THE VALUE OF ROAD SAFETY: UK RESEARCH ON INJURY VALUATION

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1. INTRODUCTION

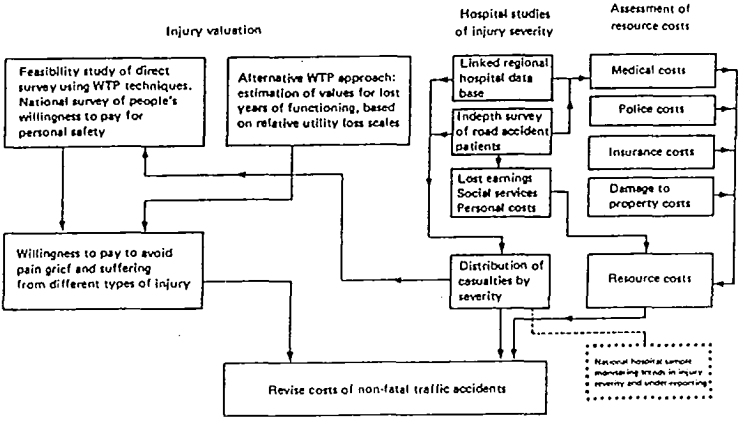
In 1988 the Department of Transport (DTp) made a major change in the method used to value the prevention of fatal casualties. A valuation based on Willingness-To-Pay (WTP), ie the amount that individuals are willing to pay for a reduction in the risk of a fatal accident, replaced the method which had been in place since 1968, which was based on loss of output, medical costs and an estimate of human costs, termed pain, grief and suffering.

The new WTP estimate for the value of preventing a fatality was based on a consensus evaluation of existing research findings (Dalvi, 1988). However, for non-fatal injuries there was no equivalent information, and therefore the DTp set in train a programme of research to investigate WTP valuation methods for serious[1] casualties. At the same time, a parallel programme of research was commissioned from TRRL to consider direct economic costs - medical costs, lost output, police and damage costs. This is summarised in Figure 1.

Two research projects were managed by TRRL with the aim of providing estimates of the value of avoidance of serious road injuries. The first, undertaken by the University of Newcastle upon Tyne and the University of York, which is the subject of this paper, is concerned with eliciting WTP values for avoidance of a serious road injury using a national sample survey of the general public. The second, undertaken by the Environmental Risk Assessment Unit of the University of East Anglia, looked at the application of the relative utility loss approach (RULA), as used in health economics in the

measurement of quality of life, to estimating the values of avoidance of serious road casualties.

Figure 1 TRRL Programme of Research



Source: TRRL LF2047.

This paper will summarise the national sample survey using willingness to pay methodologies and discuss some of the results. In particular it will look at the effects of demographic and economic factors on individual valuations.

2. METHODOLOGY

In 1982 the University of Newcastle upon Tyne carried out a national sample survey of WTP for avoidance of a fatal injury for the DTp (Jones-Lee et al, 1985). Experience from this study and extensive piloting of various questionnaire approaches resulted in a national study of non-fatal injuries using two questionnaires: Standard Gamble (SG) questions in one; and Contingent Valuation (CV) questions in the other. The inevitable complexity of the questionnaires meant that:

i. experienced interviewers should be used for the national sample survey, TRRL interviewers were therefore chosen and;

ii. respondents needed to be carefully prepared by a full explanation of the risk concept to be used and tested on their understanding of it before completing the complex valuation exercise.

CV questions in the national study asked how much the respondent would be willing to pay for a hypothetical safety feature that could reduce the

risk of given injuries by a specified amount and that had to be renewed annually. SG questions asked the respondent to suppose that he/she had incurred a road injury which, if treated in the normal way, would have a given prognosis. Respondents were then asked to suppose that an alternative medical treatment was available which, if successful, would return them to normal health but if unsuccessful would result in a specified health state (e.g. death) that would usually be regarded as worse than the prognosis associated with normal treatment. In both the SG and CV questionnaires respectively, respondents were asked to indicate:

i. the largest annual amount they were sure they would pay, or the greatest risk of failure at which they were sure they would accept the alternative treatment;

ii. the smallest annual amount they were sure they would not pay, or the lowest risk of failure at which they were sure they would reject the alternative treatment; and

iii. the annual amount, or risk of failure, which would make it most difficult for them to decide whether or not to buy the safety feature or to take the alternative treatment.

Follow-up interviews were carried out with a subset of each sample to test for temporal consistency and also to ask the type of question that had not been asked in the first interview. This allowed direct within-subject comparisons of the CV and SG responses.

