REVALUATION OF NON-FATAL CASUALTY COSTS:
A REPORT OF THE APPLICATION OF THE RELATIVE
UTILITY LOSS APPROACH (RULA)

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RE_EVALUATION OF NON-FATAL
ROAD TRAFFIC CASUALTY COSTS :

RELATIVE UTILITY
LOSS METHODOLOGIES

REPORT ON STAGE 2

January 1992

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Working papers are available on demand from the Road User Safety Division, TRL, or Publications Division, TRL.
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* Dr. R.V. Kemp has since joined Dames and Moore
EXECUTIVE SUMMARY

BACKGROUND AND OBJECTIVES
1. In 1988 the Department of Transport reviewed its valuation of a fatal casualty arising from a road traffic accident. A figure of approximately £500,000 was adopted, based upon a review of Value of Life studies, paying particular attention to the Willingness to Pay (WTP) methodology including its own study carried out by the Universities of Newcastle-upon-Tyne and York. Following this, it became necessary to revalue serious non-fatal and slight injuries.

2. After consultation, two alternative approaches were selected. The first would be carried out by the Universities of Newcastle-upon-Tyne and York, and would again be based upon more-or-less direct value elicitation methods on a nationally representative sample. It was felt that this approach was theoretically sound and, in addition, it had the clear advantage of consistency with the methods used by the Department to value a fatality.

3. In addition, however, it was also decided to investigate the 'Relative Utility Loss Approach' (RULA) which had been identified as a complementary approach in an earlier study by the University of East Anglia. While breaking new ground, it was considered that RULA had potential significant advantages of its own. This report describes the conduct of the RULA study and its outcomes.

OUTLINE OF RULA
4. In principle, RULA is straightforward. Designated health states are assigned a utility score on a scale zero to unity (sometimes zero to one hundred), where unity represents full health and zero represents death (fates worse than death could be included and would have a negative value). The monetary value of the impairment is then computed from the product of the relative utility loss of that impairment, which is the difference in utility between that state and full health, and the value of life (VOL).

5. Although RULA scores could in principle be obtained from national surveys, for the purpose of this study it was decided to make use of existing research and expert opinion. Within the technical literature there is a wealth of information on various kinds of utility scales which have been devised as a means of aiding prioritisation in many spheres, from health service investment to radiological protection, to mention but two. Although none had formerly been used by the Department of Transport for the valuation of injuries arising from road traffic accidents, the decision was made that the methodology should be evaluated.

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1 This figure has been increased, for inflation, to a current value of approximately £564,000. This value is intended to include all direct costs of a fatality as well as its associated pain, grief and suffering. For the present study, a figure of £620,000 was agreed to represent purely the 1992 value of pain, grief and suffering associated with a road traffic accident fatality.
6. The perceived advantages of RULA had been identified as being:
   - permits examination of the views and valuations of specific subsets of society which have special
     knowledge of, or reason to be concerned about, transportation-related injuries;
   - permits a more detailed study of the relative perceived importance of alternative injury states than could
     be contemplated in a nationally-representative survey;
   - values of injury would be calculated using the existing VOL as a starting point. The existing VOL would
     thus act as a reference point for the valuation of injuries;
   - relative utility scores should be unchanging with time (except in the light of new research) and hence
     there would be no need to carry out periodic resurveys to determine their value. Only the VOL need be revalued
     from time to time.

7. Although there is weakness in methods reliant solely upon expert opinion, there are several bridges which
   connect the above methodology to public preferences. First is that the Value of Life which is used by RULA is, at
   least in part, based on public preferences. Second is that many of the health state utility scales, although designed
   primarily by experts, rely for their actual numerical valuations upon sample groups who may be representative of
   public opinion. There is, in addition, a view within the risk profession, that the ultimate solution to issues involving
   trade-offs between risks and benefits, and that which is most accountable, may be achieved by an appropriate
   balance of expert and lay opinion.

APPLICATION OF RUL APPROACH TO ROAD TRAFFIC ACCIDENTS

8. First, following directly from work by Professor Galasko and colleagues at Hope Hospital in Salford, a serious
   road traffic injury was subdivided into eight specific injury types, each with its own estimated probability of
   occurrence. The task was then to assign utility loss scores to each of the eight injuries, and weight them
   accordingly to compute the utility loss of an aggregate serious injury.

9. The Environmental Risk Assessment Unit (ERAU) at the University of East Anglia reviewed the literature to
   identify a selection of utility loss indices which might be applied to the eight road traffic injuries. Four indices
   were ultimately chosen. These were:

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2 For the purpose of this study, the probability of occurrence of each substate is based on police accident reporting statistics, unless otherwise stated.

3 The Rosser and Rosser-revisited utility loss indices actually use the same (Rosser) matrix but with different utility loss values.
10. The exercise of mapping the eight Galasko injury descriptors onto the utility loss indices and the visual analogue scale (VAS) was performed by a group of ten experts, comprised of three external health economists, five nurses with particular experience in the long-term consequences of road traffic accidents, and two government health economists. A structured approach was used in which ERAU developed and tested a series of questionnaires to be used by the consultants in the mapping exercise.

11. In the case of the VAS, the consultants were asked to rate the complete injury descriptors. However, for the main group of utility loss scales, it was decided to subdivide the eight Galasko injury states into component parts, in order to study separately the contributions of various phases of each nonstatic injury state, albeit within the context of the overall prognosis. The consultants were invited to comment freely during the task, and in particular at a subsequent round-table debriefing.

12. Following the mapping exercise, the ERAU obtained the appropriate RULA scores from the utility loss matrices, and computed an overall median RULA score for each of the eight injury states. This required non-trivial assumptions about the validity of transferring utility values based on one duration to the context of injuries of different durations. Ultimately, it was decided that the utility losses in all four matrices should be taken as applying to a duration of one year. It was further assumed that utility loss is proportional to the time spent in a state, so that utility losses for periods longer or shorter than one year could be computed.

13. Because the utility loss matrices were taken as applying to a one-year duration, it was appropriate to first compute the utility loss of each of the injury states in terms of lost years of functioning. 4

14. Lost years of functioning (LYF) can be converted into monetary values by multiplying by the value of a life year, which is obtained by dividing the VOL by the number of remaining life years, discounted at the appropriate rate. For the purpose of this study, based on Central Statistical Office data on average life expectancy, and our instructions to rate the injuries for 'an average working-age adult', it was taken that 39 life years was the average remaining life expectancy of the road traffic accident victim.

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4 For example, a utility loss of 0.3 extending over 6 years would amount to 1.8 lost years of functioning at zero per cent discount rate.
RESULTS

15. The numbers of lost years of functioning associated with the eight injury states, using the above methodology, are as shown in Figure (i). Health states designated S, V, R, L and N all contain an element of permanent disability, and have higher associated impairment values than those which do not (F, W and X), as would be expected. Despite the assumptions and difficulties associated with the mapping exercise, and the subsequent assumptions about temporal dependence of utility, there is striking accord between the LYF scores as derived using the EuroQol, Rosser-revisited and Torrance indices for all eight injury states. The slightly higher scores of the Torrance index for those states with permanent disability might be attributable to the fact that the utility values in this matrix were based on infants, whose longer life expectancy might lead to higher utility losses in the case of permanent impairments, although there may be other explanations.

16. The main divergence is that resulting from the use of the Rosser utility loss index. It is suggested that this is attributable to the unbounded magnitude estimation methodology adopted by Rosser, and which is distinct from the approach used in Rosser-revisited and EuroQol, and also differs from that of Torrance.

