VALUE IN HEALTH ▮ (2017) ▮▮▮–▮▮▮

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Uncertainty and the Undervaluation of Services for Severe Health States in Cost-Utility Analyses

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ABSTRACT

Objectives: To test the hypothesis that the "severity effect"—the preference for more than utility-maximizing expenditure on severe health states—may be the result of, or exacerbated by, the uncertainty associated with the chance of contracting the illness that causes the severe health state. **Methods:** Survey respondents were asked to imagine that they will contract one of two illnesses and asked to allocate a budget between two insurance policies, each of which provides services for the treatment of one of the illnesses. A person's final health state varied with the amount of insurance purchased for the illness that occurred and therefore with the level of treatment. The relative cost of the two policies was altered and the selected levels of insurance compared with the levels that would be provided by a health authority that sought to maximize total utility or quality-adjusted life-years from its own budget. **Results:** Respondents selected more than utility-maximizing insurance for protection against severe health states. A number of psychological factors that affect measurement under uncertainty do not affect utility as currently measured. This difference may explain the present results and also explain the "severity paradox" that personal preferences as presently measured imply less expenditure on severe health states than do "social preferences" for the treatment of strangers. **Conclusions:** Uncertainty alters preferences. Incorporating these preferences in decision making would result in greater spending on severe health states.

Keywords: CUA, EUT, health maximization, severity.

Introduction

In cost-utility analysis (CUA), the unit of benefit is the quality-adjusted life-year (QALY), which is calculated as life-years times the utility of the life-years. In welfare theory, utility is the strength of preference for an option when a choice is to be made between options. When the options concern health and medical services, individuals commonly face uncertainty: they are usually unsure of the likelihood that they will personally contract an illness. They often have not experienced the outcomes of the possible illnesses and they cannot assess the extent to which, in their personal case, adaptation might occur and mitigate the severity of an outcome. For this reason, Kahneman et al. [1] distinguish "decision" utility—the welfare theoretic concept of preferences before health outcomes are known—from "experienced" utility, the assessment after they are known, which Kahneman et al. recommend as a replacement for decision utility in CUA [2–6]. Nevertheless, economic evaluation is still based on the use of decision utility, which permits it to retain the authority of welfare theory.

Nevertheless, the utilities presently used in CUA deviate from the welfare theoretic ideal. They are not assessed by the people who face the choice and the uncertainty of a real decision. Rather they are most commonly estimated using a multi-attribute utility instrument (MAUI) whose utility weights were derived from a representative cross-section of the population using a time trade-off (TTO), a rating scale (or visual analogue scale [VAS]), or a standard gamble (SG) [7]. The first two of these techniques evaluate risk-free health states; that is, neither risk nor uncertainty affects predicted values. In contrast, SG utilities are obtained "under risk." The SG requires respondents to compare a risk-free outcome with a gamble between full health and death. The probability that makes the alternatives equally attractive is commonly equated with decision utility because the gamble reveals preferences that take account of a person's attitude toward risk in the form of the life-death gamble. "SG utility" also gains authority because it is consistent with the appealing behavioral axioms of the expected utility theory (EUT) proposed by von Neumann and Morgenstern [8]. Nevertheless, because of the idiosyncratic and context-specific responses to risk and uncertainty, the argument that a life-death gamble will indicate people's responses to every risk and uncertainty-related situation has been historically controversial [9,10] and explicitly rejected by Morgenstern who argued that "as with von Neumann … I know of no axiomatic system … that specifically incorporates a specific pleasure of gambling" [11p181].

Conflicts of interest: The authors report no conflicts of interest.

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https://doi.org/10.1016/j.jval.2017.10.022

In sum, the utilities used in CUA seek to maximize decision utility but do so imperfectly. The context of individuals answering utility surveys differs from the context facing patients at a decision point. Like decision utility, the assessment is made by individuals who have not experienced the health state they are evaluating. The assessment, however, differs from the ideal measurement of decision utility because the individuals have not experienced the uncertainty caused by the unknown likelihood of contracting the illness responsible for the health state. The basis of the present study is the hypothesis that the disutility of this uncertainty increases with the severity of the worst possible outcome. To include this effect in CUA, severe health states would need to be weighted to increase their importance.

