Valuing Particular as Opposed to Statistical Life

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There is a remarkable consensus among those economists who have investigated the "value of life" that their analysis should be used only in relation to *statistical death* (the exposure of a number of people to small independent incremental risks of death) and not in relation to *particular death* (the death of a given, identified individual). This is so, at least for those economists who have adopted the "willingness to pay approach" and who have defined the value of avoiding one statistical death as the aggregate compensating variation for the corresponding small changes in individual risks. Thus, for example, Schelling (1968) writes:

> It is not the worth of human life that I shall discuss, but of 'life-saving', of preventing death. And it is not a particular death but a statistical death. What is it worth to reduce the probability of death — the statistical frequency of death — within some identifiable group of people none of whom expects to die except eventually?

Other writers, including the present authors, have said much the same thing — see Jones-Lee (1976) and Sugden and Williams (1978). Broome (1978) makes a similar point as part of his critique of the whole enterprise of "trying to value a life". He claims that it is illegitimate to treat cases that involve the certain death of anonymous people as though they were cases of statistical death: if a government does this, it is "playing a trick on people's ignorance".

We will argue that the distinction between statistical death and particu-

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lar death may not be as significant as it is usually made out to be. We will invoke two principles of social choice, each of which has a strong intuitive appeal and seems quite innocuous. Then we will show that any consistent set of valuations of the avoidance of statistical death necessarily entails valuation of the avoidance of particular death.

Consider the problem faced by a social decision maker who must choose between policies. To keep the analysis simple, we will suppose that all of the effects of a policy, except those effects relating to death, can be collapsed into a single index of social cost (which may be positive or negative). In addition, each policy generates a certain expected change in the number of deaths (which again may be positive or negative, a positive change reflecting an increase in mortality and a negative change a decrease). These two characteristics of a policy may be represented by an ordered pair (n,x) where n is the expected number of deaths and x is the cost. How n is to be interpreted depends on the nature of the policy. We shall distinguish between three kinds of policy. This is not an exhaustive classification; we are simply focussing on three extreme cases. In the case of *a policy concerning statistical death,* each of the N members of society faces an independent incremental risk of death of n/N; thus the expected number of deaths due to the policy is n. In the case of *a policy concerning anonymous death,* the policy is certain to cause exactly n additional deaths, but it is not known who will die. Each person has an equal probability, n/N, of being one of those who will die. In the case of *a policy concerning particular death,* the policy is certain to cause exactly n additional deaths, and it is already known who will die.

These distinctions may be dramatised by adapting an illustration used by Broome (1978). Suppose that there is a disease which is fatal unless treated. It is proposed that the treatment of this disease should be suspended for a year. First suppose that no one has the disease at the moment, but that each person has a probability of $1/N$ of catching it and dying from it during the year. Then the proposal is a policy concerning statistical death. Now suppose instead that the disease can be diagnosed up to a year before it causes death. Diagnostic tests have already been made and it is known that one person has the disease. However, the results of the tests have not yet been collated, so it is not known who this person is. Then the proposal is a policy concerning anonymous death. Finally, suppose that the results have been collated and that the name of the unfortunate person is known. In this case the proposal is a policy concerning particular death. Although these three policies generate the same expected number of additional deaths (one), they differ substantially in other respects, and so there seems no obvious reason to treat them as equally good (or equally bad) from the social point of view. Suppose, for example, that a social decision maker judges that it is worth paying up to £x, but no more, to avoid one statistical death. It does not seem that he is thereby committed to the judgement that is worth paying up to £x, but no more, to avoid one anonymous or particular death.

We will assume that the choices of the social decision maker are consistent with the following two principles:

Condition A: Von Neumann-Morgenstern Rationality

The decision maker chooses between policies (of all kinds) in a manner that is consistent with the Von Neumann-Morgenstern axioms of rational choice under uncertainty.[1]

Condition B: Non-discrimination

If two policies concerning particular death have the same costs and cause the same number of deaths, then the decision maker treats them as equally good (or bad) from a social point of view.

The first condition requires only that the decision maker's choices between policies — including choices made under uncertainty — should be rational in a sense that is quite conventional. The second condition requires that, when comparing policies which involve particular deaths, the decision maker does not discriminate between persons. At least in the absence of information about people's ages, family circumstances and so

[1] See Von Neumann and Morgenstern (1947).

on, this seems an appealing principle: it is a derivative of the more general principle of "equal treatment of equals".

Condition A entails that it is possible to assign a Von Neumann-Morgenstern utility index to every policy. The utility index for a policy that costs x and causes n statistical deaths will be written as $u(n,x)$; the index for a policy that costs x and causes n anonymous deaths will be written as $v(n,x)$. Taken together, the two conditions entail that, other things being equal, one anonymous death is equivalent to any one particular death. (A policy that involves one anonymous death amounts to a gamble with N possible outcomes, each of which is a different particular death. It follows from one of the Von Neumann-Morgenstern axioms — the 'independence condition'— that the decision maker must also be indifferent between the certainty of any one of these outcomes and the gamble itself.) This conclusion parallels Broome's argument about playing tricks on people's ignorance: an anonymous death is the death of a particular person, even if we do not know who that person is. Thus the utility index for any policy that costs x and causes n particular deaths may also be written as $v(n,x)$.

We wish to show that the decision maker's choices among policies concerning statistical death commit him to propositions about the money value of avoiding particular deaths. Consider a policy that costs nothing and that causes n statistical deaths. Since each person in society faces the same independent probability of death, n/N, it is possible to compute the probability that the policy will in fact cause no deaths, the probability that it will cause exactly one death, and so on. Let $\pi(m,n)$ be the probability that there will be exactly m deaths, given that everyone faces the probability of death n/N. Then it follows from the Von Neumann-Morgenstern axioms that, for all logically possible values of n,

$$u(n,0) = \sum_{m=0}^{N} \pi(m,n)v(m,0) \tag{1}$$

This establishes a relationship between the utility indices $u(n,0)$ associated with statistical death and the indices $v(m,0)$ associated with particular death. Taken together, the indices $v(0,0)$, ..., $v(N,0)$ amount to a 'utility function for fatalities" of the kind discussed by Keeney (1980a and 1980b).

