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Determining risk preferences for pain

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Abstract

The QALY concept is the commonly used approach in research to evaluate the efficiency of therapies in cost utility analysis. We investigate the risk neutrality assumption for time of the QALY concept: can time be included as a linear factor? Various studies show that this assumption does not hold empirically. However, the results are based on hypothetical questionnaires rather than decisions with real consequences. Experimental economists argue that experiments are necessary to avoid hypothetical bias. Our study provides the first experimental analysis of health related decision making. Using the cold pressor test we can analyze decisions when subjects face real consequences. Analog to the hypothetical studies, our experimental results of real decisions provide no linear time preferences. In conclusion, the QALY concept needs to be modified by a weighting factor for time.

1. Introduction

Health care systems of advanced economies are constantly faced with innovations from medical research that improve possibilities in patient care. However, the process of creating these advances and creating accessibility for patients also causes constantly rising costs. Therefore, the question is how to assign limited resources within the health care system. While medical practitioners focus on ensuring the best possible therapy for each individual patient, policy makers need to address the question on how to maximize benefits for the society by investing the social resources in an effective and efficient manner. Examples for policy decisions that arise are the evaluation whether a drug can be replaced by a cheaper genericum without any loss of effectiveness or choosing which treatments that are available for a given health condition should be funded. For the solution of these problems, health economics provides different methods of implementing a cost-utility-analysis in health related decision making. Research in this area allows for the evaluation of different treatments and their comparison (Breyer et al. 2004). Cost-utility-analysis for a certain treatment comprises the assessment of the costs and the benefits for the patient. This means that on the one hand, all relevant costs are taken into account and on the other hand, the various aspects of health improvement like reduced pain intensity or increased mental well-being are considered. While costs are an objective measure constantly in the focus of policy based discussions, the benefit of actions in health related decision making is based on individual preferences. Eliciting these individual preferences is the focus of the study presented in this paper.

Several approaches are available that provide outcome measures of medical decision making, but the most common approach is the concept of quality-adjusted-life-years (QALY) (Bleichrodt et al. 1997, Stason & Weinstein 1977). The QALY calculation for a specific patient comprises a procedure that combines the two central outcomes of the treatment in a single index: quality and quantity of life. Formally the QALY is based on expected utility theory (Weinstein et al. 2008, von Neumann & Morgenstern 1944). Pliskin et al. (1980) theoretically investigate which requirements must be postulated for the QALY to be consistent with EUT. They identify three criteria that have been the conditions commonly used for several years to define the frame in which QALYs are valid. First they describe utility independence related to life years and health status. The second point is a constant proportional trade-off. It means that in a theoretical trade-off situation, one does not take into account the individual life time left when trading life years for a certain health improvement. Finally they suppose that the individual is indifferent between a gamble and a sure outcome, both given in life expectancy. Here the expected value of the gamble is equal to the sure result, implying risk neutrality for decisions about life years. However this assumption of risk neutrality is rarely validated in any study. An exception are Miyamoto and Eraker (1985) who find the mean subject to be risk neutral but seldom a real study participant. Later on, Bleichrodt et al. (1997) demonstrate that in the medical context the postulation of risk neutrality for life years is enough to render QALYs to be applicable. Nevertheless the majority of studies suggest risk attitude to vary from linearity depending from multiple factors (Rosen et al. 2003; Verhoef et al. 1994). However, in order for the QALY concept to reflect preferences over health states, it needs to address the preferences over two fundamental aspects: quality of life and time.

For the evaluation of quality of life different methods are proposed in the literature which can be sorted into two categories: the first one elicits the individual value of a specific health state in comparison to death or reduced life time whereas the second category independently delivers the evaluation of the current health state. The two most commonly used methods of the first category, which are well defined with respect to the theoretical background, are the standard gamble (SG) and the time trade-off (TTO) (Drummond et al. 2005). The SG is a commonly used method to elicit preferences (Torrance 1986) and is based on expected utility theory (von Neumann & Morgenstern 1944). Because of the limited feasibility in terms of cognitive requirements and complexity (Schöffski 2002) the TTO can be used as an alternative procedure, which compares different life durations instead of survival probabilities (Torrance 1972). However, SG and TTO are considered to be impractical in health economic studies for reasons of time and effort for a single interview (Schöffski 2002). Because of these difficulties, the methods to evaluate current health states are subject to further discussion and other approaches are introduced. These also comprise descriptive systems designed like questionnaires, which subjects can administer themselves (for example the 15D, the three versions of the HUI or the EURO-Qol (Drummond et al. 2005)). After a statistical analysis a health index can be calculated which reflects the current health state of the individual. Thus, both categories, SG or TTO on the one hand, and questionnaires on the other hand, generate values which can be converted to a QALY index, representing the quality of life for one year.

