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Distribution principles for the allocation of donor liver grafts: results from a 'social' conjoint analysis survey

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Paper presented to the Health Economists' Study Group Conference, University of Birmingham, January 1999

ABSTRACT

To investigate the nature of public preferences in the allocation of donor liver grafts for transplantation a social conjoint analysis technique was developed for a self-completion questionnaire survey. A convenience sample of 800 randomly chosen employees of a British University (academic and non-academic) were invited to participate in the survey. Respondents were presented with several choice situations in which they were asked to allocate 100 donor liver grafts between two groups of 100 individuals in urgent need of a transplant. The groups of individuals differed in terms of the length of time spent waiting, the life years gained following transplantation, age, personal responsibility for their illness and whether they were primary or re-transplant candidates. Only 2 respondents (0.7%) consistently chose to give all of the donor organs to the group of individuals with the highest expected length of survival whilst 7 respondents (2%) exhibited strict egalitarian preferences, allocating equal numbers of donor organs to both groups irrespective of their characteristics. The vast majority of respondents indicated that they would be prepared to sacrifice some gain in the efficiency of the transplantation programme for an increase in equity or fairness in the allocation of donor livers.

Acknowledgements

I am particularly indebted to Nigel Rice for his econometric advice. I would also like to thank Martin Buxton, Kathy Johnston and Glenn Robert for their comments on an earlier version of this paper. Any errors or omissions are the responsibility of the author alone.

INTRODUCTION

The equity-efficiency trade off in health care

The methodology of economic evaluation in health care currently identifies the maximisation of health as the criterion by which priorities for resource allocation should be identified. Typically, within economic evaluation, potential health benefits are measured in some standardised format using life years gained or quality adjusted life years (QALY's) gained. The pursuit of health maximisation can be thought of as a pure efficiency criterion reflecting the desire to generate as much health as possible from the limited resources available. Olsen (Olsen, 1997) has referred to such an approach as reflecting a principle of 'distributive neutrality' since what matters is the total of life years or QALY's gained as a consequence of a health care intervention irrespective of the number or characteristics of the individual/s receiving the health gains. However, there is growing evidence to suggest that the pursuit of such an objective conflicts with the views of the general public. Several commentators have suggested that experiences such as the Oregon experiment in the United States illustrate that distributional considerations are at the forefront of public interest in the allocation of health care (Eddy 1991; Hadorn 1991; Nord, 1993). In addition, a number of empirical studies have consistently found that members of the general public are prepared to exchange a reduction in overall societal health in order to achieve a fairer or more equitable distribution of health gains (Ubel and Loewenstein 1995, 1996; Nord et al 1993, 1995).

One method which has been proposed for incorporating equity considerations into the valuation of the benefits of health care is the person trade off technique (PTO) (Nord,

1995). Using this approach, respondents are asked to choose between two groups of people who differ in certain key characteristics (e.g. health, age, lifestyle) but who will benefit if they receive a health care intervention. The trade off is established by asking respondents to vary the number of people in one group whilst holding constant the number in the other group, in order to find a point of indifference. Valuations from this technique can be seen as representing the trade offs that people are prepared to make between health gains for different characteristics of people and numbers of persons treated. The difficulty with this approach, however, is that it is impossible to disentangle the relative weights which respondents attach to each of the characteristics presented in determining their allocation decisions.

This paper highlights an alternative approach for incorporating equity considerations into the valuation of the benefits of health care which allows the estimation of the relative weight attached to different characteristics of individuals, a form of 'social' conjoint analysis. The technique is applied here in the context of liver transplantation allocation decisions. However the technique has potentially wider applicability as a tool for the elicitation of public preferences for the distribution of health care.