Both studies concentrated principally on injuries the Department of Transport classified as 'serious'. Due to the broad range of injuries included in this category it was necessary to develop a set of more detailed descriptions spanning the range. This was achieved with the help of Professor Galasko and his team of researchers at the Department of Orthopaedic Surgery at University of Manchester. They have been carrying out research into the effects of road traffic accident injuries at hospitals in Greater Manchester for TRRL. In separating out injuries to cover the full spectrum of serious injuries, some judgement had to be made about the number of descriptions the general public could be expected to assimilate and the amount of information and the level of detail contained in each one. Figure 2 shows the 8 injury descriptions eventually used, plus normal health and death. Each description includes information on hospital stay and duration; the after effects; amount of pain and its duration; and some indication of the recovery period or effects of disability. Beside each is the current best estimate of the annual risk facing the average driver or passenger. The risk is expressed as the probability of occurrence given that there are likely to be 100 serious injuries per 100,000 drivers per year, an approximation based on accident statistics (RAGB, 1989) and an assumption of an average annual

mileage of 10,000 miles.

Figure 2. Injury Descriptions - covering all DTp 'serious' injuries

F	No overnight stay in hospital (seen as outpatient); experience slight to moderate pain for 2-7 days followed by some pain/discomfort for several weeks; some restrictions to work and/or leisure activities for several weeks/months; afer 3-4 months, return to normal health with no permanent disability	$8x10^{-5}$
W	In hospital 2-7 days in slight to moderate pain; after hospital, some pain/discomfort for several weeks; some restrictions to work and/or leisure activities for several weeks/months; after 3-4 months, return to normal health with no permanent disability	$16x10^{-5}$
X	In hospital 1-4 weeks in slight to moderate pain; after hospital, some pain/discomfort, gradually reducing; some restrictions to work and leisure activities, steadily improving; after 1-3 years, return to normal health with no permanent disability	$30x10^{-5}$
V	No overnight stay in hospital (seen as outpatient); moderate to severe pain for 1-4 weeks; thereafter, some pain gradually reducing but may recur when you take part in some activities; some permanent restrictions to leisure and possibly some work activities	$4x10^{-5}$
S	In hospital 1-4 weeks in moderate to severe pain; after hospital, some pain gradually reducing, but may recur when taking part in some activities; some permanent restrictions to leisure and posibly some work activities	$24x10^{-5}$
R	In hospital several weeks, possibly several months in moderate to severe pain; after hospital, continuing permanent pain, possibly requiring frequent medication; substantial and permanent restrictions to work and leisure activities; possibly some prominent scarring	$16x10^{-5}$
N	In hospital several weeks, possibly several months; loss of use of legs and possibly other limbs due to paralysis and/or amputation; after hospital, permanently confined to a wheelchair and dependent on others for many physical needs, including dressing and toiletting	$2x10^{-5}$
L	In hospital several weeks, possibly several months due to head injuries resulting in severe permanent brain damage; after hospital, mental and physical abilities greatly reduced permanently; dependent on others for many physical needs, including feeding and toiletting	
Overall risk of serious non-fatal		$100x10^{-5}$
K	Immediate unconsciousness, followed shortly by death	$8x10^{-5}$

3. THE QUESTIONNAIRE

Once selected, an eligible respondent was asked about their driving/passenger experience and accident experience before being asked to rank and scale the ten injury description cards. First respondents ranked the cards in order from best to worst, then they were asked to scale the cards on a 'thermometer' type scale to give an indication of the relative 'badness' of injuries to each other. In performing both tasks respondents were becoming familiar with the injuries and in the scaling exercise were able to give more careful consideration to their responses. This was followed by the explanation of the appropriate concept of risk for each questionnaire and a test of the respondent's comprehension of the risk concept. The main valuation exercise was then completed. All questionnaires included a final section providing demographic and economic indicators including: questions on age; socio-economic group (SEG); educational qualifications; household size; and

income.

4. THE SAMPLE

Two random samples of household addresses were drawn according to pre-determined criteria from the post code address file. The sampling units were stratified into conurbations and other areas, and further stratified by SEG and car ownership level. A screening questionnaire was administered to randomly select one member of each household sampled to participate in the main study; the results were subsequently weighted according to household size. The eligible respondent was then randomly allocated to either the CV or SG questionnaire.

