The Importance of Cost and Effectiveness for Attitudes towards Lifesaving Interventions*

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Introduction

Several studies have reported large disparities in the cost per life saved for different lifesaving interventions. Such studies have been conducted in the U.S.,[1] the U.K.,[2] Japan[3] in Sweden.[4] Typically, results indicate that some interventions have benefits that outweigh the costs, i.e., a cost per life saved at or below zero, whereas others incur a cost per life saved in the range of hundreds of thousands or even hundreds of millions of dollars.

Our definition of a lifesaving intervention resembles that of Tengs et al.[5] A lifesaving intervention is defined as any measure directed

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1 John D. Graham, et al., *Evaluating the Cost-Effectiveness of Clinical Public Health Measures,* 19 **Ann. Rev. Pub. Health** 125 (1998); Tammy O. Tengs, et al., Five-hundred Life-saving Interventions and Their Cost-effectiveness, 15 Risk Anal. 369 (1995); Tammy O. Tengs et al., *Oregon's Medicaid Ranking and Cost-effectiveness: Is There Relationship?* 16 **Med. Decision Making** 99 (1996); John F. Ahearne, *Integrating Risk Analysis Into Public Policymaking,* 35 **Environment** 16 (1993); John F. Morrall, *A Review of the Record,* **Regulation** 25, Nov/Dec 1986; Bernard L. Cohen, *Society's Valuation of Life Saving in Radiation Protection and Other Contexts,* 38 **Health Physics** 33 (1980).

2 Barbara A. Soby, David J. Ball, Dawn P. Ives, *Safety Investment and the Value of Life and Injury,* 13 **Risk Anal.** 365 (1993).

3 Atsuo Kishimoto, *A Comparative Analysis of Cost-effectiveness of Risk Reduction Policies in Japan,* 8 **Japan. J. Risk Anal. 165**-(1997).

4 Joakim Ramsberg & Lennart Sjöberg, *The Cost-effectiveness of Lifesaving Interventions in Sweden,* 17 **Risk Anal.** 467 (1997); Lennart Sjöberg, Totta Ogander, **Att Rädda Liv — Kostnader och Effekter** (1994); Bengt Hellqvist et al., *Värdering av Risken för Personskador: En Jämförande Studie av Implicita och Explicita Värden,* **Ekonomiska Studier** 10 (1982).

5 Tengs, *supra* note 1, at 369.

towards changing the behavior and/or technology of individuals or organizations, where reducing the probability of premature death in a population is a primary goal or an effect of the intervention.

In a seminal article, Starr[6] concluded that divergent investments in risk reduction are roughly at a societal optimum. According to this view, society has arrived at this optimum by a trial-and-error process, in which people's preoccupation with the qualitative aspects of risk is reflected. However, as Graham and Vaupel[7] and Cropper and Subramanian[8] note, it is in no way obvious that current disparities in cost per life saved reflect public preferences.

Starr's conclusion has been debated at great length, and the cost per life saved of interventions have been suggested to vary for several other reasons. Brooks et al.[9] suggest that an intervention implementation can be driven by regulatory compliance issues, influential advocates associated with the project, an affordable budget, or politically visible risk addressed by the intervention. Cropper and Subramanian[10] argue that the manner in which the programs are funded can explain many of the differences. Although Graham[11] concludes that society may be concerned with values other than economic efficiency, he concedes that there might be serious imperfections in the political decision making process, leading to perverse variations in lifesaving investments. Graham hypothesizes that the political process devotes more attention to risks where the target population is politically organized, the costs of regulation are less visible, and the regulatory agency is subject to co-optation by the regulatee.

A few have attempted to study public preferences with respect to acceptable variation in the cost per life saved. Savage[12] found that

6 Chauncey Starr, *Social Benefit Versus Technological Risk,* 165 **Science** 1232 (1969).

7 John D. Graham & James Vaupel, *The Value of Life: What Difference Does It Make?* 1 **Risk Anal.** 89 (1981).

8 Maureen Cropper, Uma Subramanian, *Public Choices Between Life-saving Programs: How Important Are Lives Saved?* Policy Research Working Paper No. 1497 (1995).

9 D. G. Brooks, et al., *An Approach to Prioritizing Risk-Reducing Projects,* in Int'l Process Safety Managment Conference and Workshop (1993).