17. It should be noted that the data in Figure 1 are shown, for the injuries with permanent components (S, V, R, L and N), as a function of discount rate from 0 to 10 per cent. Discount rate has a marginal effect upon states F, W and X, which have no long-term components. The value of a serious road traffic injury is calculated by weighting each of the LYF values for each injury state by its relative frequency of occurrence, and multiplying the sum by the value of a life year. For consistency, the same discount rate should be adopted in the calculation of the LYF values and the value of a life year. The consequence of this, in this particular case of serious road traffic injuries, is that discount rate has little effect upon the value of a serious injury. This is because the dominant contributors to the value of a serious injury according to this methodology are the long-term impairments with a presumed constant utility loss over remaining life-span. The discounting of impairments with these dual characteristics exactly compensates for the increasing value of a life year as the discount rate is increased. This balancing out of the discount rate may also be seen as a consequence of the anchoring of the value of a life year to a predetermined VOL. In effect, the area under the curve of value of a life year versus time must remain constant and equal to the chosen VOL.

18. The resultant values of a serious injury are £144-148K (Rosser-revisited); £150-154K (EuroQol); £170-174K (Torrance); and £28-29K (Rosser). The near convergence of three valuations does not, by itself, guarantee validity, although it is probably an important indicator of the mainstream of current thinking and research in this sector. However, these valuations are not dissimilar from those arrived at by other researchers in the United States and from some of the CVM studies carried out by the Newcastle-upon-Tyne and York Universities team in the UK.
**Figure (i):** Lost years of functioning versus injury state as derived by four utility loss matrices. For states S to N, the vertical bar corresponds to the range of discount rates applied, from 0% (top) to 10% (bottom). For states F to X, the values are barely affected, if at all, by discount rate. The range in these cases corresponds to the min/max values whose derivation is described in the text.

(vi)
19. In the case of the VAS, consultants rated each of the complete injury descriptors on a scale from 0 (worst imaginable injury) to 100 (no accident or injury). Such a scale allowed for rating states ‘as worse than death’ if so desired. Subsequently, the scores of any respondents who did not rate death as 0 were normalized and reordered so that death was valued at 100% utility loss and injury states considered worse than death were considered to have a utility loss of greater than 100%. The median RULA value for each of the eight injury descriptions was multiplied by its relative frequency of occurrence to obtain the RULA value of ‘a serious injury’. Implicit in these ratings was the effect of duration. Thus, for the VAS, the RULA value of a serious injury need only be multiplied by the VOL. This resulted in an aggregate, weighted by incidence, relative utility loss of 0.42 and a corresponding monetary value of £260K for a serious non-fatal road traffic injury.

ROUND TABLE MEETING

20. A round table meeting was held to explore the views of the experts on the mapping exercise and elicit further understanding of the process and considerations which had influenced their decisions. At the meeting, the respondents expressed the most confidence in their VAS scores — as accurately reflecting the full impact of the injuries described. Of the utility loss indices, it was felt that the dimensions of the Rosser matrix best matched the way in which the injuries were described. This made it the easiest to use, but not necessarily the most reliable, in reflecting the full impact of the injuries. In addition, some members of the round table were of the opinion that the numerical utility loss valuations in the original Rosser matrix were inferior to those in Rosser-revisited because of the methodology employed, the small sample size, and the type of respondents. Torrance’s dimensions were considered the least appropriate for injuries resulting from road traffic accidents (RTAs), and consensus was reached that the EuroQol approach held the most promise for the future [with some revisions]. Specifically, each dimension of a utility loss matrix should have at least three levels — injuries do not typically result in all or no loss, but more typically in 'some' loss.

21. Preliminary results indicating the apparent concord between the Torrance and Rosser-revisited indices were available at the meeting, and came as somewhat of a surprise to the experts in view of their very different bases. Opinion was, that were the EuroQol results to fall into line, a very encouraging result would have been achieved in support of the RULA methodology.

22. The experts indicated that their ratings on the VAS were 'multifaceted' and took into account considerations beyond those allowed by the two dimensions of Rosser’s matrix, four dimensions of Torrance’s matrix, and six dimensions of the EuroQol. In particular, they had considered the wider impact of the injury on the family members of the injured victim — their distress, isolation and non-monetary sacrifices.

23. The magnitudes of the monetary values for a serious RTA which were emerging were considered by the consultants as quite reasonable as representative of the associated pain, grief and suffering. The values, they
commented, were perhaps too low for injuries like \textit{N} (quadraplegia/paraplegia) and \textit{L} (severe brain damage), and too high for short-term injuries like \textit{F, W and X}. But if a \textit{single} value for this wide range of injuries were required, then that emerging was probably a fair estimate.

CONCLUDING REMARKS

24. Health state utility scales have never before been applied to the valuation of RTAs in the UK. The results of this study may be regarded as highly encouraging, with three of the utility loss scales yielding very similar results, despite their diverse origins and purposes. This would suggest that the wealth of research on utility scales may have a far wider application than has so far been realised.

25. From a purist (economic) viewpoint, the use of \textit{RULA} scales in this way may present some philosophical problems. However, in other spheres, where trade-offs between risk, costs and benefits are made, there is an emerging view that the best outcome may be that which relies upon a proper balance of expert and lay opinion. In any event, the relative utility loss approach, as applied here, is closely tied to public attitudes via the \textit{VOL}, and via the \textit{RULA} matrices themselves whose valuations are drawn from opinion surveys of selected groups.

26. Returning to the main issue - the revaluation of a serious RTA - the convergence of three of the valuations arising from the \textit{RULA} indices, points towards a value for pain, grief and suffering in the region of £140K to £170K, an order of magnitude higher than the existing value used by the \textit{DTP}, and about 25 per cent of the equivalent component of \textit{VOL}. It might reasonably be argued that the Rosser-revisited and \textit{EuroQol} indices are most appropriate when dealing with accidents to 'average working-age adults'. In this case, the figures would point to a value in the region of £150K (24 per cent of \textit{VOL}). Values of this order were considered not unreasonable by the expert group involved. Indeed, their predilection was to some extent for the yet higher valuation arrived at by the \textit{VAS} (£267K; 43% of \textit{VOL}), were the wider impact of a serious RTA upon family and friends incorporated.

27. It comes as no surprise that the \textit{RULA} data find states \textit{F, W and X} to be qualitatively and quantitatively different from the other injury states. \textit{LYF} scores for these non-permanent injuries are significantly different from those of the permanent injuries, as was shown in Figure 1. These results, buttressed by the comments of the experts at the round table meeting, indicate that there may be merit in adding a 'moderate' category of RTA to the present 'slight'/ 'serious' classification. Whiplash injuries would almost certainly fall within this new category, while 'slight' injuries would be just that - minor lacerations and contusions - and would be appropriately valued by their direct costs alone. However, for the purpose of this study, and on the basis of certain assumptions which are described in the text, the valuation of the personal component of a slight injury excluding lost income is found to lie in the range £1.6K at zero per cent discount rate to £5.8K at ten per cent discount rate. This cost largely results from the inclusion of whiplash injuries in the slight category.
28. Overall, many questions remain as would be expected with the application of an existing methodology to a new field. Two of the sub-categories of injuries (R and S) figure very highly in the valuation of a serious RTA which we have arrived at. R and S have a high frequency of occurrence and are also permanent injuries, and their RULA scores should therefore be given careful scrutiny. Fundamental also are the assumptions concerning the time dependence of utility losses. Nonetheless, just as we do not believe it is unreasonable for very serious permanent injuries (such as Land N) to have a RULA value approaching that of death (or even higher perhaps), nor are we surprised at the values arrived at for other injuries bearing permanent consequences. Other RULA researchers have expressed this -- a disabled person continues to suffer for the remainder of his or her life (not to mention the burden placed on family members and the substantial medical and social support which may be required). In contrast, a death, especially as characterised by state K (immediate unconsciousness followed shortly by death), brings with it pain, grief and suffering for the survivors, but which is likely to diminish over the years, as is the loss of the victims’ contribution to society. His or her family members can usually go on contributing to society.

