_i = X_i[(80 - A_i)/\lambda]^\rho = X_i L_i^\rho, \qquad \rho > 0, \lambda > 0, \tag{9}$$

where L_i, the number of life years saved per person, is approximated by a linear function of age. If $\rho = 0$, then life years saved do not matter. If $\rho = 1$, programs are ranked solely on the basis of life-years saved. A value of $\rho > 1$ implies that younger people are weighted more than in proportion to life-years saved. This might reflect the view that quality of life diminishes as one ages; hence saving a person with 40 years of life remaining is more than twice as valuable as saving a person with 20 years of life remaining.

Preferences may, however, be more complicated than in equation (9). If, for example, society deems it more important to save a 30-year-old than a person who is 20 or 50—possibly because the 30-year-old is raising children—utility will be a hump-shaped function of the age of the victim. One utility function that allows middle-aged persons to be valued more highly than the old or the young is

$$U_i = A_i^{(\omega-1)} \exp(-\psi A_i^{\omega}) X_i, \qquad \psi > 0, \omega > 1. \tag{10}$$

In (10), ψ is a scale parameter and ω a parameter that determines the shape of the utility function. Equation (10) implies that there is a most preferred age for life-saving, A_i^*, where

$$A_i^* = [(\omega - 1)/\psi\omega]^{1/\omega}, \tag{11}$$

and which increases the larger is ω and the smaller is ψ.

To explore preferences regarding age, we faced respondents in our national survey, and half of the respondents in the Washington poll, with the following question:

Question 3

> Now I'd like to ask you about two medical programs to find cures for diseases. As you know, some diseases kill younger people, and some diseases kill older people. Suppose a choice must be made between two medical programs. The two programs cost the same but there is only enough money for one.
>
> Program A will save 200 lives from diseases that kill 20-year-olds.
>
> Program B will save [*fill in*] lives from diseases that kill 60-year-olds.
>
> Which program would you choose?

As in the discounting portion of the survey, this question was accompanied by a follow-up question in which the number of lives saved by Program B was increased if the respondent chose Program A in Question 3 and decreased if the respondent chose Program B.

The responses to the age trade-off questions in our national survey are summarized in table 8. In that survey the fraction of persons who wish to save younger persons generally increases as the ratio of young to old persons saved increases; however, the results are not strictly monotonic. A more surprising finding is that responses are almost identical regardless of whether younger persons are twenty or forty. If the distributions in table 8 are smoothed,[20] the median number of 60-year-olds who are equivalent to one younger person is approximately seven.

Table 8. Preferences for saving persons of different ages

No. of 60-yr-olds saved	No. of young persons saved / No. of 60-yr-olds saved	Proportion favoring saving of 20-yr-olds	Proportion favoring saving of 40-yr-olds
6,000	.033	.398	.396
3,500	.057	.448	.449
2,000	.100	.476	.393
1,000	.200	.557	.498
600	.333	.858	.833
400	.500	.852	.858
250	.800	.835	.887
100	2.000	.952	.915

The results in table 8 suggest that, in judging life-saving programs, the age of the victims clearly matters; however, most respondents do not weight people strictly by their life expectancy.[21] In the national survey, the program that saves 60-year-olds (Program B) saves more total life-years than the program that saves 200 20-year-olds, provided $X_B \geq 600$; Program B saves more life-years than the program that saves 200 40-year-olds as long as $X_B \geq 400$. Even when saving 200 40-year-olds saves only 7,600 life-years, and saving 6,000 60-year-olds saves 120,000 life-years, 40% of the respondents prefer saving the 200 40-year-olds. This suggests that, for most of the respondents, life-years saved per person receives a greater weight than is implied by the total life-years saved criterion.

The fact that 20- and 40-year-olds are treated similarly suggests, however, that a utility function such as (10) is more appropriate than (9). To estimate the parameters of (10), we assume that $\psi \sim N(\mu_\psi, \sigma^2_\psi)$ and use maximum likelihood methods. Pooling data from the national survey and the Washington poll, the results of maximum likelihood estimation suggest that $\omega = 2.6$ and $\mu_\psi = 1.04 \times 10^{-4}$, implying that the "most preferred" age at which to save lives is 28 years (see table 9). Table 9 also shows that the mean of μ_ψ is lower for men, for blacks, and for college-educated persons than for women, members of other racial groups, and persons without a college education. Persons in the first three groups thus have higher preferred ages for saving lives than their opposites.