10 Cropper, *supra* note 8.

11 John Graham, *Some Explanations for Disparities in Lifesaving Investments,* 1 **Policy Studies Rev.** 692 (1982).

mean willingness to pay to reduce four different risks varied by a factor of three and that the variation was associated with the psychometric risk attributes dread and unknown.[13] Mendeloff and Kaplan,[14] and Cropper and Subramanian[15] have both examined the issue of acceptable variation in cost per life saved. The results in both of the latter studies indicate that the median respondent supports a variation factor of two or three in certain circumstances. In other words, a more publicly preferred program could be a third less effective at saving lives saved than a less preferred program and still be chosen in a pair-wise comparison.[16] A majority of the respondents however, were not willing to trade lives for qualitative characteristics beyond that point. Thus, the large variation that we see in actual costs per life saved, which varies by a factor of thousands or millions, could not be justified or explained in any of the studies.

Gregory and Lichtenstein[17] sought to determine which respondents would sacrifice lives for psychometric risk attributes, without trying to determine the accepted variation in cost per life saved. The results were mixed. Most respondents were willing to make some tradeoff, but a large group refused to make any tradeoff at all.

Hypothesis and Research Question

Thus, lay respondents have been found to accept or support a variation in cost per life saved factor of two or three in at least three well-conducted studies. However, the authors of this article feel that additional insight into the issue of accepted variation in cost per life

12 Ian Savage, *An Empirical Investigation into the Effect of Psychological Perceptions on the Willingness-to-pay to Reduce Risk,* 6 **J. Risk & Uncert.** 75 (1993).

13 *See* Paul Slovic et al., *The Psychometric Study of Risk Perception,* in **Risk Evaluation and Management, Contemporary Issues in Risk Analysis** 3 (1986), for a comprehensive discussion of psychometric risk attributes.

14 John M. Mendeloff, Robert M. Kaplan, *Are Large Differences in "Lifesaving" Costs Justified? A Psychometric Study of the Relative Value Placed on Preventing Death,* 9 **Risk Anal.** 349 (1989).

15 Cropper, *supra* note 8.

16 This was the Cropper and Subramanian study; Mendeloff and Kaplan did not use pairwise comparisons, but the intuition is the same.

17 Robin Gregory & Sarah Lichtenstein, A *Hint of Risk-Tradeoffs Between Quantitative and Qualitative Risk-Factors,* 14 **Risk Anal.** 199 (1994).

saved could be gained by incorporating the following three aspects into the context for evaluation:

1. We wanted respondents to evaluate a fairly large number of diverse programs; it might increase the degree of accepted variation.

2. We did not want respondents to choose between programs; this focuses on tradeoffs made when choosing one program over another. Consequently, in this setting, cost-effectiveness becomes very salient. In many instances people do not consciously choose between programs; more likely, they evaluate programs one at a time.[18] Further, when people form a preference or an attitude about a government program, they are frequently have information about neither the program's cost nor its cost-effectiveness. As a result, people often evaluate programs without important information.

3. We wanted to use the respondent's own primitive beliefs (perceptions) about cost, effectiveness and various qualitative attributes of the programs rather than imposing these on the respondent.

Our motivation for these design choices flows from the fact that any kind of preference-elicitation exercise is potentially sensitive to the question framing,[19] i.e., how the question is stated will affect the answer. Moreover, it is probable that preferences are formed by the valuation process.

Regarding preferences elicited in contingent valuation studies, one of the method's most vocal proponents, Hanemann,[20] has said that the subject need not have held these preferences before the survey was conducted. It is unnecessarily strict to require people to have well-defined preferences, "utility functions engraved in their brain",[21] — for perhaps previously unknown public goods. In fact, Hanemann goes on to say that according to modern neuroscience and cognitive psychology, people do not even have well-defined preferences for most ordinary market goods. This is not necessarily a problem; most empirical research is sensitive to the design of the instrument it uses and

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18 Michael F. Drummond, et al., *Methods for the Economic Evaluation of Health Care Programs,* **Oxford Medical Publications** (1997).

19 Baruch Fischhoff, *Value Elicitation: Is There Anything There?,* 46 **Am. Psych.** 835 (1991).

20 Michael W. Hanemann, *Valuing the Environment Through Contingent Valuation,* 8 **J. Econ. Perspectives** 19-(1994).

21 *Id.* at 23.

it would be surprising if the same was not true for preference elicitation. It does, however, raise the issue of how to frame the question correctly.

We hypothesized that respondents would accept a larger variation with our format. However, if our hypothesis was correct, it would still be an open question as to what format best describes underlying reality. We do believe that our framing captures some features of how real life preferences, or attitudes, might be formed and expressed. Yet, we recognize that, normatively, our format is inferior; this is not a way to elicit the public's well-considered preferences. In particular, a person's incorrect assumptions or beliefs about a certain phenomena might affect that person's actions. In such an instance, it is relevant to take the beliefs as given in a descriptive study. However, for our purposes, we are unaware of any reason to give beliefs moral or normative significance.