29. The final decision on which values to use for serious and slight injuries requires consideration of the relative values for other non-market parameters such as time and environmental protection.
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1. INTRODUCTION

1.1 Background

Following the Department of Transport’s review of the valuation of a fatal casualty in 1988, the Department recognised the need to reconsider the valuation of non-fatal casualties and instituted exploratory work from six academics in 1989. Non-fatal casualties are classified as either 'slight' or 'serious'. A 'slight' injury is defined as "an injury of minor character such as a sprain, bruise or cut which are not judged to be severe, or slight shock requiring roadside attention". A 'serious' injury is defined by the Department as "an injury for which a person is detained in hospital as an 'in-patient', or any of the following injuries whether or not he/she is detained in hospital: fractures, concussion, internal injuries, severe cuts and lacerations, severe general shock requiring medical treatment, injuries causing death 30 days or more after the accident". An injured casualty is coded as seriously or slightly injured by the police, on the basis of information available within a short time of the accident, which generally does not include the results of a medical examination.

As part of the Department’s programme, the Environmental Risk Assessment Unit (ERAU) at the University of East Anglia conducted an exploratory study during 1989/1990 into the methodologies by which the value of non-fatal road accidents might be assessed (Ball et al., 1991). A seminar based upon the combined results of that work was held in October 1989, and the primary recommendation was that a method of valuation, based on Willingness-to-Pay using questionnaire methods, should be piloted by Professor Jones-Lee and Dr Graham Loomes. In parallel, it was recommended that the feasibility of relative utility loss approaches (RULA) to the valuation of injury, which had been identified by the ERAU exploratory study as a complementary approach with a number of potentially useful attributes, should also be studied. This approach makes use of the willingness-to-pay derived value of life and from this perspective would also be consistent with the Department’s valuation of life.

In principle, it was felt that RULA should provide a practicable approach which would not be dependent upon large, potentially expensive, public surveys in order to obtain results. A further advantage is that the relative utility loss approach draws upon an extensive field of knowledge concerning health state measurement and utility valuation. This brings on board expert experience and opinions in a way which is judged would be likely to command public acceptance. There is, of course, a recognised need to include mechanisms for public accountability in the method. Subsequently, in June 1990, the ERAU was awarded a contract through the Transport and Road Research Laboratory (TRRL), the first phase of which was known as the Stage 1 study.

The Stage 1 study (Ives and Kemp, 1991) examined existing international research into the measurement of relative utility loss. The study also identified available scales in the literature which might be applicable to the valuation of non-fatal road traffic injuries. The Stage 1 study concluded that two potential options existed for the Department’s revaluation of non-fatal road traffic injuries using RULA methodologies. As a long-term option, it was recommended that the feasibility of a functional capacity index of the type currently being developed by MacKenzie...
et al. (1989) in the USA be examined as a potential way forward in a UK context. The comprehensive nature and potential for linkage with UK road accident statistics of the MacKenzie approach appeared to offer attractive opportunities. It was further proposed that in the short-term an empirical RULA study could be undertaken. This study would use a battery of relative utility loss indices from the literature, as no single scale reviewed in the Stage 1 report proved to be entirely appropriate for application to the valuation of road-traffic injuries. Expert opinion was to be utilised to provide utility scores, and consultants were to be selected for their familiarity either with the utility scales, or with the types of injuries resulting from road traffic accidents.

Injury categories identified by Professor Galasko at Hope Hospital, Salford were taken to be representative of 'serious' UK road accident injuries, and were used as the starting point for the rating exercise. This was to ensure that the results from the RULA survey would be comparable with those derived from the parallel WTP study by Professor Jones-Lee and colleagues. A subsequent focus group survey was advocated, to assess the validity of the estimates and to increase public accountability.

1.2 Objectives

For Stage 2 of the revaluation of non-fatal road traffic injuries it was agreed that the short-term option proposed in Stage 1 should be pursued, with the ultimate objective being the empirical application of a relative utility loss index to derive monetary values for 'serious' non-fatal road traffic injuries. To this end, the Stage 2 study should develop a questionnaire 'packet' for presentation to external expert consultants, the details of which are provided in Chapter 2. As such, the study was intended to provide a range of utility values for each injury description so that a monetary value may be calculated for a 'serious' injury (tied to a statistical value of life agreed with the Department of Transport). The sensitivity of the valuation to the choice of utility scale, the type of rater (health economist or clinician) and the discount rate was to be examined. Finally, an overall monetary value for a DTp classified 'serious' injury should be derived. Areas of special concern or uncertainty and other implications arising from the expert valuation were to be identified. It was noted that the application of a RULA approach would be breaking new ground in this context and might raise further questions.

1.3 Overview of Methodology

Figure 1 illustrates, in schematic form, an overview of the methodology used in the relative utility loss approach. The aim of the exercise is to assign a monetary value to a DTp classified 'serious' non-fatal road traffic injury. The injury state descriptions developed by Professor Galasko, taken as representative of the spectrum of 'serious' road-traffic injuries, are used as the starting point for the valuation exercise. Each of the Galasko injury state descriptions are subsequently 'mapped' onto four different utility indices by expert consultants chosen for

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Footnote: Three utility scales were used, one with two sets of assigned utility loss values.
their familiarity with either the utility indices or the injury states resulting from road traffic accidents. Following the procedure of ‘mapping’ Professor Galasko’s injury descriptions onto the four utility matrices, utility scores for each injury state can be read directly from the matrix and the utility loss computed. When multiplied by the duration of the injury (discounted appropriately), the number of lost years of functioning (LYF) associated with each injury state can be calculated. Subsequently, the LYF value of each Galasko injury state is weighted by its probability of occurrence, to derive an overall LYF value for a DTp classified ‘serious’ non-fatal road traffic injury. To derive a monetary value from estimates of LYF, it is first necessary to derive the value of a life year (VOLY) from the DTp value of life (VOL) of £620,000² (£1990), by the application of an appropriate discount rate. By multiplying the monetary value of a life year (VOLY) by the number of lost years of functioning, a monetary value is produced for a DTp classified serious road traffic injury. The RUL scores from the Visual Analogue Scale (VAS) exercise were simply weighted by their frequency of occurrence and the weighted RUL score multiplied by the VOL to derive a monetary value or injury.

1.4 Structure of Report

In Chapter 2, the design and development of the questionnaire is discussed in detail. The rationale behind the choice of utility loss scales, and the decision to use expert consultants to undertake the mapping procedure is explained. In Chapter 3, the results of the empirical study are presented, including the ranges of both utility scores and monetary value of injury estimates. The findings of the structured de-briefing and round-table meeting with consultants concerning the rating procedure are also discussed and an overall value for a DTp ‘serious’ injury is calculated. In Chapter 4, the quantitative data from the questionnaire and the more qualitative data from the round-table session are discussed and matters arising from the rating procedure are highlighted. Finally, in Chapter 5, the recommendations and conclusions of this report are set out.