BACKGROUND

The case of liver transplantation

Unfortunately there are not enough donor liver grafts available to transplant all individuals who are in need of a liver transplant. Despite greater use of split livers (two liver grafts from one donor) and those from marginal donors (e.g. non-heart beating donors, those over 60 years of age) the supply of donor livers in the UK has remained relatively constant (Neuberger, 1997). However, more patients are being referred for transplantation and the transplant waiting list has increased markedly during the last decade (UKTSSA, 1997). A similar situation has arisen also in the United States where the waiting list for liver transplantation has increased by 200% within the last five years (Neuberger 1998). Given this situation, decision criteria have to be employed to determine which patients should be given priority in receiving a donor organ. Unlike the United States, the UK has no explicit

guidelines for the allocation of donor liver grafts. A recent publication indicated that the majority of transplant clinicians believe that patients should be treated irrespective of the cause of their liver failure and based upon their capacity to survive and benefit (Ghent, 1996). This view appears to be in general accordance with the traditional health economics view that scarce resources should be allocated according to the criterion of health maximisation (Williams, 1997). However several recent surveys of the general public's allocation decisions in liver transplantation have suggested that their preferences may differ quite markedly in that they would be willing to exchange an overall reduction in the efficiency of the transplantation system, as defined by health maximisation, for a fairer or more equitable distribution of donor organs for transplantation (Ubel and Loewenstein,1995, 1997; Neuberger, 1998).

Liver transplantation offers an attractive application for the investigation of public preferences in allocating scarce health care resources for several reasons. Firstly, it represents a high cost medical technology. The opportunity costs associated with the provision of a liver transplantation programme are large. Secondly, the natural constraint of a shortage of donor organs is real and therefore appears plausible even to those respondents who are unwilling to accept the need to set priorities on the basis of financial resource constraints. Thirdly, liver transplantation if often a life saving technology and any allocation decisions are potentially choosing between life and death. This situation may force people to think more seriously about the issue than they would in other less dramatic situations. Fourthly, the success of transplantation is dependent upon public willingness to donate organs. It has been suggested that the public's willingness to donate organs may be reduced if decision criteria are set which are not in accordance with their views. A recent study undertaken in the US found that those members of the public who elected not to donate organs had little trust in the fairness of organ allocation and were uncertain about the success of transplantation (Peters et al, 1996).

Conjoint Analysis

Traditional conjoint analysis (CA) is a stated preference technique designed to establish the

impact of individual attributes in the overall utility of a good or service. It involves the presentation of hypothetical scenarios to individuals. Respondents use ranking, rating or discrete choice exercises to represent their preferences for these hypothetical scenarios which then allows the estimation of their respective utility functions. The CA technique has been used widely and reported upon for many years in the transport and environmental economics fields. In recent years, the technique has also gained prominence within health economics, with an increasing number of applications of CA appearing in the literature (see for example Scott *et al* 1998; Ryan and Hughes, 1997; Van der Pol and Cairns 1997). The majority of these applications have been undertaken to establish individual's preferences for characteristics associated with the health care process, either in addition to or in isolation of health care outcomes. However, the technique has also been applied recently in determining the public's preferences for priority setting in health care (Bryan, 1998)

METHODS

In order to investigate the nature of individual preferences in the allocation of donor liver grafts a 'social' conjoint analysis exercise technique was developed. The 'social' CA presented here differs from the CA exercises previously undertaken and reported upon in the health economics literature in two main ways. Firstly, individuals were not asked to indicate their own preferences for health care treatments which may affect them directly. Respondents were asked how they would allocate donor livers amongst two groups of people to which they did not belong. Secondly, individuals were not asked to rank, rate or choose directly between two hypothetical treatment scenarios or health care programmes. Instead, individuals were asked to allocate a finite number of donor organs between two groups of individuals with differing characteristics. Using this technique, it is not possible to estimate a utility function directly. However, it is possible to establish the relative importance of each characteristic in determining individual's allocation decisions and to predict individuals' strength of preference for different groups of patients with differing characteristics.

Traditional CA exercises are typically made up of five mains stages: identifying the

attributes to be included in the study, assigning levels to each of the attributes included, presenting hypothetical scenarios involving different levels of the attributes to individual; obtaining preferences for these scenarios and analyzing the responses (Ryan, 1996). This structure was also adopted for the conduct of the social CA exercise

The generation of the attributes and their levels

The CA literature recommends a maximum of five or six attributes in any CA exercise, in order to avoid cognitive overload on respondents (Ryan, 1996). Five attributes were chosen to reflect key decision criteria which respondents may choose to apply in discriminating between potential recipients for donor organs in a situation where there are insufficient donor organs available to transplant all patients on the waiting list.