Besides the quality of life resulting from treatment, the factor time is considered in the QALY concept as well. What is problematic in terms of the interpretation of the results is that in empirical research the temporal aspect and the quality of life aspect are investigated in combination. For example the use of the TTO method combines a certain level of quality of life with different time intervals. For example, participants have to choose between different life spans in combination with associated health statuses between perfect health and death (Oliver & Cookson 2010, Stiggelbout et al. 1994). However, the theoretical foundation of the QALY concept postulates independence of preferences in the two dimensions and assumes time to be a linear factor in the QALY index. Although there is a theoretical necessity for using linear time preferences (Bleichrodt et al. 1997), empirical findings contradict this assumption (Bleichrodt et al. 1997, McNeil et al. 1978). Furthermore, time preferences and risk attitudes towards life expectancy systematically depend on the socio-economic background of patients (Stiggelbout 1994). This emphasizes the importance of risk preferences for time to model individual preferences that are in line with empirical findings. That means, while the theoretical foundation of the QALY concept requires the assumption of time being a linear factor in the calculation of the index (Bleichrodt et al. 1997), the individual choice behavior revealed in various empirical studies does not reflect risk neutrality for time (Oliver & Cookson 2010, Stiggelbout et al. 1994).

The QALY concept is designed to describe tradeoffs between the two central dimensions, quality of life and time, in health related decision making. In economic research such tradeoffs are generally described by multi-attribute utility functions. The empirical research on preferences in health contexts relies on questionnaires and hypothetical choice situations. However, the utility function elicited from stated preferences can vary between hypothetical and real choice situations, as shown for the utility function for money (Holt & Laury 2002, 2005). Therefore it seems necessary to apply experimental methods, where subjects face real consequences of their choices, to research on health related decision making.

The study presented in this paper applies experimental methods to elicit individual preferences for the two attributes essential for the QALY concept: time and quality of life. However, the operationalization of the latter rather abstract construct in an experimental setting is difficult. Therefore, the quality of life is replaced in the experimental setting by pain, a factor regularly associated with medical decision making and an essential aspect in quality of life. In this paper, we elicit both preferences for different pain durations and intensities using the Holt and Laury procedure (2002), with the modification that the consequences of the original lotteries are replaced by pain and time. The utility function for pain is elicited using the cold pressor test (CPT), a pain-inducing experimental design using a cold water bowl in which one hand of the subject is immersed. The cold water induces a deep tonic, thermal pain of constant intensity and is a commonly applied procedure in pain research (Lorenz 2002, Hines & Brown 1936, Streff et al. 2010, Lafleche et al. 1998, Lovallo 1975, Kahneman et al. 1993). Chéry-Croze (1983) demonstrate, that pain induced by cold temperatures between 20° till 0° correlate linearly with pain sensation. This means that temperature is a useful scale to represent pain intensities.

In our treatment concerning time, the lottery outcomes in the Holt-Laury-procedure are related to different immersion-durations. The second treatment concerning pain varies the temperatures of the cold water bowl and thus the experienced level of pain. Using both, the procedure from Holt and Laury (2002) and the CPT, subjects face decisions about real consequences in the dimensions essential to health related decision making.

Following the empirical evidence from research in health economics, we expect subjects to show risk averse behavior for decisions about time (McNeil et al. 1978, Stiggelbout et al. 1994). The risk attitude towards pain has not been determined in empirical studies so far. However, both factors under consideration, immersion duration and pain, can be interpreted as a loss since it can be reasonably assumed that the higher the immersion duration or the higher pain intensity, the lower the level of well being. Prospect Theory assumes risk seeking behavior for losses (Kahneman & Tversky 1979, 1992). Thus, Prospect Theory and the empirical findings in health related decision making provide different predictions.

2. Experiment

The group of participants consists of 64 students (26 females) from different fields of study recruited using ORSEE (Greiner 2004) and assigned to two experimental treatments. 34 subjects take part in the first and 30 subjects in the second treatment. The experiment is conducted at the laboratory of the Department for Sensor Technology at Otto-von-Guericke-University Magdeburg in sessions with one participant each. The laboratory provides the equipment to administer the CPT using four circulating coolers. These machines include a water bowl for which the water temperature can be regulated by a thermostat. Additionally a pump guarantees that within the bowl the temperature is the same everywhere, on the surface as well as on the ground or in the area close to the immersed hand. The pump immediately counteracts every thermal fluctuation, for example when a warm hand is immersed. Thereby the pain level is held constant for every subject and during the entire experiment with thermal fluctuations less than 0.03° C around the assigned temperature.