² This estimate of the VOL represents purely intangible costs, such as pain, grief and suffering and does not include the direct economic costs of road traffic injuries.
Figure 1. A Schematic Overview of the RULA Methodology
2 METHODOLOGY

A questionnaire was developed which would result in a systematic mapping of the Galasko injury states onto four different utility scales and which include a Visual Analogue Scaling Exercise. Following this, it would be possible to derive a utility score for each Galasko injury state and, by taking note of the frequency of occurrence of each of the injury states, ultimately determine the value of a 'serious' road traffic injury. The questionnaire package (Appendix A) consisted of 1) an introductory letter; 2) a TRRL information sheet providing general background to the revaluation of non-fatal injuries project; 3) a list of general instructions and points to consider before beginning the exercises; 4) three health status indices and a visual analogue scaling exercise for each injury description and 5) an appendix including brief descriptions of the development and characteristics of each utility index. Each of the utility indices included was printed on card and accompanied by detailed instructions on how to approach the rating exercise, together with several colour-coded 'answer sheets'.

The answer sheets incorporated descriptions of the injury states identified by Professor Galasko as representative of DTp classified 'serious' UK road traffic injuries. The order of the rating tasks was varied among the consultants, to try to control for any fatigue effects which might influence the ratings. Each separate index and its associated answer sheets were colour-coded for clarity. Substantial space for general comments was provided throughout the questionnaire and the consultants were invited to comment freely. Consultants were reminded that they should keep in mind the subsequent round table meeting and be prepared to discuss at that time, the rationale behind their ratings and any problems or comments which they had concerning the rating procedure in general.

2.1 Injury Descriptors

The injury descriptions developed by Professor Galasko at Hope Hospital, Salford, for the parallel WTP study by Professor Jones-Lee et al were intended to be broadly representative of the whole spectrum of 'serious' road traffic injuries. These descriptions were formulated based on the incidence of cases reported in police statistics, and were used as the starting point for the rating task. In their initial form, the Galasko descriptions comprised eight injury states (plus 'Your normal state of health' and 'Death'), held to be representative of all DTp classified 'serious' road traffic accident injuries occurring in the UK. The frequency of occurrence of each injury category described by Professor Galasko has also been estimated.

The distribution of 'serious' road traffic injuries is taken from police statistics in Road Accidents Great Britain. Professor Galasko, from the preliminary results of his longitudinal survey of road traffic accident victims (Galasko et al., 1986), identified two injury states which did not appear to be covered by the original classification. These were cases with slight injuries admitted to hospital overnight and serious injuries not admitted to hospital (misclassified by police as 'slight'). To discuss the discrepancies between Galasko and Police data and to amend the estimates of incidence of the original Galasko descriptors, a meeting of DTp, ERAU and Professor
Jones-Lee and Professor Galasko was held on the 23/5/91. The revised health states, codes and associated risks which emerged from the meeting in May 1991 are shown in Table 1.

Professor Galasko provided specific examples of the types of injury states covered by the categories shown in Table 1. Some of the injury examples provided are shown below:

| STATE F. | Fracture of a toe  
| Fracture of a clavicle  
| Sprain of a shoulder  
| Sprain of an acromioclavicular joint  
| Bruising around the knee |
| STATE X. | Rupture of a collateral ligament of a knee requiring surgery  
| Simple skull fracture  
| Whiplash |
| STATE S. | Compression fracture of spine  
| Fracture of calcaneus |
| STATE R. | Fracture of os calcis involving subtalar joint  
| Fracture/dislocation of cervical spine without damage to spinal cord  
| Fracture involving the acetabulum (hip joint)  
| Brachial plexus injury  
| Burns and cuts causing prominent scarring  
| Permanent back injury  
| Permanent stiff scarred knee |
| STATE V. | Fractured sternum  
| Laceration involving muscle  
| Corneal abrasion  
| Closed fracture maxilla |

### 2.2 Questionnaire Design

The questionnaire was designed with the intent to use the Galasko descriptors as the basis for a rating exercise. The Galasko descriptors were originally devised for use in the parallel WTP survey. For the WTP study, which deals with the general public, it was considered feasible to rate only 10 states at maximum, due to time limitations, possible cognitive limitations and problems of interview fatigue. For the RULA method, which uses expert, rather than lay, judgment, a more extensive rating task is a feasible option, enabling a larger number of injury
<table>
<thead>
<tr>
<th>Injury Code</th>
<th>Description</th>
<th>Summary Description</th>
<th>Annual Risk Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>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; after 3-4 months, return to normal health with no permanent disability</td>
<td>Recover 3-4 months (outpatient)</td>
<td>$8 \times 10^{-5}$</td>
</tr>
<tr>
<td>W</td>
<td>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</td>
<td>Recover 3-4 months (inpatient)</td>
<td>$16 \times 10^{-5}$</td>
</tr>
<tr>
<td>X</td>
<td>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</td>
<td>Recover 1-3 years</td>
<td>$30 \times 10^{-5}$</td>
</tr>
<tr>
<td>V</td>
<td>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</td>
<td>Mild permanent (outpatient)</td>
<td>$4 \times 10^{-5}$</td>
</tr>
<tr>
<td>S</td>
<td>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 possibly some work activities</td>
<td>Mild permanent (inpatient)</td>
<td>$24 \times 10^{-5}$</td>
</tr>
<tr>
<td>R</td>
<td>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</td>
<td>Some permanent disability with scarring</td>
<td>$16 \times 10^{-5}$</td>
</tr>
<tr>
<td>N</td>
<td>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 toileting</td>
<td>Paraplegia/quadriplegia</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>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 toileting</td>
<td>Severe head</td>
<td>$2 \times 10^{-5}$</td>
</tr>
<tr>
<td>K</td>
<td>Immediate unconsciousness, followed shortly by death</td>
<td>Death</td>
<td>$8 \times 10^{-5}$</td>
</tr>
</tbody>
</table>

Overall risk of serious non-fatal
categories to be used. However, for the purposes of comparison between the studies, both the WTP and the RULA studies were based on the same set of injury descriptors. Various versions of the questionnaire were proposed, some of which were piloted, before a final version was arrived at.

### 22.1 Version 1

In the first version of the questionnaire the complete Galasko descriptions were used as the basis for the rating exercise with three utility scales selected from the literature and a visual analogue scale (see Section 2.3.). The Galasko descriptions, which attempt to encompass all types of 'serious' UK road traffic injuries into just 8 categories, are, of necessity, rather broad. One injury may thus be described as enduring "from several weeks to several months" with "moderate to severe pain". State X illustrates the broad and imprecise nature of the duration and pain descriptions in each overall description:

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**State 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.

---

As it was considered that the duration of the state and the level of pain might have a significant impact on the perceived utility loss, it was decided that each Galasko description be disaggregated into all their possible permutations. This would serve also to shed some light on the influence of duration and level of pain, and the influence of hospitalisation on the mapping exercise and the resulting utility scores. The option of including specific examples of the different injury states to help enhance the respondents' ability to envisage them was debated and finally rejected. This was because it was considered likely that it might introduce an inadvertent source of bias into the ratings by encouraging the respondents to focus purely on the specific example given, which might not be truly representative of the injury category in general. As a result of these considerations, a second version of the questionnaire was developed.

### 22.2 Version 2

The subsequent version therefore dealt with subsets of the complete Galasko states, which respondents would then be asked to map individually onto the utility matrices. Thereby a range of utility scores could be determined for each injury sub-state. For example, State X was permuted into states X1 and X2 to account for the two different levels of 'pain'.

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**State X1**: In hospital 1-4 weeks in slight 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.

**State X2**: In hospital 1-4 weeks in 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.

---
As a further example, State R was permuted to explicitly represent four possible permutations of the overall description - two in the severity of pain and two in the duration of pain.

State R1: In hospital several WEEKS in MODERATE pain; after hospital, permanent pain/discomfort, possibly requiring frequent medication; substantial and permanent restrictions to work and leisure activities.