One problem with our approach is that it would be very hard to ground it firmly in utility theory. Instead of assuming that respondents have a utility function, we make the much weaker assumption that they have an attitude function. Utility functions are constructed from preferences, which always concern relations between objects. For preferences to be represented by a utility function, a necessary (but not sufficient) condition is that preferences are rational. Rational preferences are defined as being complete and transitive. Attitudes, on the other hand, can be directed towards single objects, which means that we do not have to assume rationality of the respondents. In particular, we do not have to assume transitivity, which has been a problem in earlier studies of similar issues. The transitivity assumption can, for example, be violated by framing effects, which often are present in contingent valuation studies. For our purposes, the study of attitudes seemed to be both feasible and sufficient to generate some interesting insights into what might be influencing (or not influencing) attitudes towards lifesaving.

Our particular interest in studying attitudes was to examine the importance of cost and effectiveness, as predictors of attitudes.

The Present Study

A straightforward way of obtaining attitudes in a survey setting is to ask the respondents to state the importance of an intervention.

Respondents are assumed to have an attitude function towards objects of the form:

$$A=\sum_{i=1}^{T} b_i e_i$$

where b is the belief about an aspect of the object and e is the importance weight of the aspect. A person might for example hold a belief about the content of sugar in grams in a chocolate bar and attach a certain importance to this sensation.[22]

Our additive attitude function lends itself easily to linear regression analysis. The regression coefficients we later will obtain can be interpreted as the importance weights e, from our model.

Our method is akin to the "headline-method" developed by Kahneman and Ritov.[23] An assumption behind our model was that people can evaluate lifesaving interventions without being given complete information about the intervention. This could be expressed as an assumption that people have attitudes based on underlying primitive beliefs about the lifesaving interventions. We presumed that the subjects had ideas about various qualitative and quantitative characteristics of the programs; we did not want to impose these upon the respondent and, as discussed earlier, we did not want to make cost-effectiveness a salient feature in the study.

Kahneman and Ritov justify the rudimentary amount of information (they gave even less information than we did) given to respondents by the hypothesis of process continuity. Errors and biases that affect quick and intuitive judgments are also present in more elaborate judgments.[24]

Apart from the cost and effect of the intervention, we wished to include other qualitative and quantitative characteristics of the risks in order to capture a large proportion of the variation in preferences for lifesaving interventions. Since our survey would be lengthy even without inclusion of risk characteristics, we chose to include only a small number of such variables.

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22 Martin Fishbein & Isac Ajzen, **Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research** (1975).

23 Daniel Kahneman & Ilsa Ritov, *Determinants of Stated Willingness to Pay for Public Goods: A Study in the Headline Method,* 8-9 **J. Risk & Uncert.** 6 (1994).

24 *Id.*

It is sometimes assumed that perceived level of risk is strongly correlated with demand for risk mitigation. However, Sjöberg[25] found that this is not necessarily true and that perceived consequences were a better predictor.[26] Therefore, we wished to include both probability and consequences in our analysis, both personal and societal. In addition we included variables representing individual control, and annual fatalities. Individual control is often assumed to be important; it also partly coincides with voluntariness.[27] Perceived annual fatalities was needed to assess the importance of effectiveness. An interesting finding by Fetherstonhaugh, et al.[28] was that respondents to a survey judged an intervention that saved the same number of lives more beneficial when fewer lives were at risk. That is, to save, e.g., 10 lives out of 100 at risk is more valuable than saving 10 lives out of 1000 at risk. This can be interpreted to mean that the respondents were putting a value on efficiency. This is a question we also were interested in. We assumed that these variables, together with socioeconomic background variables, would capture a large part of the variation in attitudes for lifesaving interventions.

Method

Sample and Response Rate

In May 1996, a questionnaire was mailed to a Swedish sample (N = 250), age 18 or older. It was randomly drawn from a probability sample of the Swedish population who had previously indicated willingness to participate in one more survey. Respondents received a lottery ticket worth SEK 25 (SEK 6.50 = USD 1) with the questionnaire. By July 1996, 189 responses were obtained (75.6%).