At the beginning of each session the subjects are informed that the experiment is about pain and they can familiarize themselves with the experimental apparatus for pain induction. For that purpose, subjects are asked to immerse their hand into the water in order to experience the pain that is caused by the CPT before making their decisions. As the first treatment is about pain intensity, subjects immerse their hand in four water bowls tempered 16°, 12°, 8° and 4° Celsius for two minutes each. The other treatment focuses on pain duration; here only one water bowl of 4° Celsius is tested for two minutes. Then, subjects are asked to sign a consent form given they agree to participate in this experiment. It has to be noted, that none of the recruited participants who signed the consent form after the trial phase refused to participate for the entire duration of the experiment.

After the consent form is signed, the actual experiment starts and the decision sheet is handed out. The participant is asked to perform a total of 20 decisions between two lotteries, ten in each treatment. The possible lottery outcomes are the same for all lotteries, but the probability for receiving the outcome varies between .1 and 1.0 in steps of .1. In treatment one the consequences of the lotteries are given as different water temperatures varying between 16°C and 4°C in steps of 4°C in which the subject has to immerse her hand for five minutes. In the second treatment the consequences of the lotteries are given as different immersion durations varying between 2 and 12 minutes with a water temperature of 4° C (the lotteries are provided in table 1). For all these durations, immersing without break does not include a longer time than two minutes. Each participant has to make a warm-up break before taking the next two minutes and is free to change the hand. At the end of the experiment only one of the 20 choices is determined by a random draw. The identified lottery is played out and the resulting immersion condition is realized. All of this information is known to the subjects prior to making their decisions.

Both the decision sheets for different pain intensities and for pain duration are subdivided in answering possibilities reflecting risk seeking or risk averse preferences. A change from lottery B to lottery A between items 1-5 on the decision sheet for pain intensity (treatment 1) reflects risk averse behavior whereas a later change stands for risk seeking preferences. On the decision sheet for pain duration (treatment 2) risk aversion is reflected through a change from lottery A to B between items 7 and 10, accordingly a switch before item 6 stands for risk seeking preferences. For the pain duration treatment there is one specialty concerning a switch between item 6 and 7: it represents risk neutral decision making.

Treatment	Lottery number	Lottery A		Lottery B		EV diff.
Treatment 1 (pain intensity)	1	0.1, 8° C	0,9, 12° C	0.1, 4° C	0.9, 16° C	-3.2
	2	0.2, 8° C	0,8, 12° C	0.2, 4° C	0.8, 16° C	-2.4
	3	0.3, 8° C	0,7, 12° C	0.3, 4° C	0.7, 16° C	-1.6
	4	0.4, 8° C	0,6, 12° C	0.4, 4° C	0.6, 16° C	-0.8
	5	0.5, 8° C	0,5, 12° C	0.5, 4° C	0.5, 16° C	0
	6	0.6, 8° C	0,4, 12° C	0.6, 4° C	0.4, 16° C	0.8
	7	0.7, 8° C	0,3, 12° C	0.7, 4° C	0.3, 16° C	1.6
	8	0.8, 8° C	0,2, 12° C	0.8, 4° C	0.2, 16° C	2.4
	9	0.9, 8° C	0,1, 12° C	0.9, 4° C	0.1, 16° C	3.2
	10	1.0, 8° C	0,0, 12° C	1.0, 4° C	0.0, 16° C	4
Treatment 2 (pain duration)	1	0.1, 2 x 2 min	0.9, 4 x 2 min	0.1, 2 min	0,9, 6 x 2 min	3.4
	2	0.2, 2 x 2 min	0.8, 4 x 2 min	0.2, 2 min	0,8, 6 x 2 min	2.8
	3	0.3, 2 x 2 min	0.7, 4 x 2 min	0.3, 2 min	0,7, 6 x 2 min	2.2
	4	0.4, 2 x 2 min	0.6, 4 x 2 min	0.4, 2 min	0,6, 6 x 2 min	1.6
	5	0.5, 2 x 2 min	0.5, 4 x 2 min	0.5, 2 min	0,5, 6 x 2 min	1
	6	0.6, 2 x 2 min	0.4, 4 x 2 min	0.6, 2 min	0,4, 6 x 2 min	0.4
	7	0.7, 2 x 2 min	0.3, 4 x 2 min	0.7, 2 min	0,3, 6 x 2 min	-0.2
	8	0.8, 2 x 2 min	0.2, 4 x 2 min	0.8, 2 min	0,2, 6 x 2 min	-0.8
	9	0.9, 2 x 2 min	0.1, 4 x 2 min	0.9, 2 min	0,1, 6 x 2 min	-1.4
	10	1.0, 2 x 2 min	0.0, 4 x 2 min	1.0, 2 min	0,0, 6 x 2 min	-2

(Tab. 1; The shaded boxes show the lotteries a completely risk averse individual would chose. The arrows show which answers the sample takes for the median)

3. Results

The Holt-Laury procedure as used in both experimental treatments is designed to elicit individual risk preferences. Following the differences in expected values of the two lotteries, subjects are expected to switch from lottery B to lottery A, which all participants do. For both treatments, subjects individual risk preferences can be calculated using this switching point. For the purpose of this analysis we classify subjects only in terms of risk averse and risk seeking behavior.