State R2: In hospital several WEEKS in SEVERE pain; after hospital, permanent pain/discomfort, possibly requiring frequent medication; substantial and permanent restrictions to work and leisure activities.

State R3: In hospital several MONTHS in MODERATE pain; after hospital, permanent pain/discomfort, possibly requiring frequent medication; substantial and permanent restrictions to work and leisure activities.

State R4: In hospital several MONTHS in SEVERE pain; after hospital, permanent pain/discomfort, possibly requiring frequent medication; substantial and permanent restrictions to work and leisure activities.

Internal pre-piloting of this version illustrated that the scales on which the consultants were to rate the injuries were insensitive to these types of changes in the duration and, to some extent, the severity of pain so that the scores for the permutations of each state such as R1, R2, R3 and R4, were showing little variation. Hence, this method, which took substantially longer to complete than version 1, did not appear to be providing extra useful information and was therefore abandoned.

2.23 Version 3

In the third version of the questionnaire, an alternative way of disaggregating the complete injury descriptors was developed, which it was hoped, would provide more useful data. Each Galasko description effectively represents a time profile or injury path from the initial impact of the injury (time spent in hospital or treatment as an outpatient) to the resulting end point (recovery or some level of permanent disability). In order to rate, for example, State X as a whole, the respondent would have to implicitly weight the seventy and duration of each component part in the whole time profile to give an 'overall' score to the state. For example, the respondent may have to rate State X on a scale of 0-7 for pain. The respondent would then have to consider the 1-4 weeks spent in slight to moderate pain, and then 1-3 years spent in 'some' pain to come up with an overall rating of pain for State X. It was therefore decided to disaggregate the descriptors to allow each identifiable component of the time profile to be rated independently. For example, State X is disaggregated to form sub-states X1, X2 (the in-hospital states at different levels of pain), and X3 (the resultant state describing duration to recovery).
State 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.

State X1: In hospital 1-4 weeks experiencing SLIGHT pain.

State X2: In hospital 1-4 weeks experiencing MODERATE pain.

State X3: For 1-3 years, experiencing some pain/discomfort, which gradually reduces and some restrictions to work and leisure activities, which steadily improve, after which return to normal health with no permanent disability.

The other seven of Professor Galasko's injury states were similarly sub-divided; State F into six components, States V and R both into five components, State W into four components, and States L, N, X and S each into three components, producing a total of 33 sub-states (including death) from the original eight injury states. There was concern that rating the component parts of the time profile out of context of the overall injury description would alter the perception of the state and, therefore, the rating given. This may arise were the perception of a current state influenced by the prognosis, where the victim may have either a complete recovery or a permanent disability. It was therefore decided to retain the overall Galasko descriptor at the top of each page to enable each sub-component to be rated in context of the overall injury state. Each of the injury states was disaggregated in this manner and presented along with the injury description in its entirety (See Appendix A). Respondents were also asked to comment on how their ratings would be adjusted if the victim being rated were an elderly person or a child.

State J 'Your Normal State of Health' was excluded from the rating exercise, leaving eight composite injury descriptors and death. The expert consultants were asked to 'envisage an average working age adult' in the population, when estimating the impact of the injuries in the rating tasks. It was felt unlikely that they would be able to estimate an average normal state of health for such a population, and therefore this state was excluded. The remaining eight injury descriptors (plus death) were subsequently disaggregated into 33 sub-components which the expert consultants were asked to map onto the utility scales provided.

Following this exercise, the utility scores associated with the sub-components of the original descriptions could then be re-aggregated to produce a range of utility loss scores for each injury descriptor. The scores need to be weighted by the duration of each of the sub-components. This was accomplished under the challengeable assumption that utility has a linear relationship with time. In this way, a 'lost years of functioning' (LYF) approach is adopted. The utility loss associated with each sub-component is explicitly multiplied by the duration of each state to derive a LYF score. This approach assumes that utility loss increases with increasing duration in a linear fashion related directly to the number of years impaired, although there is evidence to suggest that the assumption of
linearity over time is questionable (Sackett and Torrance, 1978). At present, research has failed to establish the actual relationship between duration and utility and it is therefore standard practice in many areas, for example, in the calculation of Quality Adjusted Life Years (QALYs) by the National Health Service, to assume a linear relationship between utility and duration (Gudex, 1986; Williams, 1985). In light of a lack of evidence to determine the actual relationship between utility and time, the adoption of such a strategy is pragmatic, until further research more clearly defines the relationship between utility and duration.

2.3 The Utility Scales

It was concluded from the Stage 1 review of the literature (Ives and Kemp, 1991) that no single scale was entirely appropriate or suited to the task at hand. Several authors (Sintonen, 1981; St Leger, 1988; Williams, 1988) have commented that no ‘gold standard’ or single, all-purpose index that is superior to others has been developed at present. The limitations of each utility scale reviewed are discussed in more detail in the Stage 1 report. Different utility instruments appear to produce different utility values (Read et al., 1984; Torrance, 1976a; Wolfson et al., 1982) and several authors recommend that a battery of different indices be tested together to identify areas of divergence in utility values produced and to generally improve understanding of the problems of utility scaling (Kind, 1988; Read et al., 1984; St Leger, 1988).

Several criteria were used to select the scales for use in the questionnaire package:

1) Global/Generic Scales seemed most able to rate the many different states resulting from road traffic injuries. Disease specific scales were felt to be of little use in this context.

2) Scales should produce interval or ratio level data as it is necessary to know the relative relationship between scores given rather than just a simple ranking.

3) Scales requiring detailed clinical information were considered unsuitable, as they would be difficult to use with aggregated statistical data, where detailed data on individual patients, such as social circumstances or emotional well-being is not available.

4) Scales producing a single value rather than a profile of scores are preferable for use in a RULA approach.

5) Scales should be able to incorporate ‘fates worse than death’.

Three scales were noted in the Stage 1 review which came closest to satisfying the above criteria and were therefore considered appropriate for use in the empirical survey. These were the EuroQol Descriptive Classification, the Torrance Health Classification System and the Rosser and Kind Classification of Illness States. Brief descriptions of each of the scales, as outlined in Appendix A of the questionnaire package, are included below, and the summary characteristics of each index are described in Table 2.

2.3.1 Rosser’s Classification of Illness States

Through consultations with physicians, Rosser and Watts (1978) identified two dimensions of a patient’s condition which influenced judgments about the severity of their illness - disability and distress. The same two dimensions
Table 2: Summary Characteristics of the Utility Loss Indices

<table>
<thead>
<tr>
<th>Utility Loss Scale</th>
<th>Dimensions</th>
<th>Possible Number of Health States</th>
<th>Measurement Instrument</th>
<th>Duration</th>
<th>Subjects</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosser’s Classification of Illness States</td>
<td>Disability Distress</td>
<td>29</td>
<td>Unbounded Magnitude Estimation</td>
<td>Ambiguous*</td>
<td>Health volunteers Doctors Medical nurses Medical patients Psychiatric nurses and patients</td>
<td>70</td>
</tr>
<tr>
<td>Rosser-revisited/ York MHV Study</td>
<td>Disability Distress</td>
<td>29</td>
<td>Magnitude Estimation</td>
<td>20 years, followed by death</td>
<td>General public</td>
<td>&gt;140</td>
</tr>
<tr>
<td>Torrance’s Health State Classification System</td>
<td>Physical function Role function Social-Emotional function Health problems</td>
<td>112</td>
<td>Time Trade-off</td>
<td>Permanent</td>
<td>Parents of school-age children</td>
<td>112</td>
</tr>
<tr>
<td>EuroQol</td>
<td>Mobility Self-care Main activity Social relationships Pain Mood</td>
<td>216</td>
<td>Magnitude Estimation</td>
<td>One year</td>
<td>General public**</td>
<td>310</td>
</tr>
</tbody>
</table>

* Subjects were first asked to consider health state descriptions as treatable, where no change would occur over time if left untreated. They were then asked to consider the descriptions as permanent states which would not or could not be treated.