Questionnaire

The questionnaire had been tested in advance on a small group of subjects interviewed after responding to the questionnaire. Later, a focus group was conducted, and a pilot survey was sent out to 50

25 Paul Slovic, *Perception of Risk*, 236 **Science** 280 (1987).

26 Lennart Sjöberg, *Perceived Risk vs. Demand for Risk Reduction,* **J. Risk Research** (1997) in press.

27 Cass R. Sunstein, *Bad Deaths,* 14 **J. Risk & Uncert.** 259 (1997).

28 David Fetherstonhaugh, et al., *Insensitivity to the Value of Human Life: A Study of Psychological Numbing,* 14 **J. Risk & Uncert.** 283 (1997).

people. Data from the pilot study are not included in these analyses.

Table 1
Twenty different risks evaluated by respondents

Influenza	Smoking
Traffic	Radon
Drunken driving	Lightning
Dietary habits	Prostate cancer
Sun bathing	Radiology
Food additives	Domestic Violence
Car exhausts	Aids
Train accidents	Alcohol
Electromagnetic fields	Suicide
Fire in health care institution	Narcotics

The questionnaire was 37 pages in A4 format; 22 questions called for a total of 251 responses. Besides background data, respondents were asked for judgments concerning:

- personal and general probabilities and consequences of the 20 risks presented in Table 1.
- the annual fatalities in Sweden caused by those risks.
- the degree of personal control over those risks.
- 24 different lifesaving interventions regarding:
  - how desirable they are,
  - how many lives would be saved by them, and
  - their relative costs.

Results

Background Data

The background data show rather good agreement between the respondents and the general population in Sweden. However, compared to the national average, there were too many highly educated, too few unemployed and too many above-average income respondents. These differences call for caution when generalizing the findings from the study. However, they are not serious enough to question the whole study, especially since background data typically explain only a very small part of the variation in preferences for lifesaving interventions.[29]

Perceived Risks

We do not present the perceived risks as these are not of central interest to our study. As a result, we will use them only as explanatory

[29] Lennart Sjöberg, *Demand For Risk Reduction,* **Meeting Organized by Society for Risk Analysis - Europe: Risk in a Modern Society: Lessons from Europe** (1996).

variables. Moreover, the overall pattern they display, that people tend to rate personal risk as lower than general risk, is a result that has been replicated numerous times.[30] This tendency has been called optimist bias.[31] Now, risk has two components; the probability of a negative event and the consequences of the negative event. In the present questionnaire, we made an attempt to separate the probability and the consequence of a negative event and we found, as expected, that for most risks people rated both the probability and the severity of the consequences as larger for the general public than for themselves.

Annual Fatalities

In an open-ended question, the respondents were asked to assess the annual number of fatalities from the different risks. The overall pattern is that the subject's estimates of annual fatalities was reasonably realistic, apart from the tendency to overestimate small risks and underestimate large risks.

The Interventions

In the next section of the questionnaire, the 24 lifesaving interventions listed in Table 2 were evaluated by respondents. In the questionnaire, the risk addressed by the intervention was also briefly described.Table 2

The 24 Lifesaving Interventions Evaluated

1. Vaccination against influenza for the whole population in Sweden. *Influenza vaccination*
2. A special education program on suicide prevention for general practitioners. *Suicide prevention.*
3. Medical treatment for high levels of cholesterol. *Cholesterol treatment*
4. Information campaign against malignant melanoma. *Melanoma campaign*
5. Information campaign regarding indoor radon. Radon information
6. Start enough treatment centers to give all alcoholics who wish adequate care. *Alcohol treatment*
7. Concrete barriers between sections of all divided highways. *Barriers*
8. Double the resources for the police to control drunken driving. *Drunken driving*
9. An 18 years age limit on smoking combined with information campaigns against smoking among children and the young. *Age limit on smoking*
10. Preventive fire protection in all health care institutions. *Fire protection*

Continued

30 Lennart Sjöberg, *Determinants and Consequences of Perceived Risk,* **Meeting Organized by Society for Risk Analysis-Europe: Risk in a Modern Society: Lessons from Europe** (1996).