Face to face interviews were conducted during July and August 1991. The target sample for each survey was 450 completed interviews with 50 of each being followed up a few weeks after the main survey. There were a total of 409 completed SG interviews and 414 CV interviews; also 53 SG follow-up interviews and 48 CV follow-up interviews were completed. Each interview lasted an average of 39 minutes for SG questionnaires and 45 minutes for CV questionnaires.

Comparisons in Figures 3 and 4 show that in terms of income and age the cumulative frequency distributions are very similar to national distributions, shown by the General Household Survey (GHS) and the Family Expenditure Survey (FES).

When broken down by gender it was found that 52% of each sample were female, which matches the national distribution.

Figure 3: Cumulative frequency distributions for age.

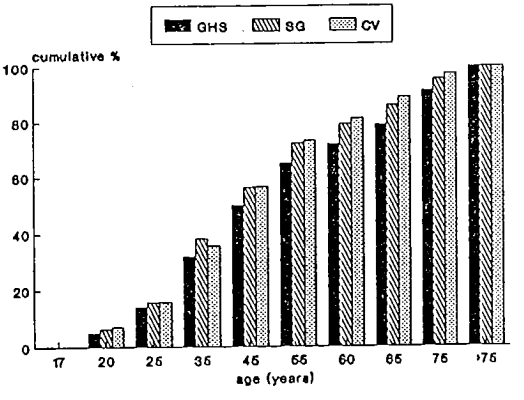
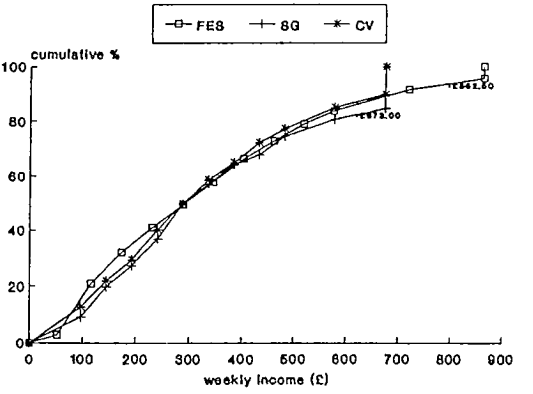


Figure 4: Cumulative frequency distribution for household income



When the samples are compared with national statistics it is important to note that non-drivers and those that were motor vehicle passengers less than three times in the last twelve months were omitted from the study. This accounts for the high proportion of respondents in the driver category as compared with the national distribution shown in Table 1. Overall the response rates and the representativeness of the two samples were considered satisfactory.

Table 1 Distribution of sample according to driver/non-driver

	SG	CV	GB
Driver	73.6%	66.4%	52%
Non-driver	26.4%	33.6%	48%

5. RESULTS

The large number of correct responses to the risk test questions (85% and 97% for the SG and CV samples respectively) suggests a good understanding of the risks presented in the questionnaire. This was attributed to the thorough explanation of risk and the 'credible' scenario presented in these questions. Interviewers reported that respondents appeared to have a good understanding of the injury description cards. Comparison of the ranking

and scaling of injury descriptions, common to both questionnaires, found there to be a very high degree of agreement. Interestingly many people regarded the prospect of severe permanent brain damage as being as bad as or worse than death.

5.1 The value of avoidance of serious injury

For both SG and CV responses means and medians were calculated although only the mean results are reported below. The results are given as the ratio of the marginal rate of substitution of wealth for risk of serious injury (MI) to the marginal rate of substitution of wealth for risk of death (MK). This is done so that the two methods can be compared. The MI/MK ratio can easily be converted into monetary values by multiplying it by the current DTp value of avoidance of a fatality. The 1988 value of a fatality is uprated annually for inflation and GDP, the pure WTP component of DTp's current value is estimated to be £620,000 (1990 prices).

For both types of questionnaire a number of internal consistency checks were made, such as comparison of the results of the ranking and scaling exercise with the subsequent valuations and within subject comparisons were made using the sub-sample of follow-up interviews. The checks showed no great prevalence or strong pattern of strict inconsistencies between rankings and subsequent orderings implied by the SG and CV responses. Random errors were no more than expected in any survey consisting of unpremeditated answers to lengthy and demanding questions.