** Actual survey data was available for only 16/216 states - the remaining values have been extrapolated by Paul Kind.
were identified by a group of economists and health administrators. Eight levels of disability and four levels of distress were identified.

The $4 \times 8$ matrix results in 29 possible health states. (It was thought that an unconscious patient at disability level 8 would experience no distress, precluding combinations of level 8 with distress levels 2-4.) Thus, for example, the combination of Disability Level 3 and Distress Level 2 results in a health state described as: "Severe social disability and/or slight impairment of performance at work; able to do all housework except very heavy tasks; mild distress."

Using magnitude estimation techniques, Rosser then asked physicians, nurses, medical and psychiatric patients ($n = 70$) to rate the 29 health states. Subjects were asked first to consider the health states described as treatable, where no change would occur over time if left untreated. Then they were asked to consider the descriptions as permanent states which could not or would not be treated. Any changes in their valuations, which were few, were noted. In her sample, physicians rated the health states significantly different from nurses and patients, with doctors placing relatively less emphasis on the importance of death and more emphasis on the importance of subjective suffering.

### 2.3.3 Torrance's Health State Classification System

This health status index is a widely-accepted, well-known index which incorporates an innovative approach to obtain weights for a large number of health states. Originally developed to assess the life long health outcome of infants who received neonatal intensive care at birth, it includes four dimensions: physical function, role function, social-emotional function and health problems. Each dimension has several levels.

Since this system defines such a large number of health states ($6 \times 5 \times 4 \times 8 = 960$), Torrance adopted a procedure based on Multi-Attribute Utility Theory (MAUT) to obtain ratings from a sample of parents of school-age children in Canada ($n = 87$) for each health state (Torrance, 1976b). First, a visual analogue scale was used to rate the levels within each dimension, assuming each health state was permanent. Then Time Trade-off (TTO) techniques were used to establish the relationship between dimensions. Finally, the data were combined according to MAUT rules to derive a multiplicative function which allowed values to be calculated for each of the 960 health states. Thus an injury classified as, for example, $P_1, R_2, S_3, H_8$, was rated 0.429 compared to $P_1, R_1, S_1, H_1$, or perfect health, which is rated as 1.0 and death rated as 0.

Torrance reports that respondents had some difficulty coping with three of the four dimensions because of the double content of those dimensions. For example, the dimension "physical function" incorporates both mobility and physical activity. In addition, the eight levels of the dimension "Health Problems" do not form an exhaustive list, creating problems for respondents. Further information on the Torrance scale is available from Torrance (1979; 1982; 1984; 1986).
2.3.3 The EuroQol Descriptive Classification

Work is underway in Europe to develop a transnational approach to measuring health states. A group of health economists, philosophers, mathematicians, psychologists, sociologists, and medical researchers from the UK, Finland, Sweden, The Netherlands and Norway have formed a coalition, calling themselves the EuroQol Group (EuroQol, 1990). Their goal is to develop a standardised, non-disease specific instrument for describing and valuing health states that can be used across Europe and can enable cross-national comparisons of health state valuations. The group has sought to develop an instrument that is simple enough to be used in large-scale postal surveys, incorporates some form of test-retest into the design, and yields a single number for any given health state. They have developed a set of six dimensions, each with two or three levels, resulting in 216 possible health states. Further information about the EuroQol can be found in Brooks et al. (1991) and Nord (1991).

Work is in progress to obtain utility scores for each of the 216 health states from a sample of the general public in each of the represented nations. A revised version of the questionnaire is also being developed (Kind, personal communication). For the present, Paul Kind, of the EuroQol group, has extrapolated scores for each of the health states based on the scores of 14 states and death obtained from a public survey. Those scores have not been published so are not provided in this report. Dr Kind has generously allowed us to use them to derive a Value of a Serious Injury for comparative purposes only.

2.3.4 The Visual Analogue Scale

For each Galasko injury state category respondents were asked to complete a visual analogue (VA) scale rating exercise. The visual analogue scale is in the form of a thermometer with a scale from 0 (worst imaginable injury) to 100 (no accident or injury). Respondents were asked to rate the injury descriptions in their entirety (not the disaggregated parts) on the visual analogue scale. Respondents ratings on the VA are not constricted by the dimensions and levels of a preformulated index, as they are with the Rosser, Torrance and EuroQol scales. They are thus free to make unconstricted ratings of the whole injury state. It was felt that these more 'direct' valuations might provide a useful contrast to those derived through the application of existing indices to derive utility scores and for this reason the VA was included in the exercise.

2.3.5 Rosser Revisited: the York Measurement and Valuation of Health Project (MHV).

The MHV or 'Rosser Revisited' valuation matrix is a utility valuation matrix based on the two-dimensional disability/distress Classification of Illness States developed by Rosser and Watts (1978). The MHV project, which was carried out by a group at the York Health Economics Consortium, aimed to reproduce the valuation matrix from the original Rosser and Watts index. As it was deemed impossible to replicate the original study in all respects, and because one aim of the replication was to obtain scores using a more representative sample than the original, the MHV represents a partial replication study. Much criticism has been levelled at the sample size used in the original valuation exercise and the MHV study aimed to rectify this using a sample size exceeding 140. Multiple scaling procedures (magnitude estimation, time trade-off and category scaling) were used to elicit valuations for a common set of health states based on the original Rosser and Watts Classification. Respondents
were asked to imagine being in the state for a period of twenty years, after which they would die. The MHV study differs in several respects to the original, including in the detail of the ME procedure, the manner in which the subjects were managed in the interview setting, the characteristics of the study population (age distribution, etc.). The median scores were adopted as representative, as in the original valuation matrix.

In the present study, the consultants only had to rate each injury description on the disability/distress matrix once, but two sets of utility scores could be derived, one using the Rosser valuation matrix and the other using the Rosser-revisited valuation matrix.

23.6 The Instrument of Health Related Quality of Life (IHQL)

The IHQL, a new instrument currently being developed by Dr Rosser at Middlesex Hospital, incorporates pain, disability and distress as dimensions. The new scale is an improvement on the earlier Classification of Illness States (See section 2.3.1.) which has many recognised limitations. A critique of Rosser’s original scale and the resulting valuation matrix is provided by Gudex (1986). The new instrument utilises standard gamble questions. At present, no other scale has produced utility values based on standard gamble questions which are suitable for use in the RULA questionnaire. Utility values for the new scale are being derived from a general population (n=1000) survey in Bloomsbury, London (Rosser, 1987a; 1987b). It is, however, unlikely that the scaling task will be completed before 1992 (pers. comm. Rosalind Rabin, 1991) and therefore it was not possible to include this scale in the questionnaire.

2.4 Raters

The Stage 1 report noted that the controversy over using expert or lay judgment to provide valuations in policy making remains unresolved. Some authors recommend the use of expert opinion to provide utility ratings for health states (Kind, 1988; Mushkin, 1979) due to the difficulties noted in the general public’s ability to deal with small probabilities and complex rating tasks and their unfamiliarity with the health states. In contrast, some authors (Schelling, 1968; Torrance, 1976a) recommend the use of the general public, generally along the lines that public policy making is for the general public who therefore have a right to have their views represented. There appears to be growing consensus, however, that a survey to elicit utility values for health states might enjoy widest support and greatest credibility were it to include a wide number of respected expert groups and the general public, from groups differing in sex, experience of illness, education, socioeconomic status etc. (Gudex, 1986; Gudex and Kind, 1988; Rosser and Watts, 1978; Williams, 1988). It is worth noting in this respect that in the field of risk assessment in general, the emergent view is that both the public and experts have something to contribute and that this is the likely preferable option.