31 Neil D. Weinstein, *Optimistic Bias About Personal Risks,* 246 **Science** 1232 (1989).

11. Protective measures against electromagnetic fields in the work place for groups exposed to strong electromagnetic fields. *Work-EMFS*
12. Move all day-care centers that are exposed to electromagnetic fields from power lines. *Child-EMFS*
13. Mandatory child-proof lids on all wells. *Lids*
14. A special "security package" to all women who are threatened by severe domestic violence. In some cases a life guard or a specially trained dog may be considered. *Security packages*
15. Use coal-fiber cassettes in radiotherapy, whenever possible. *Coal-fiber cassettes*
16. Mass detection program for prostate cancer for men aged 50 and over. *Prostate cancer screening*
17. Virus-decontamination of all donated blood to protect patients against, e.g., AIDS. *Virus-decontamination*
18. Reconstruct 50% of all train tunnels to facilitate evacuation and increase accessibility for the rescue forces in case of a fire. *Tunnels*
19. Start enough treatment centers to give all drug addicts who wish adequate care. *Narcotics treatment*
20. Require all new lamp posts that are erected along the roads to have a "slip-base". *Lamp posts*
21. An annual quit-and-win contest for smokers combined with a large information campaign against smoking. *Quit-and-win*
22. Reduce car exhausts by 50% through tighter standards. *Reduce car exhausts*
23. Double the resources for research on, and testing of, food additives to detect carcinogenic substances. *Food additives testing*
24. Information campaign about lightning and subsidize lightning conductors. *Lightning prevention*

Importance of the Intervention

First, the importance of interventions was rated on a scale from 0 to 6 (should definitely *not* be to definitely *should* be implemented). Respondents were told that these were to be implemented by local or national governments. Results are in Table 3.

Cost

The cost of the interventions was the single most interesting explanatory variable for our purposes. The alternatives at hand for dealing with the cost of interventions seem to either present a cost for each intervention or to let the respondent assess the cost of the intervention. The main problem with the first approach is that the subject's attitude towards the intervention could be influenced by his perception of the total cost, a factor that would be lost if a cost is given. Also, it is possible that the respondents would not believe any cost factor that is portrayed as true.

Table 3
Rated Importance of 24 Interventions on a 0–6 Scale

Variable	*Mean*
Virus decontamination	5.42
Fire protection	4.81
Age limit on smoking	4.75
Lids	4.60
Child-EMF	4.56
Security packages	4.54
Work-EMF	4.42
Prostate cancer screening	4.40
Coal-fiber cassettes	4.39
Radon information	4.37
Drunken driving	4.35
Melanoma campaign	4.27
Reduce car exhausts	4.13
Quit-and-win	4.05
Food additives testing	3.95
Lamp posts	3.84
Cholesterol treatment	3.65
Alcohol treatment	3.53
Narcotics treatment	3.46
Suicide prevention	3.19
Tunnels	3.03
Barriers	2.95
Lightning prevention	2.24
Influenza vaccination	1.46

The second approach captures respondents perception of cost. The major disadvantage is of course that it may be hard to construct a question that can be understood and answered by the subjects. In an attempt to solve this problem, we have used a pair-wise comparison format for determining the perceived relative costs of the interventions.

The respondents are presented with several pairs of interventions to evaluate with respect to cost. If there is a large number of stimuli to evaluate, people are in general not capable of giving adequate reports of the perceived difference in their strength. To circumvent this problem, stimuli can be presented in pairs. This procedure was originally

developed for physical stimuli, such as the intensity of light, but it has also been used to measure social phenomena.

There are several scaling methods that assume that the subject can give valid reports of ratios between subjective magnitudes.[32] The instructions usually require the subject to report one or two numbers that reflect the ratio between two subjective magnitudes. In our application, the respondent is asked, in each pair, to choose the intervention which they believe is the most expensive. That intervention is given the number one hundred. The respondent is then asked to assign the other intervention a number between zero and one hundred that reflects the relative cost of that intervention as compared to the more expensive one. This is repeated for a number of pairs. Ideally, all possible pairs should be evaluated by all respondents, but that would be too strenuous on the respondents (since the number of pairs would be quite large). Fortunately, it is not necessary to evaluate all pairs in order to construct the whole matrix of magnitudes; the diagonal is sufficient.

It is assumed that the subject's response is a correct estimate of the ratio between the subjective magnitudes. This assumption was called the ratio assumption in Sjöberg.[33] Furthermore, it is assumed that each stimuli gives rise to one, and only one, subjective magnitude regardless of what other stimuli it is compared with. This assumption is called the invariance assumption.[34]

The ratio assumption is mostly technical; if a subject reports that he thinks one object is, for example, twice as heavy as another, we can see no compelling reason to believe that he really thinks otherwise. It does not matter what the actual weight is, the assumption concerns the subjective magnitudes. The invariance assumption is a bit stronger. The subjective magnitude of how sweet a chocolate bar is could possibly be different if the chocolate is compared to a lemon instead of honey. However, because we asked the subjects to compare costs, the invariance assumption seems reasonable. In particular; if a subject thinks a chocolate bar costs one dollar, that should not change when it is compared to a jar of honey instead of a lemon.