4. Conclusion

The results presented in this article, because they rest on telephone surveys, may be viewed with skepticism by some researchers. We would be the first to admit that relatively brief (12–15 minute) telephone interviews are an imperfect vehicle for eliciting preferences with regard to choices as difficult as these. Furthermore, there is some evidence to suggest that the order in which questions were asked had a slight effect on the responses to our discounting question.[22]

On the other hand, the results reported here reflect consistent responses to our questions by over 3,000 households. Respondents have reacted in a sensible way to the number of lives saved and the time at which they are saved. Their reasons for preferring

Table 9. Estimates of the utility function for age of persons saved

Mean of ψ	1.04E−4 (51.2)
Standard deviation of ψ	6.09E−5 (26.9)
N	1,395
Intercept	1.12E−4 (20.9)
Age < 45	5.42E−7 (0.13)
Male	−1.40E−5 (3.45)
Married	1.39E−E (0.33)
Black	−8.86E−6 (1.86)
College degree	−1.42E−5 (3.22)
Income ≤ \$30,000	−2.23E−6 (0.51)
Standard deviation of ψ	5.98E−5 (25.9)
N	1,299

Note: Figures in parentheses are $|t\text{-statistics}|$.
Source: Washington poll (30 v. 60-year-olds)
National survey (20 v. 60 and 40 v. 60-year-olds)

to save lives now or in the future, and for preferring to save either younger persons or older persons, are, for the most part, reasonable.

For these reasons we believe that our findings, although preliminary, have important policy implications. In evaluating health and safety programs, some government agencies express mortality benefits in terms of life-years saved—as did the Food and Drug Administration in its Regulatory Impact Analysis of nutritional labelling requirements—while others do not—for example, the Environmental Protection Agency in its analysis of the benefits of banning asbestos in certain manufactured products. The results of our surveys suggest that the age at which premature deaths are averted should routinely be included as part of Regulatory Impact Analyses.

As for the discounting of lives saved, the Office of Management and Budget has for years argued that lives saved in the future should be discounted at the same rate at which costs are discounted. While the economic argument for this is sound, we find it comforting that the general public appears to agree with the discounting of future lives saved, and, furthermore, that its discount rate for life-saving is, on average, equal to its discount rate for money.

5. Appendix: statistical methods used to analyze double-sampled data

An advantage of asking dichotomous choice questions rather than open-ended (matching) questions is that the former are easier for respondents to answer (Tversky, Sattath, and Slovic, 1988). This advantage, however, comes at a cost: Open-ended questions provide a discount rate for each respondent. That is, if we know how many persons Program A must save to make the program equivalent to Program B, we know the value of b/a exactly for the respondent, and hence his discount rate. The answer to a choice question, however, indicates only that the respondent's discount rate is greater or less than a threshold amount. For example, if we know that the respondent prefers Program A to Program B at a given X/Y ratio, all we know is that $b/a < X/Y$.

The use of double-sampling—an initial dichotomous choice question, followed by a second question—provides more information than a single dichotomous question (Hanemann, Loomis, and Kanninen, 1991). For example, if we know that the individual prefers Program A at $X/Y = Z$, we can lower the X/Y ratio and see if he still prefers Program A. If at $X/Y = Z_d < Z$ the individual prefers Program B, then we know that his b/a value lies in the interval (Z_d, Z). If he still prefers Program A, we have lowered the upper bound on his b/a value from Z to Z_d. Similarly, if at $X/Y = Z$ the individual prefers Program B, we would raise X/Y to Z_u to make Program A appear more attractive, in an attempt to bound the respondent's marginal rate of substitution.

The responses to double-sampling questions can be analyzed using either parametric or nonparametric methods. We describe the analysis using parametric techniques first.

5.1. Parametric analysis of individual responses to double-sampled data

To continue the above example, there are four possible responses to the pair of questions confronting the respondent: AA, AB, BA, and BB, where "AB" signifies that the respondent chooses Program A in Question 1 and Program B in Question 2. Suppose that the respondent chooses Program A when $X/Y = Z$ *and* when $X/Y = Z_d$. The probability that he does so, assuming that b/a is distributed with cumulative distribution function F, is

$$\begin{aligned}\pi_{AA}(Z, Z_d) &= \Pr[(b/a) < Z \text{ and } (b/a) < Z_d] \\ &= \Pr[(b/a) < Z \mid (b/a) < Z_d]\Pr[(b/a) < Z_d] \\ &= \Pr[(b/a) < Z_d] \\ &= F[Z_d],\end{aligned} \tag{12}$$

since, with $Z_d < Z$, $\Pr[(b/a) < Z \mid (b/a) < Z_d] = 1$.