As a result, an initial small scale study utilising the expert opinion of health economists (familiar with using the utility indices), and medical experts (familiar with the long term impacts of the injuries), was decided upon as the way forward for Stage 2. Eight expert consultants were invited to undertake the rating task, including three health
economists and five nurses from Professor Galasko’s team, who had had extensive experience of the outcome of road traffic injuries. In addition, two members of the DTp steering group, both health economists, completed the questionnaire. Lay opinion is, of course implicitly incorporated into the RULA scores because the scores in the matrices were obtained from a variety of such groups. For example, Torrance’s scores were derived from the parents of school age children, the EuroQol and York MHV scores from a random sample of the general public, and Rosser’s from a group of patients, doctors and nurses.

25 Quantitative Analysis

Several steps are involved in progressing from the individual utility loss scores for each disaggregated injury state, to an overall 'lost years of functioning' score for a DTp classified 'serious' injury and ultimately to a monetary value of a serious injury. The steps are described, in consecutive order, below.

25.1 Calculating RULA Scores for the Disaggregated States

Raw data from the completed questionnaires is in the form of a series of points on each health status dimension for each injury state. For example, on the Rosser scale, a respondent may have scored a state, such as X1 (which is a disaggregated component of the whole state X), 4 on the 'Disability' dimension and 2 on the 'Distress' dimension. This location (4,2) can then be found on Rosser’s valuation matrix, yielding a score of 0.96 utility. The utility loss is subsequently calculated as (1 - 0.96) = 0.04. This location or score (4,2) can also be found on the unpublished 'Rosser-revisited' matrix to determine another utility score for that combination. Similarly, with the EuroQol scale, a respondent may have described one of the disaggregated states as mobility (1), self-care (1), main activity (2), social relationships (2), pain (3) and mood (2). This rating of (1, 1, 2, 2, 3, 2) is then determined using the EuroQol valuation matrix to yield a utility score of 0.36, equivalent to a utility loss of 0.64. Similarly on the Torrance scale, respondents may have designated a state as physical function (1), role function (3), social-emotional function (2) and health problems (1). In contrast to the other scales, these scores (1, 3, 2, 1) are first located on Torrance’s matrix of scores to provide the valuations (1.00; 0.77; 0.96; 1.00) respectively and these are subsequently entered into his multi-attribute utility equation to provide the overall utility score of 0.63, or 0.37 utility loss, for the state.3

3Torrance’s Multi-attribute Utility Equation:

\[ U = 1.42(m_1m_2m_3m_4) - 0.42 \]

Where:

- \( U \) = utility of health state
- \( m_1 \) = multiplicative utility factor for level on attribute X1 (physical function)
- \( m_2 \) = multiplicative utility factor for level on attribute X2 (role function)
- \( m_3 \) = multiplicative utility factor for level on attribute X3 (social-emotional function)
- \( m_4 \) = multiplicative utility factor for level on attribute X3 (health problem)
In contrast to the other three scales, the Visual Analogue (VA) scale directly provides utility scores on a scale between 1 (no injury) and 0 (worst possible injury). The resulting VA based utility scores were then 'normalised' (if State K, death, was not rated at 0) so that death is set at a value of zero, to enable direct comparison of scores from different raters. Also, the RULA valuation of injury methodology is tied to the DTp value of a life of £620,000 which is the value of 100% utility loss associated with a fatality. It is therefore unfeasible to allow £620,000 to equal 90% utility loss for one person, while £620,000 equals 110% for another respondent. Scores from the Rosser, 'Rosser Revisited' and Torrance scales did not require normalisation, as the state of death was set at 100% utility loss in the original valuation matrices. With the extrapolated EuroQol scores, however, on a scale of 0-100, death was rated as 10.6 and full health (scored 1,1,1,1) rated at 92. These scores therefore required transformation to enable direct comparison with scores from the other three scales, and to enable calculations based on the VOL, using the following equation:

\[
\frac{F - x}{F - d}
\]

Where:
- \(x\) = utility associated with injury state
- \(F\) = utility of full health (score 1,1,1,1 = 92)
- \(d\) = utility associated with death ( = 10)

In this way, utility loss scores were obtained for each of the disaggregated injury states from each index. Median RUL scores have been used as a basis for further calculations and were calculated from the raw RUL scores provided in Tables B1-B4 in Appendix B. Median values are used because the distribution is not skewed and the standard errors are small. When dealing with small sample sizes (in our case \(n = 10\)), median values are generally regarded as more reliable than means since the latter may be unduly influenced by a few extreme values. Also, on examination of the results, it appears that very little difference exists between mean and median values (see Appendix C, Tables C3-C6). The median is therefore used as the basis for subsequent calculations, to derive RUL_{min} and RUL_{max} values, as explained in the following section.

252 Calculating LYF Scores for the Galasko Injury States

LYF scores for each complete injury state description were calculated by adding together the minimum relative utility loss components, multiplied by the minimum duration for one end of the range, and adding together the maximum relative utility loss components multiplied by the maximum duration for the other end of the range. For example, state F consists of six sub-parts, each of which are rated separately:
State F: Not admitted to hospital (seen as an 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 for several weeks/months; after 3-4 months, return to normal health with no permanent disability.

F1. No overnight stay in hospital, but seen as an outpatient experiencing SLIGHT pain.

F2. No overnight stay in hospital, but seen as an outpatient experiencing MODERATE pain.

F3. Experience SLIGHT pain and some restrictions to work and/or leisure activities for 2 to 7 days.

F4. Experience MODERATE pain and some restrictions to work and/or leisure activities for 2 to 7 days.

F5. Experience some pain/discomfort and some restrictions to work and/or leisure activities for several WEEKS, after which return to normal health with no permanent disability.

F6. Experience some paid discomfort and some restrictions to work and/or leisure activities for several MONTHS, after which return to normal health with no permanent disability.

In the calculation procedure, the range of utility scores for each state has been maximised. The maximum and minimum possible utility score for a state are represented by RUL_{max} and RUL_{min}, respectively. In this example the complete injury description consists of (F1 or F2) + (F3 or F4) + (F5 or F6). To derive RUL_{min} for state F the lowest score in each of the three sub-parts (in this case F1, F3 and F5) are multiplied by their respective durations and are then added together to give the lowest possible utility loss score associated with state F. In turn, to derive RUL_{max} the highest utility scores from each of the three sub-parts (in this case F2, F4 and F6), multiplied by their respective durations, are added together to give the maximum possible utility loss score for state F.

\[
F_{min} = RUL(F1) \times \frac{1}{365} + RUL(F3) \times \frac{2}{365} + RUL(F5) \times \frac{5}{52} \\
F_{max} = RUL(F2) \times \frac{1}{365} + RUL(F4) \times \frac{6}{52} + RUL(F6) \times \frac{8}{12}
\]

Duration is calculated in terms of years (so one day in a state is represented by \(1/365\) and 7 days as \(1/52\)) as we are dealing with lost years of functioning and the value of a life year in our calculations. Based on the round table meeting with the consultants, the calculations are based on the assumption that 'several weeks' is approximated as five weeks and 'several months' as 8 months. Calculations had also been performed maximising the range to the extreme, interpreting 'several weeks' to mean as few as three, and 'several months' to mean as many as 11. Even so, the resulting range of LYF scores for the calculations was not very wide and therefore the precision of the
interpretation of 'several' was considered to be of minor importance. For permanent injuries, RUL scores were multiplied by thirty-nine years, assumed to be the average remaining life expectancy of an 'average working-age adult' in the population.