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32 Lennart Sjöberg, *Three Models for the Analysis of Subjective Ratios,* 12 **Scandinavian J. Psych.** 217 (1971).

33 *Id.*

34 *Id.*

Let w_{ij} be the reported ratio between two subjective magnitudes. Our model then assumes that

(1) $$w_{ij} = R_i/R_j$$

where R_i and R_j are subjective magnitudes corresponding to stimuli i and j. In general, it can not be assumed that the report is error-free and thus, an error term will be needed in practical applications. This model implies that:

(2) $$w_{ij} w_{jk} = w_{ik}$$

From equation (1) it can be seen that

(3) $$\log w_{ij} = \log R_i - \log R_j$$

When the model is expressed in linear form, as here, it is possible to use linear regression procedures to estimate the parameters. We need to give the solution entirely in terms of the observed w'_{jk}, and to do this it is necessary to specify a unit of measurement. If $\log R_1 + \log R_2 + ... + \log R_n$ is set to 1, the system of equations can be described as

log (R2/R1) = log R2 - log R1
log (R3/R1) = log R3 - log R1
log (Ri/Rj) = log Ri - log Rj
log (Rn-1/Rn) = log R4 - log Rn
log (0) = log R1 + log R2 +... + log Rn

In matrix form the model can be expressed:

(4) $$AR = w +$$

where the matrix A defines the right-hand side equations to be determined and all its entries are -1, 0 or +1. For n = 5 this identity matrix would, as an example, be:

-1	1	0	0	0
-1	0	1	0	0
0	-1	1	0	0
0	-1	0	1	0
0	0	-1	1	0
0	0	-1	0	1
0	0	0	-1	1
1	1	1	1	1

The vector R has the entries $(R_1, R_2,...,R_n)$. The vector w contains the log ratios and e the errors. The standard least squares estimate of R is:

(5) $$r = (A'A)\text{-}1A'w.$$

The required inverse exists because of the prior specification of a unit. The estimated scale values (R'_i) themselves are given by the antilogarithms of log R'_i. The estimated scale values do not contain any cardinal information about actual interventions cost. Scale values reflect the respondent's perceived relative cost of the interventions and the means of these are presented in Table 4, where the cost of the least expensive intervention has been normalized to 1.

Table 4

Mean Estimated Relative Cost and Lives Saved for the 24 Interventions

Intervention	*Mean cost*	*Mean number of lives saved*
Tunnels	47.32	59
Narcotics treatment	32.76	419
Alcohol treatment	22.93	616
Barriers	19.93	136
Child-EMF	11.39	86
Influenza vaccination	8.22	733
Reduce car exhausts	7.54	237
Drunken driving	6.44	213
Prostate cancer screening	5.05	370
Lamp posts	4.41	112
Food additives testing	3.49	285
Work-EMF	2.98	76
Fire protection	2.95	54
Virus-decontamination	2.78	175
Cholesterol treatment	2.58	1,737
Security packages	2.07	91
Suicide prevention	1.93	240
Quit-and-win	1.85	508
Coal-fiber cassettes	1.83	52
Lids	1.58	22
Lightning prevention	1.56	15
Age limit on smoking	1.46	1,394
Melanoma campaign	1.15	199
Radon information	1.00	186

Quite a large number of responses were missing from the data. If more than 20% of the responses, i.e., more than nine pairs, were

missing from a case, it was deleted. If less than nine pairs were missing the values of the missing entries were calculated using the relationship in equation (2). In all, 38 cases were deleted and 36 calculated ratios were entered.

Note that the variation is about 1:50, a rather large number. The present design maximizes the chances of measuring a large range in perceived cost.

The Number of Lives Saved

In an open ended question, the respondents were asked to estimate the annual number of lives saved by the interventions. The result is presented in Table 4, together with the estimated costs.

Analyses

Accepted Variation in Cost Per Life Saved

To examine the variation in cost per life saved that was implicitly accepted by the respondents, the ratio of the highest and lowest cost per life saved was calculated for all interventions that had a rating of five or six on the importance scale. This is a conservative estimate of the accepted variation in cost per life saved, because a value of three indicated that the interventions probably should be implemented and a six indicated that the intervention should definitely be implemented. The cost per life saved was computed as the relative cost of the intervention divided by the number of lives saved. Note again that the number in itself did not contain any cardinal information about the subjects' beliefs about the real costs. The median variation factor was 97. This reveals that 50% of the respondents would accept that the most expensive intervention costs 97 times as much as the least expensive. The percentiles are presented in Table 5.