In the first treatment, subjects perform decisions about pain intensities. The median of subjects switch from lottery B to A between a probability of receiving the lower pain intensity of .2 and .3. Following the differences in expected values the median observation is classified as risk averse behavior. Additionally, only 3 subjects are classified as showing risk seeking choice behavior (Tab. 2). Therefore, when making decisions about pain intensities subjects show significant risk averse behavior (Binomial-Test, 1%-level).

	Risk averse					Risk seeking		
First item where lottery A is chosen	1	2	3	4	5	6	7-10	∑
Frequency	15	2	5	4	5	3	0	34

Table 2

The lottery outcomes in our experiment can be categorized as losses. Subjects face pain in any case, in the first treatment varying only in intensity. According to Prospect Theory, people behave risk seeking in decision situations that refer to losses (Kahneman & Tversky 1979). However the behavior of the subjects in this experiment does not show risk seeking preferences for pain intensities.

In the second treatment concerning pain duration the median of the sample switches between item 6 and 7. Thus a change from lottery B to lottery A is preferred though A has a probability of 0.3 for the longest immersion duration. Accordingly the median observation is risk seeking. 12 subjects drop out of this behavioral pattern: 6 test persons behave risk neutral and 6 are risk averse (Tab. 3). We compare the risk averse group with the risk seeking one which shows that our sample is significantly risk-seeking (Binominal-Test, 5%-level).

	Risk seeking						Risk neutral	Risk averse			
First item where lottery A is chosen	1	2	3	4	5	6	7	8	9	10	∑
Frequency	0	0	0	4	9	5	6	4	1	1	30

Table 3

Again in the second experiment we are working with outcomes that must be perceived as a loss. Subjects have to spend different durations immersing their hand in cold water which induces a tonic pain. Consonant with Prospect Theory our subjects behave risk prone for the described decision situation for losses. On the other hand, for example the mentioned empirical study presented from Oliver and Cookson (2010) demonstrates risk averse behavior for decisions on life years. Consequently also the results of our pain duration experiment cannot easily be integrated in the results of other investigations. The question comes up how effective a real scenario with instant consequences is in comparison to hypothetical settings used by Kahneman and Tversky (1979) or in the other empirical studies (McNeil et al. 1978, Stiggelbout et al. 1994, Oliver & Cookson 2010). In general it seems highly important to focus on this core difference as its influence might be strongly underestimated. A significant indicator therefore is the difficulty to combine our results with the existing literature. We must enlarge research that includes real scenarios for example using experimental approaches.

Two central aspects of the QALY concept are key variables in our experiment: limitations in quality of life and remaining life expectancy. What we demonstrate in our study is that people are not risk neutral when it comes to limitations in quality of life, they are risk averse. Additionally when a temporal factor is included, subjects behave risk seeking. These findings clearly demonstrate that people are not risk neutral when it comes to their health. Hence the QALY assumption of linear time preferences is hard to defend. Our scenario includes both, limitations in quality of life and different time durations. In both experiments, people even behave differently which makes it very difficult to understand the risk preferences underlying the decisions. What we neither found in the first nor in the second experiment is risk neutrality. On that score an adjustment of the QALY seems inevitable if we want to represent how people really interpret situations. To do so, more experiments are necessary to better understand the decision making process in health related decision making. Experimental analyses must be central in this research questions to allow real consequences in the setting.

4. Conclusion

In our study we use two treatments to investigate risk preferences for decisions about pain intensity and pain duration. We realize the experiments using the cold pressor test as a standard method for investigating pain perception. This method allows us to elicit risk preferences involving pain intensity and duration using choice scenarios where subjects face real consequences of their decisions. To investigate the risk preferences we use two similar decision sheets designed analog to Holt and Laury (2002): one for different temperatures, the other for different immersion durations. We find that people are risk averse for pain intensity and risk seeking for pain duration.

This result is relevant in terms of the central QALY assumption of risk neutrality for life years. It shows that subjects´ behavior is not in line with linear time preferences; hence this simplistic assumption cannot be confirmed. Additionally out treatment for pain durations shows risk seeking behavior which cannot be integrated in the empirical findings where subjects are identified as risk averse.

Further experimental research is necessary to understand the risk attitudes for real health related scenarios in order that the QALY concept can be adapted accordingly.

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