Similarly, it can be shown that

$$\begin{aligned}\pi_{AB}(Z,Z_d) &= F[Z] - F[Z_d] \\ \pi_{BA}(Z_u,Z) &= F[Z_u] - F[Z] \\ \pi_{BB}(Z_u,Z) &= 1 - F[Z_u].\end{aligned} \tag{13}$$

In this framework, the log likelihood function takes the following form,

$$\begin{aligned}\ln L = \sum_j & I(Z_j)\, \mathrm{I}(Z_{dj}) \ln \pi_{\mathrm{AA}}(Z_j, Z_{dj}) \\ & + \mathrm{I}(Z_j)\,[1 - \mathrm{I}(Z_{dj})] \ln \pi_{\mathrm{AB}}(Z_j, Z_{dj}) \\ & + [1 - \mathrm{I}(Z_j)]\, \mathrm{I}(Z_{uj}) \ln \pi_{\mathrm{BA}}\,(Z_{uj}, Z_j) \\ & + [1 - \mathrm{I}(Z_j)]\,[1 - \mathrm{I}(Z_{uj})] \ln \pi_{\mathrm{BB}}(Z_{uj}, Z_j),\end{aligned} \tag{14}$$

where $I(Z_j) = 1$ if Program A is chosen in Question 1, $I(Z_{dj}) = 1$ if Program A is chosen in Question 2 for those that chose Program A in Question 1, $I(Z_{uj}) = 1$ if Program A is chosen in Question 2 for those who chose Program B in Question 1, and j is the subscript indexing respondents. The parameters of $F(\ )$ can be estimated by maximizing (14).

5.2. *Nonparametric analysis of double-sampled data*

If one wants to avoid making an assumption about the distribution of the marginal rate of substitution between lives saved now and lives saved T years from now, a nonparametric method could be used to estimate the cumulative distribution function F( ). Following Kristrom (1990), one nonparametric method of estimating the cumulative distribution function for b/a is to use sample proportions.

In order to explain the computation of sample proportions for double-sampled data, let Z represent the value of X/Y in Question 1. Suppose Z is the same for all respondents. Further, let

W_1 = fraction of sample choosing Program A in Question 1 (Stratum 1)
W_2 = fraction of sample choosing Program B in Question 1 (Stratum 2).

Suppose that m different values of $Z, Z_1, Z_2, \ldots, Z_m$, are chosen in Question 2. Let n_{ik} be the number of persons in cell k from stratum i, $i = 1, 2$, and let p_{ik} be the proportion of these persons favoring Program A. $F(Z_k)$, the value of the distribution of b/a at Z_k, can be estimated by

$$\pi_k = W_1 p_{1k} + W_2 p_{2k}, \quad k = 1, \ldots, m. \tag{15}$$

If this sequence of proportions is monotonic and non-decreasing, then it provides a distribution-free estimator of the probability of choosing Program A.

Acknowledgements

This work has benefitted greatly from comments by Johnny Blair, Richard Carson, Bill Evans, John Horowitz, Ralph Keeney, Sam Kotz, Michael Jones-Lee, Mel McMillan, Robert Mitchell, John Mullahy, Wally Oates, Edgar Olsen, Stanley Presser, Howard

Raiffa, Richard Thaler, W. Kip Viscusi, and Richard Zeckhauser. Bill Evans deserves special thanks for writing the computer programs used to analyze our data, as does the National Science Foundation for its support under grant DIR-8711083.