For the purposes of this exercise, the 'expected length of survival' of the transplant recipients was chosen as a proxy for health outcome. This attribute was measured in life years gained. Three levels were chosen for the exercise (5, 10 and 15 years). The range for life years gained was based upon long term age adjusted survival data for liver transplant recipients in the UK (UKTSSA, 1997). For ease of interpretation, it was decided to use life years gained rather than QALY's (quality adjusted life years gained) as a proxy for health outcome. It was considered that, given the mode of delivery of the questionnaire, some individuals may experience difficulties in understanding and interpreting the QALY concept.

The second attribute reflected whether the liver disease of the potential recipient was caused by naturally occurring liver disease or whether it was induced by the excess consumption of alcohol. This attribute was chosen on the basis that the inclusion of patients with alcoholic liver disease (ALD) in liver transplantation programmes remains controversial (Howard and Fahy, 1997). In 1989 ALD became the most common indication for liver transplantation in the US and a similar situation exists in the UK. It seems likely that increasing numbers of ALD patients will be referred to transplant units in the future. This rising trend of transplanting patients with ALD may provoke concern among health

professionals and the general public as there are fears that these patients may return to alcohol misuse, become non-compliant and have a poor medical outcome (Howard and Fahy, 1997). Some authors have suggested that patients with ALD are personally responsible for their illness and should not be given the same priority as patients who have acquired liver disease through no fault of their own (Moss and Siegler, 1991). There is some evidence to suggest that the general public share this view. In the survey highlighted previously by Neuberger et al (1998), individuals consistently gave a low priority to patients with ALD when compared with patients with other liver diseases.

The third attribute included in the study was the time already spent on the waiting list for transplantation. With the exception of very severely ill patients who are given urgent priority, this criterion is already used as a mechanism for determining allocation decisions in liver transplantation. Once considered suitable for transplantation, patients are placed in a queue to receive a donor organ. Patients are ranked in order of length of time on the waiting list. The sequence of offers depends upon the length of time on the waiting list and the blood group matching of the patient and donor. The levels chosen for the waiting time attribute reflect the current expected waiting times for patients transplanted within the UK (HERG, 1997).

The fourth attribute was the age of the patient. Several previous studies have indicated that, in a situation of limited health care resources, members of the general public are willing to prioritize in favour of the young and away from the elderly (Wright, 1986; Charny and Lewis, 1989; Busschbach et al, 1993; Bjork and Rosen, 1993, Nord et al 1996). However, with the exception of the study by Nord et al, previous studies have failed to distinguish between equity reasons for ageism and efficiency reasons (given that young people will live longer and hence more health will be gained relative to older people). One of the aims of this study was to attempt to isolate equity reasons for ageism by including the expected length of survival as an additional attribute, and thereby reducing the potential for efficiency reasons for ageism to enter into individual's preferences. The levels chosen for the age attribute are based upon the age range for the majority of patients

recently transplanted for liver disease in the UK (HERG, 1997).

The final attribute chosen for the exercise was whether the patient was a primary or a re-transplant candidate. A recent article from the USA has suggested that re-transplant candidates should not be given the same priority as primary transplant candidates on the basis that prognosis after transplant is generally lower for re-transplant candidates (Ubel et al 1993). One might also consider that re-transplant candidates have already been afforded one chance and therefore should not be given the same priority as those patients who are still waiting for their first chance at a transplant. Alternatively, members of the general public may feel that such candidates should be given an equal or even a higher priority on the basis that their first transplant failed and hence such patients should not be abandoned.

The attribute descriptions and their levels as presented to respondents for the pilot survey are detailed in Table 1 in the Appendix.

The presentation of hypothetical scenarios

The attributes and their associated levels were formulated into scenarios which could be presented to individuals as reflecting the key characteristics of a group of individuals awaiting transplantation. The attributes and levels selected gave rise to a very large number of possible scenarios. This was reduced to a more manageable number for the purposes of a self-completion questionnaire using the computer software package SPEED v2.1 (Hague Consulting Group, 1988). This software produces a fractional factorial design which ensures the absence of multicollinearity.