Table 5
Factor of Variation in Accepted (rated 5 or 6 on 0 –6 scale) Variation in Cost per Life Saved for the 5, 10, 25, 50, 75, 90 and 95 Percentiles of Respondents

Percentile	5	10	25	50	75	90	95
Variation Factor	6	10	21	97	341	1,324	2,270

The distribution shows an interesting skewness (5,58). There seems to be a group of respondents who put very little weight on the cost-effectiveness of the interventions. About 10% of the respondents accept what must be called an extremely large variation in cost per life saved. This observation was also made by Gregory and Lichtenstein[35] and was further confirmed by Cropper and Subramanian.[36] It becomes even more clear in the extreme values, which are presented in Table 6. To let the cost per life saved vary with a factor 97, like the median, may also seem like a very large variation, but compared to the actual variation in cost-effectiveness of lifesaving interventions, it is in fact not.

We want to apply extreme caution in interpreting these results. A variation with a factor 97 can mean, for example, that the least expensive intervention is perceived to cost $1 million per life saved and the most expensive $97 million per life saved, a difference of $96 million. But it could also mean that the least expensive intervention is perceived to cost $1,000 per life saved and the most expensive $97,000 per life saved, a difference of only $96,000. We have no ground whatsoever to speculate on what kind of absolute values the subjects had in mind when answering the questions, because there is no baseline in our cost-question. However, the same is true for the Mendeloff and Kaplan, and Cropper and Subramanian studies.

Table 6
Factor of Variation in Accepted (rated 5 or 6 on 0 –6 scale) Cost per Life Saved

Five highest	*Five lowest*
12,311.00	1.62
11,806.67	1.71
5,873.50	2.34
3,840.00	3.79
3,832.00	4.31

The Importance of the Attributes

A number of analyses were carried out to examine the importance of cost, effectiveness, the qualitative attributes and background variables

35 Gregory, *supra* note 17.
36 Cropper, *supra* note 8.

for the rated importance of the interventions. All regressions were run with Importance of intervention as the independent variable.

Linear Regressions on the Individual Data

We analyzed the individual data, first by means of linear and then of logistic regression. The highest adjusted R_2 we could achieve was 0.27, which was obtained for a regression on the importance of the intervention Lightning prevention, with outliers eliminated.[37] In most of the 24 regressions, the adjusted R_2 was typically in the range 0.05-0.15. This is not satisfying because it means that one or more important explanatory variables were not included in the model and these omissions affect the power of the significance tests to an unknown extent. At the same time it is not surprising; regressions on individual data frequently generate low values of R_2.

Regarding the individual independent variables, we note several results. Background variables like *age, sex, income* and *place of residency* did not explain much variation, as expected, although *age* and *sex* were significant in several regressions. For the variables *cost, severity of the consequences for people in general, effectiveness of the intervention, and individual control,* the number of regressions, out of the total 24, in which the variable was significant at 1, 5 and 10% are presented in Table 7. Generally, we found low values for all the independent variables. Sometimes, coefficients had an unexpected sign. *Severity of the consequences for people in general,* as opposed to *personal consequences,* was the strongest explanatory variable. The variable was significant at the 5% level in 12 of 24 regressions. This is in accordance with earlier findings. *Effectiveness of the intervention* had some importance and was significant at the 5% level in 6 regressions, but generally had low values. *Cost* was insignificant in most regressions and had low values, sometimes with the wrong sign. This supports our hypothesis that cost is not a strong determinant of people's attitudes towards lifesaving interventions. *Individual control* also turned out to be insignificant in most regressions.

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[37] An even higher adjusted R2 of .42 was achieved when we ran the regression on the aggregated data, i.e. the means, instead. This was expected because some of the errors cancel each other in the means. The adjusted R2 is better than what was reported by Mendeloff and Kaplan, supra note 14, which is the only comparable study. They found an adjusted R2 around .30. However, we do not believe this is the best way of using the data. Instead, regressions should be run on the individual observations.

Table 7
Number of Regressions out of 24, in Which the Variable Was Significant at the 1, 5 and 10 % Levels

Independent variable	
Cost	Significant at 5% in 1 regression Significant at 10% in 1 regression
Effectiveness	Significant at 1% in 2 regressions Significant at 5% in 4 regressions Significant at 10% in 1 regression
Consequence for people in general	Significant at 1% in 8 regressions Significant at 5% in 4 regressions Significant at 10% in 2 regressions
Control	Significant at 1% in 1 regression Significant at 5% in 1 regression Significant at 10% in 1 regression

We note that different explanatory variables were significant in different regressions. The explanation for this is that our approach analyses why different people judge one and the same intervention differently; it is not surprising that a single model fails to explain individual differences in attitudes towards all 24 interventions. It is, for example, conceivable that men would think that an intervention against prostate cancer is more important than women do, but we do not expect a gender difference in attitude towards, for example, an indoor-radon intervention.