This conclusion has also been reached in a significant number of empirical studies reviewed by Shah [12] and Nord and Johansen [13]. These studies are, however, based on people's social preferences, that is, their judgment of how best to allocate resources between other people. They imply what might be called the "severity paradox." The importance of a severe health state is found to be greater when it is experienced by a stranger than when it is assessed by the decision utility of the person experiencing the health state. In contrast, the present study is based on an analysis of personal preferences and does not imply less self-concern than concern for anonymous "others."

The aim of this study was to test the "uncertainty aversion hypothesis": the hypothesis that aversion to uncertainty results in a personal preference for greater expenditure on severe health states than would be provided by authorities seeking to maximize utility *as presently measured*. The methods used to test the hypothesis are described in the next section and results are presented in the following section. The Discussion section discusses possible reasons for the results.

Methods

The hypothesis was tested by contrasting the insurance decisions of survey respondents with the insurance decisions of a health authority seeking to maximize global utility as utility is currently measured and described earlier. Survey respondents faced the (hypothetical) certainty of illness A or B but uncertainty concerning which of the two illnesses they would contract. The severity of health states after treatment could be mitigated by the purchase of additional insurance for additional treatment. The study hypothesis was therefore tested by observing whether more than utility-maximizing insurance was purchased to avoid severe health states. Utility and expected utility-maximizing insurance were estimated from the assumption that the decision maker assigned an equal probability to the likelihood of each of the two illnesses, an assumption that was tested empirically. The results are subsequently referred to as "optimal" insurance (A^* or B^*) and "optimal" utility (U^*_A or U^*_B); and the results of choices by survey respondents as "selected insurance" (A or B) and "selected utility" (U_A or U_B).

The Survey

Members of the Australian public enrolled with a panel company, CINT Pty Ltd., were recruited into 12 demographic cohorts until a predetermined quota was filled. The survey protocol is presented in Table 1. It had two main components: a budget allocation exercise and the evaluation of the health states used in the allocation exercise. The survey, which was administered by a speaking avatar, is reproduced in Appendix 5 in Supplemental Materials found at http://dx.doi.org/10.1016/j.jval.2017.10.022. It was approved by the Monash University Human Research Ethics Committee (approval ID: CF15/411-2015000201).

Health State Evaluations

Respondents were asked to rate eight health states using the VAS reproduced in Appendix 5 in Supplemental Materials. Four health states were selected from the possible outcomes of each illness and described using abbreviated descriptions from the five-level EuroQol five-dimensional questionnaire. The valuations occurred at the beginning of the survey to introduce the health states before the allocation exercise.

Budget Allocation Exercise

Respondents were asked to select their preferred mix of insurance A and B as the relative prices of the two insurance policies, P_A and P_B, varied. The variation was symmetrical: the final four price ratios P_A:P_B were the reciprocal of the first four ratios. The symmetry was designed to identify the effects of idiosyncratic assumptions about the health states or their likelihood of occurring, which would result in an asymmetrical allocation of the budget when the price ratios were inverted. The budget was insufficient to purchase complete insurance for both A and B and additional insurance could not be purchased. Respondents could alter the possible outcomes they faced only by altering the mix of insurance they selected.

The visual aids used to present questions were introduced and explained with a series of images and an illustrative question. An example is given in Figure 1. In this, the two scales represent the levels of insurance cover and the cost of the insurance against the two illnesses. In the example, the costs of

Table 1 – The survey protocol.

Introduction and the visual aids									
• Introduction to a VAS and the visual aid									
• Introduction to the illnesses									
• Rating eight health states (four per illness) on a VAS									
Introduction to the budget allocation exercises									
• Three numerical examples									
	The allocation exercise								
Question	1	2	3	4	5	6	7	8	9
Price of insurance									
A ($000)	5	5	5	5	5	7.5	10	12.5	15
B ($000)	5	7.5	10	12.5	15	5	5	5	5
Budget ($000)	9	9	9	9	9	9	9	9	9
Personal questions									
• Age, sex, education									

VAS, visual analogue scale.