The questionnaire was designed for self completion and was made up of three main sections. In the first section of the questionnaire, individuals were asked to indicate their degree of agreement with the five main attributes, as decision criteria for use in deciding what kinds of patients should be given priority. Additionally, they were asked to rank the decision criteria in order of their relative importance and to indicate any additional criteria

which, in their opinion, should be taken into account in decisions about how donor livers are allocated. In the second section of the questionnaire, individuals were asked to consider a hypothetical situation in which only 100 donor organs are available to distribute amongst two groups of 100 patients awaiting a transplant. All of the patients were described as equally ill and all of them would die within a few weeks if they were not transplanted. Hence, all patients could be defined as being in equal need of a transplant. The two groups differed in terms of the levels of the five principal attributes. Individuals were presented with eight choice situations in total and asked to indicate how they would distribute the donor organs amongst the two groups. Examples of two of the choice situations presented in the questionnaire (choices 1 & 4) are provided in the Appendix. The third section of the questionnaire elicited information about the characteristics of the respondent. Respondents were asked about their age, sex, whether they had ever received an organ transplant themselves, whether any friends or family members had ever received an organ transplant, whether they were the holder of an organ donor card, whether they held private insurance cover and what was the highest level of education they had achieved. The questionnaire was sent by internal mail to 800 randomly chosen employees of a British University. The sample included non-academic as well as academic staff. One reminder was sent to non-respondents after a time interval of approximately six weeks.

Data analysis

The data were analyzed in the statistical package STATA using the random effects linear regression model and a fixed effects model including dummy variables to reflect the individual respondent heterogeneity. The selection of the most appropriate specification was made using the Hausman test (Hausman, 1978). Given the censored nature of the dependent variable, the data were also analysed using simple tobit regression and the results compared with those obtained from the random effects model.

The model to be estimated is:

$$\Delta DL = \alpha_1 AGE + \alpha_2 ALCO + \alpha_3 SURV + \alpha_4 WAIT + \alpha_5 RETRAN + u + \epsilon \quad [1]$$

Where ΔDL, the dependent variable for the analysis, is the difference in the number of donor livers allocated between group A and group B for every choice and $\alpha_1 - \alpha_5$ are the parameters of the model to be estimated. 'AGE' is the difference in age, 'ALCO' indicates the difference in alcoholic status, 'SURV' is the difference in survival time, 'WAIT' is the difference in waiting time, 'RETRAN' is the difference in transplantation status, u is the error term due to differences amongst respondents and $\in$ is the error term due to differences amongst observations.

The values for DL ranged from −100 to +100, DL having a value of −100 in instances where a respondent indicated that all of the donor livers should be allocated to group A and +100 in instances where a respondent indicated that all of the donor livers should be allocated to group B. The values for 'AGE' ranged from −20 to +20, Age being −20 in instances where the age of group A was 20 years older than the age of group B and +20 in instances where the age of group B was 20 years older than the age of group A. All other attributes were coded in a similar fashion. A summary of the variables and coding used for data analysis is provided in Table 2 in the Appendix.

For every respondent, tests were carried out to see if any of the attributes were dominant and further whether a strict lexicographic order could be established (Drakapoulus, 1994; Scott A 1998). In the context of this social CA exercise, a dominant attribute implies that all of the donor livers available are allocated to the group with the higher level of this attribute, irrespective of the levels of the remaining attributes. A respondent exhibiting dominance would therefore be unwilling to accept reductions in this attribute for improvements in other attributes. A situation of dominance can be distinguished from a strict lexicographic ordering in that it places no restriction on the ordering or extent of trading for other attributes. A lexicographic ordering implies that there is an absolute order of preferences for attributes and there is no degree of substitution between any of the attributes in the CA exercise.

Similarly, tests were carried out to see if any individuals exhibited egalitarian preferences.

Egalitarian preferences would be exhibited if any individual allocated equal numbers of livers to both groups for every choice, regardless of the levels of the attributes presented.

The results from the regression models were used to test the theoretical validity of the approach. It was expected a priori that individuals would allocate relatively more donor livers to group A in situations where this group had the higher expected post transplant survival or in situations where this group had been waiting longer than group B. Given the evidence from previous studies of public preferences in this area, it was also hypothesized that individuals would allocate relatively fewer donor livers to group A in instances where this group exhibited alcoholism and group B did not; where group A were being re-transplanted and group B were primary transplant candidates or where the average age of group A was older in comparison with group B.