Logistic regression

The dependent variable, i*mportance of the intervention,* was treated as a continuous variable in the linear regressions. However, the variable was not actually continuous, as it was constructed as a scale with seven steps. It has been argued that seven steps is enough to permit this assumption of continuity.[38] Even so, a minimal precaution is to test if the results change if a logistic regression is performed. To that end, *importance of the intervention* was transformed to a binary variable, which corresponds to a referendum format, where 0 represents

[38] Eli P. Cox III, *The Optimal Number of Response Alternatives For a Scale: A Review,* 17 **J. Market. Research** 407 (1980).

that the intervention should *not* and 1 that intervention *should* be implemented. The logistic regression on this variable overall showed similar results, except that *effectiveness* had very high odds in some regressions. *Cost* did not prove to be more significant or explain more of the variation in this format.

Conclusions

The median respondent implicitly accepted that the cost per life saved varied by a factor of 97. This is considerably more than shown in other studies and is almost certainly an effect of the chosen format for assessing accepted variation — intended as a more realistic portrayal of attitude formation rather than as a normative guide.

The general conclusions of the analyses of the effect of our explanatory variables on the attitudes are that Cost did not have a strong influence on the rated importance of a lifesaving intervention and was most often not significant. Effectiveness of the intervention and consequences for people in general were the most significant and strongest explanatory variables.

To speculate a bit, nothing in our study rejects the explanation that costs per life saved vary because decision makers are influenced by the attitudes of the general public and that the general public does not place much weight on cost or cost-effectiveness, with the implication that it implicitly would accept huge variations in cost per life saved. In some earlier studies public preferences have been recognized to play a fundamental role in political decision making on risk mitigation.[39] Governments, at least in the U.S., have even been found to be predominantly reactive rather than proactive with respect to risk mitigation. With the words of Shubik: "Once a large enough political constituency appears to be actively upset... the politicians may react. Once the politicians have reacted sufficiently, the bureaucracy may respond."[40] Sjöberg found that local politicians in Sweden had attitudes to risk very similar to the general public's, and their demand

[39] Martin Shubik, *Risk, Society, Politicians, Scientists and People,* **Risk, Organizations and Society** (1991); Jan A. Stolwijk & P. F. Canny, *Determinants of Public Participation in Management of Technological Risk,* **Risk, Organization and Society** 33 (1991); Anthony Barker, *Expert Advice and Formal Public Involvement on Public Policies Involving Risk, Organizations,* **Uncertainties and Risk** 207 (1992).

[40] Shubik, *supra* note 39, at 10.

for risk reduction was strongly influenced by their perception of the public's demand for risk reduction.[41]

Overall, the results are somewhat disappointing. We were unable to explain the variation in preferences over lifesaving intervention. However, previous researchers have also had only limited success.

We would like to point out that our format for assessing the perceived cost of the intervention allows a large variation in the costs. This has not previously been done and is a methodological contribution that could be of some use. It would however be more useful if a meaningful base level could be established, such as expressing one of the costs in dollars, and the rest in relation to this value.

Limitations

We do not know the extent to which attitudes we obtained are actually expressed in public or private. The relevant attitudes to study would of course be those expressed because only those conceivably affect policy making. Attitudes expressed in public or private should be contrasted with attitudes or preferences revealed from actual decisions. It does not even have to be held internally.[42] At any rate, we do not know the connection between attitudes and decision making, which clearly limits our ability to draw firm conclusions.

Also, our survey was already too extensive to include all relevant variables. We would probably have been able to explain a larger proportion of the variation in rated importance of the interventions if we had also included the following variables which were found to be significant by Cropper and Subramanian:[43] fairness of the funding mechanism, appropriateness of government intervention,[44] and time lag before lives are saved. More investigation of these variables is recommended.



41 Lennart Sjöberg, *Risk Perception by Politicians and the Public*, Risk Research Report No. 26 (1996).

42 *See* Timur Kuran, **Private Truths, Public Lies** (1995), on preference falsification.

43 Cropper, *supra* note 8.

44 Although a recent survey in Sweden, *see supra* note 41, found hardly any area in which the respondents did not want more government intervention.