The overall MI/MK figure is calculated by weighting the mean ratio of marginal rates of substitution of injuries and death by the relative frequency of occurrence of each type of injury, interpolating from scaling scores those injuries not specifically valued. Overall for the SG sample the minimum MI/MK was 0.10, the maximum 0.15 and the best estimate was 0.12. For the CV sample the minimum mean ratio was 0.34, the maximum was 0.63 and the best estimate was 0.44. Corresponding monetary values are calculated assuming the current DTp value for avoidance of a fatality. This produces ranges of £62,000 to £93,000 with a best estimate of £74,500 for the SG sample. For the CV sample the ranges are from £211,000 to £391,000 with a best estimate of £273,000.

To test each respondent's ability to adjust for different risks, the CV questionnaire contained two values of risk reductions for injury description S. For the reduction of S by 4 in 100,000, reported in Table 2, the mean ratios ranged from a minimum of 0.48 to a maximum of 0.93, while for a reduction in risk in S of 12 in 100,000 the minimum value was 0.20 and a maximum of 0.38. These values show that respondents in the CV sample were

insensitive to the risk reductions being presented to them.

The individual contributions of each serious injury type are shown in Table 2. It can be seen that the injuries with permanent disability, particularly injuries R and S, contribute disproportionately more than those with no permanent effects.

Table 2 Ratios of marginal rates of substitution of wealth for risk of injuries vis a vis marginal rates of substitution of wealth for risk of death.

Injury type	Standard Gamble			Contingent Valuation		
	BEST	MIN	MAX	BEST	MIN	MAX
MR/MK	0.233	0.203	0.310	0.872	0.661	1.272
MS/MK	0.151	0.122	0.195	-	-	-
MS1/MK	-	-	-	0.631	0.482	0.928
MX/MK	0.055	0.051	0.069	0.229	0.176	0.336
MW/MK	0.020	0.022	0.036	0.207	0.160	0.299
All serious						
MI/MK	0.117	0.104	0.149	-	-	-
MI1/MK	-	-	-	0.438	0.340	0.633

This Table clearly shows that there are substantial and systematic disparities between the estimates from the two elicitation procedures. The CV valuations are mostly three or four times greater than the SG results, and ten times greater for MW/MK, the least severe injury type. It is felt that these disparities can be largely accounted for by the upward biases at work in the CV responses. As shown by the comparison of different risk reductions for injury description S, the CV responses tend not to take sufficient account of the probability reductions associated with the different injuries. Also respondents appear not to adequately differentiate between the severities of these injury descriptions. The result is that the marginal rates of substitution estimated from these responses do not decline as fast as one would expect as one moves from death through the more severe to less severe injuries. A similar result emerges from the scaling exercise where the less severe serious injury descriptions tend to be located further away from normal health and closer to death than expected. There are a number of possible explanations:

interviewers reported that some respondents appeared to have a 'personal safety expenditure budget' which they assigned to all safety improvements regardless of the nature of the injury or the reduction in risk; in addition, respondents may not have carefully considered the duration of pain in some temporary states in relation to their life expectancy and thereby overestimated valuations for some temporary states.

In contrast, the SG responses do not appear to be subject to any obvious major biases. This may be explained by the simple and credible scenario presented. In the SG approach it is was considered easier for respondents to focus on their own risks, independently of others. Also the type of question asked forces respondents to weigh up their future lifetime in one injury state against their future lifetime in another, thereby avoiding placing excessive weight on the relatively short initial period of pain and discomfort associated with the less severe injuries.

5.2 Demographic effects

Do some demographic and economic factors have a significant or systematic effect on MI/MK? In the following tables mean ratios for MI/MK are produced from respondents' best estimates. In the case of the CV sample a reduction of injury S by 4 in 100,000 is used. Only when there are complete responses to all relevant categories are responses used, which accounts for the smaller sample sizes.

In the 1982 study, age was observed to have an effect on the absolute level of willingness-to-pay. So it was decided to see if it also had an effect on MI/MK. When considering age it should be noted that elderly people were the most likely to be unable to complete the interview. Table 3, below, shows the mean MI/MK for each age group. In the SG sample the highest means come from those in the highest and lowest age groups. This implies that these age groups have a greater aversion to the risk of serious non-fatal injuries relative to their aversion to the risk of death. In the CV sample valuations increase with age over 41 years and may be correlated to number and age of dependents. Age was found to have significant effects in both samples, at the 6 percent level.

Table 4 shows a breakdown of MI/MK ratios for each sample according to gender. In the SG sample females have a lower aversion to the risk of non-fatal injuries relative to the risk of death than males, while in the CV sample females were prepared to pay more than males for a safety feature that reduces risks of non-fatal injuries relative to risk of death. For the CV sample gender differences were significant at the 5 percent level, while for the SG sample they were significant at the 6 percent level.