In order to check the ease of completion of the 'social' CA questions, respondents were asked how easy/difficult they found the questionnaire was to complete. Possible responses to the former question were coded on a scale of 1 to 4 where 1 represents not difficult and 4 represents very difficult.

RESULTS

A usable response rate of 38% was achieved: 303 completed questionnaires were returned plus 10 additional questionnaires where the CA choice questions were not completed. These incomplete questionnaires were excluded from the main data analysis. The majority of respondents were male (56%) with a mean age of 43 years. 63% of respondents were qualified to University level. An analysis of the characteristics of the non-respondents was made using information obtained from the personnel department at Brunel University. This analysis revealed that this group was not significantly different from the respondents in age or sex distributions. However non-responders were significantly less well educated than non-responders with 34% qualified to University level. None of the respondents reported that they had received an organ transplant themselves. However, 7.1% knew friends or family members who had received an organ transplant.

Approximately 45% of respondents indicated that they were the holder of an organ donor card.

Table 3 (Appendix) indicates the level of agreement expressed with the five main attributes as criteria for allocation decisions in liver transplantation in a situation where insufficient donor livers are available to transplant all patients. The strongest level of agreement was accorded to the criteria that 'preference should be given to people who are most likely to survive and benefit': 91% of respondents either agreed or strongly agreed with this statement. Approximately 71% of respondents agreed or strongly agreed that 'preference should be give to those individuals whose need for a liver transplant arises as a consequence of naturally occurring liver disease rather than their personal behaviour e.g. due to the excess consumption of alcohol': 63% of respondents agreed or strongly agreed that 'preference should be given to younger rather than older people' and 66% of respondents agreed or strongly agreed that 'preference should be given to those who had been on the waiting list for the longest period of time. A relatively large number of individuals (24.3%) expressed no opinion about whether preference should be given to those individuals awaiting their first transplant over those awaiting re-transplantation.

Respondents were then asked to rank the five criteria presented in order of their importance as decision criteria for allocating donor livers. The results are highlighted in Table 4 (Appendix). In terms of absolute numbers 'survive and benefit' was ranked first by the majority of respondents with 'age' ranked second and 'waiting list for the longest period' ranked third. Interestingly, first transplant over a re-transplant was the only criteria which a majority of respondents ranked either fourth or fifth overall (71%).

Of the 303 completed questionnaires, only 2 respondents (0.7%) exhibited dominant preferences. Both individuals exhibited dominant preferences for the same attribute, namely 'expected length of survival': they consistently allocated all of the donor livers to the group of individuals with the higher expected length of survival regardless of the levels of the other attributes. Neither of these individuals exhibited a strict lexicographic ordering

for the attributes presented. A total of 7 respondents (2%) exhibited egalitarian preferences. These individuals allocated equal numbers of livers to both groups for every choice, irrespective of the levels of the attributes presented in each choice.

Respondents differed markedly in the extent to which they appeared to find the questionnaire difficult to complete with 42 (14%) indicating that they found it very difficult to complete, 80 (27%) indicating that it was moderately difficult to complete, 63 (22%) indicating that it was slightly difficult to complete and (107) 37% indicating that it was not difficult to complete.

A choice between random effects linear regression model and a fixed effects model was made using the Hausman test which indicated that the random effects specification was adequate (chi^2 7.3 prob chi^2 0.1994 df=5). The results from the random effects linear regression model are given in Table 5. The data were also analysed using a tobit regression model. The results of this analysis were very similar to the random effects model. Given this finding, and due to the repeated measurement aspect of the data (whereby multiple responses are obtained from the same individual), it was decided to use the random effects linear regression model as reflecting the most appropriate model. The model was tested for misspecification using a Ramsey RESET test whereby the square of the predictions from the model were added to the equation. This variable ($GROUPDIFF^2$) was not found to be significant (p=0.584) indicating that there was insufficient evidence to reject the null hypothesis of good model specification.