In principle, it is possible to infer the values of the indices $v(0,0)$, ..., $v(N,0)$ from observations of the decision maker's choices among policies that involve statistical death. Consider any $N + 1$ different probabilities of death (other than zero). For each such probability, p, there is a corresponding policy whose cost is zero and which imposes an independent risk of death of p on each individual (and which thus gives rise to pN statistical deaths). From the decision maker's choices among probability mixtures of these $N + 1$ policies it is, in principle, possible to compute a Von Neumann-Morgenstern utility index, $u(pN, 0)$, for each policy by the standard procedure.[2] This gives $N + 1$ independent equations on the model of (1) and these can be solved for the unknowns $v(0,0)$, ..., $v(N,0)$. Thus the decision maker's choices among policies concerning statistical death entail propositions about the utilities of policies concerning particular death.

To see the significance of this result, consider a social decision maker who feels capable of choosing among policies which give rise to no deaths at all, and among policies which give rise to small numbers of statistical deaths. For example, he might use the 'willingness-to-pay' approach as a means of weighing cost savings against small increases in statistical death.[3] If his choices are consistent, it must be possible to assign Von Neumann-Morgenstern utility indices $u(0,x)$ for all values of x, representing his judgements about policies which give rise to no deaths at all. Similarly, it must be possible to assign indices $u(n,0)$ for all small values of n, representing his judgements about policies which give rise to small numbers of statistical deaths (and whose costs are zero). A judgement of the kind "it is worth spending up to x, but no more, to prevent n statistical deaths" corresponds with the equation $u(0,x) = u(n,0)$. But we

[2] See, for example, Keeney (1980a).

[3] It should be noted that under certain circumstances, use of the "willingness-to-pay" approach may lead the decision maker to act in a way that violates the Von Neumann-Morgenstern axioms — for an example, see Broome (1982). However our argument relates to cases that do not include such circumstances.

have shown that the utility indices $u(n,0)$ logically entail a utility function for fatalities, that is, they entail particular values for the indices $v(0,0)$, ... $v(N,0)$. Thus the decision maker is logically committed to certain propositions about the money value of the avoidance of particular death. For any number of deaths, m, the value of $v(m,0)$ is determined. If there is some cost, y, such that $u(0,y) = v(m,0)$, then the decision maker is committed to the proposition that it is worth spending up to y, but not more, to avoid m particular deaths. Consider y that satisfies $u(0,y) = v(1,0)$ (if such a finite y exists) and x that satisfies $u(0,x) = u(1,0)$. y and x are then the social decision maker's value of avoidance of one particular and one statistical death respectively. Will y be greater than, equal to, or less than x? In other words, is a statistical death less serious, just as serious, or more serious, from a social point of view, than a particular death? This depends on the form of the utility function for fatalities, $v(n,0)$. If this function is convex, it follows that $v(1,0) < u(1,0)$, which means that a statistical death is to be preferred to an anonymous or particular one. Conversely, if the function is concave, a particular death is to be preferred to a statistical one. If the function is linear, neither kind of death is to be preferred to the other. It is difficult to decide, on *a priori* grounds, whether it would be most plausible to assume convexity, concavity or linearity. Convexity may be regarded as a kind of risk-proneness at the social level and concavity as a kind of risk-aversion (Keeney, 1980a). Keeney himself regards convexity as the most plausible assumption, but his reasons are not entirely compelling. All that we wish to establish is that if he is to be consistent in the sense of the Von Neumann-Morgenstern axioms, then a decision maker's attitudes to policies concerning statistical death commit him to judgements about the relative significance of statistical and particular death.

We must stress that we would not necessarily advocate the use of the kind of reasoning employed in this paper as a basis for placing a value on the avoidance of particular death. Perhaps, in the end, one may have to agree with Schelling (1968), and distinguish between statistical and particular death on the grounds that "the success of organised society depends on traditions, attitudes, beliefs and rules that may appear extravagant or sentimental to a confirmed materialist". Nonetheless, an economist can hardly be very comfortable with the idea of rejecting economic logic for reasons of sentimentality. We hope we have shown that it is difficult to give good grounds for drawing a sharp distinction between statistical and particular death, and for claiming that economic analysis is relevant in the case of the former but not in the case of the latter.

References

Broome, J. "Trying to Value a Life." *Journal of Public Economics* 9(February 1978).

________. "Uncertainty in Welfare Economics and the Value of Life" in M. W. Jones-Lee (ed.), *The Value of Life and Safety.* Amsterdam: North Holland, 1982.

Jones-Lee, M. W. *The Value of Life: An Economic Analysis.* London: Martin Robertson and Chicago University Press, 1976.

Keeney, R. L. "Evaluating Alternatives Involving Potential Fatalities." *Operations Research* 28 (January/February 1980a)

__________. "Equity and Public Risk." *Operations Research* 28 (May/June 1980b).

Schelling, T. C. "The Life You Save May Be Your Own" in S. B. Chase (ed.), *Problems in Public Expenditure Analysis.* Washington: Brookings, 1968.

Sugden, R., and Williams, A. *The Principles of Practical Cost Benefit Analysis.* Oxford: Oxford University Press, 1978.

Von Neumann, J., and Morgenstern, O. *Theory of Games and Economic Behavior.* Princeton: Princeton University Press, 1947.