Table 3 MI/MK, from best estimates, for different age groups.

Age	SG	n	CV	n
< = 20	0.1159	25	0.3634	32
21-30	0.0958	93	0.4417	65
31-40	0.1089	68	0.4076	75
41-50	0.0804	68	0.4301	62
51-64	0.1296	67	0.4597	75
65+	0.1451	42	0.5408	37

Table 4 MI/MK, from best estimates, according to gender.

Gender	SG	n	CV	n
Male	0.1219	170	0.4093	164
Female	0.0981	195	0.4669	182
Total	0.1092	365	0.4396	347

All respondents were asked to estimate their household income: some refused and some were unable to reply. In the CV questionnaire respondents were asked to bear in mind what they could afford. The variations in MI/MK according to income were not found to be significant. However, income was found to be a significant factor when considering absolute values from the CV sample rather than the MI/MK ratios presented here.

Both questionnaires asked if respondents had ever been injured in a road traffic accident or had a close relative killed or injured in a road traffic accident. This question was incorporated to assess the impact of personal accident experience on accident valuations and also to allow those that might become distressed by the questionnaire an opportunity to abort the interview. Again the variations were not found to be significant and were not consistent between the two samples.

Finally we looked at the effect of SEG. Like income and accident experience, SEG was not found to have a significant effect on MI/MK.

5. CONCLUSIONS

The national sample survey of WTP to reduce the risk of serious non-fatal accidents was considered an ambitious project providing a number of practical and theoretical challenges; with the outcome considered more successful than expected.

The most striking results are the substantial and systematic disparities between the estimates from the different elicitation procedures. The CV valuations are consistently three or four times greater than the SG results. It is felt that this disparity can be largely accounted for by the upward biases at work in the CV responses. In effect CV responses (a) tend not to take sufficient account of the probability reductions associated with the different injuries and (b) do not adequately differentiate between the severities of these injuries. The result is that the marginal rates of substitution estimated from these responses do not decline as fast as one would expect as one moves from more to less severe injuries. There are a number of possible explanations: respondents may not have carefully considered the duration of pain in some temporary states in relation to their life expectancy and thereby overestimated the severity of some temporary states; in addition, interviewers reported that some respondents appeared to have a 'personal safety expenditure budget' which they assigned to all safety improvements regardless of the nature of the injury or the reduction in risk.

It is therefore felt that CV valuations, which at the outset were considered most promising, should be considered as a 'ceiling'. In contrast the SG responses do not appear to have been subject to any obvious major biases. This may be accounted for by the simple and credible scenario that is presented. It is easier for respondents to focus on their own risks independently of others. In addition, this type of question forces the respondent to take into account their future lifetime in one injury state against their future lifetime in another.

The results presented here show that the values of MI/MK do vary for different age groups and according to gender. However, other demographic variables appear to have no consistent and significant effect on both the SG and CV values for MI/MK. This suggests that it is individual personality and psychological disposition rather than demographic and economic factors that account for most of the observed variation in MI/MK.

This research is a major contribution to the injury valuation element of the revaluation of non-fatal casualty costs research programme. The results of each study have now been reported and it is hoped that, after a period of public consultation, the non-fatal casualty costs will be revalued by early 1993. The revised and updated valuations will be incorporated into the cost-

benefit analysis that the Department of Transport uses to assess the costs and benefits of major road schemes (COBA). The values for avoiding casualties will also be used to enable road safety schemes with the highest rate of return on investment, in terms of costs and benefits, to be given greatest priority, thereby facilitating the efficient use of resources available for road safety.

NOTES

[1] In the UK road casualties' injuries are classified as either fatal, serious or slight. Typically, this is done within a short time of the accident by a police officer attending the accident. A serious injury is an injury for which a person is detained in hospital as an 'in-patient', or for any of the following injuries whether or not the patient is detained in hospital: fractures, concussion, internal injuries, severe cuts and lacerations, severe general shock requiring medical treatment, and injuries causing death more than 30 days after the accident.

BIBLIOGRAPHY

Dalvi, M Q. The value of safety: a search for a consensus estimate. HMSO, 1988.

Department of Transport, Road Accident Statistics Great Britain 1988. HMSO, 1989.

Jones-Lee, M.W., Hammerton, M., Philips, P.R.. The Value of Safety: Results of a National Sample Survey. Economic Journal, Vol 95 p 49-72, 1985.

TRRL, LF2047 Accident Costing Research. TRRL, 1991.

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