The results from the random effects linear regression model (Table 5) indicate that all of the attributes are significant in influencing respondents' allocation decisions. The results also provide some support for the model's theoretical validity since, with the exception of the primary versus re-transplant attribute (RETRAN), the signs of the coefficients for the attributes are in the expected direction. The negative sign on the age attribute (AGE) indicates that the number of livers allocated to group A is generally greater than the number of livers allocated to group B in instances where the age of the individuals in group

A is less than the age of the individuals in group B. Hence, respondents generally exhibited a preference for younger people over older people in their allocation decisions. Similarly, the negative signs on the alcohol attribute (ALCO) indicates that respondents generally had a preference for patients with naturally occurring liver disease as opposed to alcoholic liver disease. The positive signs on the survival (SURV) waiting time (WAIT) and re-transplant attributes (RETRAN) indicates that the number of livers allocated to group A is generally higher in instances where these individuals have a higher expected post-transplant survival time or in instances where these individuals have been on the waiting list for the longer period of time or in instances where these individuals are being re-transplanted.

The results from the model can be used to predict how respondents would make allocation decisions between two groups of individuals in instances where the characteristics of the two groups are different. The difference in the number of livers allocated between group A and group B can be estimated by inserting the levels of the attributes for each group and the estimated coefficients into equation [1]. In choice 1 of the exercise for example (see Appendix), the individuals in group B are older, have a lower expected survival time and have been waiting for a shorter period of time relative to the individuals in group A. In all other respects the groups are assumed to be the same. Using the estimated equation for DL in Table 5 and the coding for the levels of the attributes presented in choice 1 from Table 2, this gives:

$$DL = -1.49\,(10) - 38.18\,(0) + 4.05\,(-5) + 1.14\,(-3) + 7.90\,(0) - 0.50 \qquad [2]$$

Solving this equation gives a value for DL of -40 which means that on average respondents would allocate 40 less livers to group B than to group A. The total allocation being 69 livers to group A and 31 livers to group B. Similarly in choice 4, (see Appendix) the individuals in group B are younger, and have naturally occurring liver disease whereas those in group A are older and have alcoholic liver disease. In all other respects the groups are assumed to be the same. Using the estimated equation for DL in Table 5 and the coding for the levels of the attributes presented in choice 4 from Table 2, this gives:

$$DL = -1.49\,(-10) - 38.18\,(-1) + 4.05\,(0) + 1.14\,(0) + 7.90\,(0) - 0.50 \qquad [3]$$

Solving this equation for DL gives a value of +54 which means that on average the group would allocate 54 more livers to group B than to group A.

DISCUSSION

The results from this pilot survey suggest that respondents are able and willing to differentiate between groups of individuals in deciding priorities for scarce health care resources on the basis of their characteristics. Although the health outcome as a consequence of transplantation was found to be an important factor in determining preferences between the two groups of individuals, the vast majority of respondents chose not to make their allocation decisions on the basis of this attribute alone. Respondents were prepared to sacrifice some gain in the efficiency of the transplantation programme for an increase in equity or fairness in the allocation of donor livers. This finding has potentially important implications for the methodology of economic evaluation in health care since it suggests that the views of the public are at odds with traditional health economic thinking.

Respondents in this study exhibited a very strong preference in favour of individuals with naturally occurring liver disease and away from individuals with alcoholic liver disease. In common with previous studies which have explored public preferences for resource allocation in health care, respondents also expressed a preference for younger rather than older people. The time already spent on the waiting list was also found to be an important factor with longer waiting times given a higher priority. Respondents in this study chose to give a larger number of donor organs to re-transplant candidates than primary transplant candidates. This allocation decision may have been made on the premise that re-transplant candidates deserve to be given another chance given that their first transplant failed due to medical reasons. It is possible that respondents felt that such patients should not be abandoned by the medical system. However, further work is required to substantiate this result and to establish the 'cognitive' reasoning used by respondents in determining their allocation decisions.

Care should be taken in interpreting the results from this pilot survey since it was undertaken on a convenience sample which cannot be considered as representative of the general public. On average, respondents to this survey were better educated than members of the general population. This study does however add to an increasing literature which suggests that the objectives of members of the general population differ from those which are implicitly assumed by health economists.

In contrast to other techniques proposed in the health economics literature for incorporating equity considerations into the valuation of the benefits of health care e.g, the PTO, the social CA approach adopted has the advantage that the relative weight attached to each characteristic presented can be ascertained. Although the approach has been developed and applied within the liver transplantation context, it has much wider potential applicability. The dependent variable used in the exercise could be made more generalisable to reflect the difference in the numbers of individuals who receive treatment; the independent variables reflecting key characteristics which may influence individual's preferences for resource allocation in health care e.g. age, length of time spent waiting for treatment, severity of illness etc. Further research is required to assess the theoretical and empirical validity of this approach as a tool for eliciting public preferences in health care decision making.