Notes

1. While this may seem like an abstract question, it is not. In 1991, a U.S. Court of Appeals overturned regulations issued in 1989 by the Environmental Protection Agency (EPA) governing asbestos-containing products. Among the court's objections to EPA's regulations was the fact that the Agency had discounted the future costs associated with the regulations but refused to discount the lives that would be saved by the rules.
2. One of the characteristics of this question is that it is relatively context-free. It does not contain information as to how the two programs will save lives, other than by reducing exposure to pollution. In written pretests of our surveys, discounting questions were posed in the context of specific environmental programs such as hazardous waste disposal and drinking water cleanup. Unfortunately, respondents' choices between programs, such as incineration of hazardous waste versus land-based disposal, were not well behaved: The percentage of persons favoring the future-oriented program did not increase as the future-oriented program was made more attractive. An examination of respondents' stated reasons for their choices revealed that qualitative aspects of the programs—e.g., an aversion to incineration—dominated people's answers. To be able to isolate the effects of the length of the time horizon and number of persons saved from the qualitative aspects of the programs, abstract questions were used in the telephone surveys.
3. The gain in efficiency from using a double-sampling approach is described in Hanemann, Loomis, and Kanninen (1991).
4. A complete listing of the questionnaires administered in our surveys is available from the authors upon request.
5. The remaining respondents in the Washington poll were asked the age trade-off questions described in section 4 below.
6. We can allow for diminishing marginal utility of lives saved, i.e. $U_A = aX^n$ and $U_B = bY^n$; however, we cannot estimate n separately from z. Question 1 also prohibits estimating utility functions with an interaction term cXY. In written pretests of the questionnaire, however, we found that $c = 0$, and therefore abandoned more complicated questions (ones in which Program B saved lives today and at T) in favor of Question 1.
7. Because we used a follow-up question, the likelihood function to be maximized is more complicated than suggested by (3). Details are provided in the appendix.
8. The appendix describes how p_i is computed from double-sampled data.
9. We also examined the effect of altering the order of questions on individuals' response. Sensitivity to the order of questions is reported in an appendix available from the authors. We also resurveyed some respondents after the Washington poll to see how stable responses were over time. The results of this follow-up survey are also reported in this appendix.
10. In each figure, a Kolmogorov-Smirnoff test of the null hypothesis that the two distributions are equal can be rejected at the .01 significance level.
11. Debriefing questions were also asked at the end of the Maryland poll; however, respondents were given a set list of reasons to choose from.
12. To relate the responses in figures 1 and 2 to discount rates, recall that each curve in figures 1 and 2 describes the empirical distribution of z, the rate of substitution between lives saved now and in the future. For example, the fact that at $T = 25$ and $X/Y = .2$, 51% of respondents choose the present-oriented program implies that 51% of all respondents have z values less than .2 or, equivalently, discount rates greater than or equal to .0644, since $0.2 = \exp[-.0644(25)]$.
13. An interesting question is how many of these respondents would never choose the future-oriented program regardless of how many lives it saved. To answer this question, in our national survey we probed

respondents who initially chose the present-oriented program program to see if they would ever choose the future oriented program. 8.7% of persons faced with a five-year horizon and 12% of persons faced with a ten-year horizon said that they would never choose the future-oriented program regardless of how many lives it saved.

14. Quantile plots of the discount rate distributions in figure 2 suggest that δ is normally distributed.
15. Formal statistical tests confirm this hypothesis. Kolmogorov-Smirnoff tests of the null hypotheses that the following discount rate distributions are equal can be rejected at the .05 level: $F(\delta_5) = F(\delta_{10})$, $F(\delta_{10}) = F(\delta_{25})$, $F(\delta_{25}) = F(\delta_{50})$, $F(\delta_{50}) = F(\delta_{100})$.
16. The discount rates in table 3 are consistent with the rates at which workers discount future life-years saved, according to estimates obtained from labor market data by Viscusi and Moore (1989). The latter range from 1 to 14%, depending on the model used.
17. In eliciting income information, respondents were first asked whether their household income was greater or less than $30,000. This was followed by more detailed questions designed to place the respondent in a narrower income bracket. Many respondents refused to answer these follow-up questions; hence, to avoid deleting respondents from the analysis, only the initial income question was used.
18. Hausman (1979) uses data on purchases of room air-conditioners to estimate discount rates. Depending on the assumption made about the durability of the air-conditioners, the mean discount rate is either 15% or 25%. To infer the discount rate of Navy enlisted personnel, Cylke, Goldberg, Hogan, and Mairs (1982) compare two reenlistment bonus payment schemes—one where bonuses are paid in annual installments over the reenlistment period and another where the entire bonus is paid lump sum at the date of reenlistment. They estimate a discount rate of 20% for a four-year horizon when the probability of contract default is assumed zero.
19. Smoothing was done using the adjacent violator pooling algorithm (Kristrom, 1990).
20. Because each respondent answered two dichotomous choice questions, we know only the interval in which his discount rate falls, not the discount rate itself. Since two of these intervals are open intervals, it is preferable to use dummy variables rather than the midpoints of the intervals.
21. As the editor correctly pointed out to us, most people do not know life expectancy at different ages, and we did not give them this information in the surveys. In that sense, it is unfair to compare the weightings implied by table 8 with ratios of life-years saved. The weightings implied by the table are, however, so extreme—saving one 20-year-old is equivalent to saving seven 60-year-olds—that surely they do not correspond to people's beliefs about the ratio of life-years saved. (That is, most people would believe that saving a 20-year-old would save less than 7 times the life years as would saving a 60-year-old.)
22. In the national survey, half the respondents were given the monetary discounting questions first, and half were given the discounting lives questions first. The intercept of the discount rate function for saving lives was 0.37 for the first group and 0.30 for the second. People who received the discounting lives questions first thus had discount rates that were 20% lower than people who received the monetary discounting questions first.

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