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APPENDIX

TABLE 1: The attributes used in the social CA exercise

Attributes and their descriptions	*Levels*
'Age' where this refers to the age range of the group of individuals at the time of the transplant operation	40 years 50 years 60 years
'Alcoholic liver disease' where 'Yes' indicates that this group of individuals have a type of liver disease which is acquired by the consumption of alcohol and 'No' indicates that that this group of individuals have a type of liver disease which is naturally occurring	Yes No
'Expected length of survival' where this is defined in years and relates to the expected length of life following the transplant operation	5 years 10 years 15 years
'Time already spent on the waiting list' where this refers to the amount of time in months the individuals have already spent on the waiting list for a liver transplant	3 months 6 months 12 months
're-transplanted' where 'Yes' indicates that this group of individuals have received a liver transplant previously and 'No' indicates that this group of individuals are being transplanted for the first time	Yes No

TABLE 2: Variables and their coding for data analysis

Variable	Type	Coding
DL – difference in the number of livers allocated as move from group A to group B	Continuous	-100 to +100
AGE – difference in age as move from group A to group B	Continuous	-20 to +20
ALCO – difference in alcoholism as move from group A to group B	Discrete Alcohol Yes = 1 Alcohol No = 0	-1, 0 , + 1
WAIT – difference in waiting time as move from group A to group B	Continuous	-9 to +9
RETRAN – difference in transplantation status as move from group A to group B	Discrete Re-transplantation Yes = 1 Re-transplantation No = 0	-1, 0 , + 1

TABLE 3: Opinion on the use of specific medical and social criteria in the selection of transplant recipients

Criteria	Strongly Agree	Agree	Disagree	Strongly Disagree	No opinion
A) Younger rather than older people	14.8%	51.5%	18.9%	5.1%	9.8%
B) Naturally occurring liver disease	24.0%	47.6%	14.5%	6.8%	7.1%
C) Survive and benefit	53.7%	37.4%	5.1%	1.7%	2.0%
D) Waiting list for longest period	15.2%	47.6%	20.6%	2.4%	14.2%
E) First transplant over a re-transplant	11.1%	44.6%	16.6%	3.4%	24.3%

TABLE 4: Ranking of specific medical and social criteria in order of importance

Criteria	First	Second	Third	Fourth	Fifth
Younger rather than older people	12.6%	32.4% (2)	23.9%	14.7%	16.4%
Naturally occurring liver disease	8.1%	18.5%	27.2% (4)	21.6%	23.0%
Survive and benefit	66.7% (1)	19.2%	5.9%	6.6%	3.3%
Waiting list for longest period	9.8%	19.2%	27.2% (3)	29.3%	14.5%
First transplant over a re-transplant	2.8%	10.7%	15.8%	27.8%	42.8%

TABLE 5: Random effects regression model

Attributes	Coefficient	p	95% CI
AGEDIFF	- 1.4937	0.000	-1.7343 to -1.2531
ALCODIFF	- 38.1816	0.000	-41.2835 to -35.0797
SURVDIFF	4.0472	0.000	3.6224 to 4.4719
WAITDIFF	1.1372	0.006	0.3307 to 1.9438
RETRANSDIFF	7.8922	0.003	2.6800 to 13.1043
CONSTANT	-0.5046	0.606	-2.4241 to 1.4150

Number of observations = 2413
N = 303
Chi^2 = 1632.4 (p = 0.000)
R^2 = 0.43

Choice 1	Group A	Group B
Age	50 years	60 years
Alcoholic liver disease	Yes	Yes
Expected length of survival	15 years	10 years
Time already spent on waiting list	6 months	3 months
Re-transplanted	Yes	Yes

How would you allocate the available livers between the two groups of individuals?
(the total for the two groups should add up to 100)
(please write the number of livers allocated to each group in the boxes below)

Group A	Group B	
		TOTAL=100

Choice 4	Group A	Group B
Age	50 years	40 years
Alcoholic liver disease	Yes	No
Expected length of survival	5 years	5 years
Time already spent on waiting list	3 months	3 months
Re-transplanted	No	No