In this way, LYF scores can be derived for each of the eight complete injury states using each of the indices. This calculation procedure is based on the crucial assumption that the Rosser, Torrance and EuroQol indices all use a year duration as the base for the scores. However, as we have seen earlier, Torrance's scores are based on the assumption of states being permanent, Rosser-revisited on a 20 year duration, while Rosser's are of indeterminate duration. This assumption is adopted as a *modus operandi*, in the absence of a more obvious approach, with the intention of reviewing its consequences.

For the states which do not involve permanent impairment (F, W and X) the formulae in Appendix C, Table C1 were used. However, for all injuries involving permanent pain or impairment (S, V, R, L and N) the LYF value was found to be dominated by the final term in each equation. For example, inclusion of V2 and V4 terms in the calculation of $V_{\text{max}}$ from the equation

$$V_{\text{max}} = V_2 \times \frac{1}{365} + V_4 \times \frac{4}{52} + V_5 \times 39$$

increases the value of $V_{\text{max}}$ by < 0.1% from 15.60 (the RUL score of V5 alone) to 15.61 LYF (using the Rosser-revisited median values for V2, V4 and V5 in Appendix C, Table 5). Consequently, only the final term is used in further computations involving states S, V, R, L and N. The comparative insignificance of the earlier terms in those equations involving long-term consequences also means that the differences between the 'min' and 'max' values of those states are trivial, so only a single value is reported.

### 2.5.3 Calculating LYF Scores for a Serious Injury

The next stage in the calculation is to weight the LYF scores for each of the eight complete injury states by its relative frequency of occurrence, in order to determine an overall LYF estimate for a DTp classified 'serious' injury. The resulting scores in units of lost years of functioning represent the sum of each injury multiplied by its relative frequency in the distribution of 'serious' injuries.

$$\text{LYF}_{SI} = \sum_i (\delta U_i \delta t) \cdot \delta P_i$$

Where:

- $\text{LYF}_{SI}$ = lost years of functioning associated with a 'serious non-fatal injury'
- $\delta P_i$ = fraction of serious injuries which constitute type $i$
- $\delta U_i$ = relative utility loss associated with injury state $i$
- $\delta t$ = duration of injury in years
25.4 Calculating a Monetary Value for a Serious Injury

Finally, the LYF scores resulting from each of the four indices, (Torrance, Rosser, Rosser-revisited and EuroQol) are multiplied by the Value of a Life Year (determined at a variety of discount rates from the DTp Value of Life) to derive a monetary value for a 'serious' road traffic injury. The sensitivity of the estimates of the value of a 'serious' injury to the index used and to the discount rate applied can then be determined. The VA scores are handled differently. They remain RUL scores, which, after they are weighted for incidence are then multiplied by the VOL, rather than converting to a LYF value and multiplying by the Voly.

255 The Discounting Procedure

The calculation of LYF values for discount rates other than zero was accomplished by the use of the appropriate values in Appendix C, Table C2. For example, the multiplier of X3 in the formula for $X_{\text{max}}$ is three years at a 0% discount rate. For other discount rates, that number was substituted with the appropriate value on line 3 of Appendix C in Table C2, 2.94 at a 2% discount rate, 2.89 at a 4% discount rate, and so on. Likewise, where the value of 39 years appears in the equations for S, V, R, L and N in Appendix C, Table C1, this was replaced with the appropriate value from the bottom line of Appendix C, Table C2.

The discounted monetary values shown in Appendix C, Table C2 are present value calculations, at the middle of year zero, of a stream of annual mid-year payments of £1 starting in year zero. The formula used to arrive at the values is as follows (HMSO, 1991):

$$\text{Present Value} = \frac{1}{(1+r)^n} \left(1 + \frac{1}{r}\right)$$

where $r$ is the discount rate expressed as a decimal, and $n$ is the number of payments made. The same formula can be applied to the discounting of future years, as we have done, if one accepts that a constant discount rate is valid in these circumstances.

26 Qualitative Analysis

Qualitative information about the rating task was derived from two primary sources. The first source being the written comments of the consultants on the questionnaire itself, and the second source the verbal discussion of the mapping exercise at the round table meeting and debriefing session.

26.1 Comments from the Questionnaire

Consultants were asked to comment freely and at length on any difficulties encountered in accomplishing the mapping exercise, both in broad terms and with specific reference to each utility scale and each injury state. Consultants were also asked to keep in mind the subsequent round table meeting, where their comments would be discussed in greater depth. A full transcript of the comments written on the questionnaire is provided in Appendix D, and discussed in Chapter 3.
2.6.2 The Round-table Meeting

On 13th December 1991 a 'round table' focussed discussion session was held to derive qualitative data from the expert consultants. The meeting was a validation exercise, designed to act as a forum in which the advantages and limitations of the exercise in general and of the specific scales, could be highlighted. It was hoped that the discussion would help to make explicit the underlying rationale behind the consultants ratings, for example, how duration was considered or how adjustments were made for children and the elderly. By instigating an in-depth discussion of the problems encountered by the respondents in the rating exercise it was hoped that a clearer indication would emerge concerning which index was considered the most useful and appeared most suited to the task, and which was able to reflect the perceptions of the expert consultants to the greatest extent.

At the meeting, the TRRL Research Programme was briefly explained and a brief introduction to RULA given. The development of the questionnaire was described, including the development of the original injury state descriptions, the disaggregation of injury states into component parts (which presumes a LYF approach) and the four approaches (Rosser/Rosser-revisited, EuroQol, VAS, Torrance). General issues for discussion included the injury descriptors their clarity, precision, etc), the dimensions of functioning (were any omitted or irrelevant?), the definitions of the dimensions (How well did they fit road traffic accidents?; Are they exclusive/exhaustive categories?), duration (whether and how the duration was taken into account in the ratings; How were "several weeks" and "several months" interpreted?), the impact on family and friends, whether or not consultants were able to disregard financial effects, and age effects (including general trends for adjusting scores for the elderly and for children). Specific issues for discussion were chosen based on comments in the questionnaires. The difficulties and insights of using each of the four scales in the rating procedure were discussed. Consultants were asked which index they thought was best able to accurately reflect their perceptions of the injuries. Finally, the preliminary results, in terms of LYF, and monetary values for a serious injury were presented. Consultants were asked to discuss the extent to which the numbers appeared reasonable. The main points arising at the meeting are discussed in Chapter 3.
3. RESULTS

3.1 Quantitative Data

The calculation procedure and the associated underlying assumptions were described in detail in section 2.5. A brief summary is provided here before the data are presented. The quantitative data emerging from the questionnaire is presented in several stages. The median relative utility loss (RUL) scores are weighted by the duration of the injuries to give the minimum and maximum number of lost years of functioning for each of the Galasko injury states. The formulae for the calculation of minimum and maximum scores are shown in Appendix C Table C1. For states N/L, R, V and S which involve permanent residual disability, the calculations were found to be dominated by the final term in the equation, with the short term in-hospital or out-patient conditions having negligible impact on the overall score. Therefore, in the remaining tables, only scores for N3, L3, R5, V5, and S3 are given. For the non-permanent states X, W and F, minimum and maximum scores are given for each state. The LYF for a DTP classified 'serious' injury can then be calculated by weighting the LYF of each injury type by its relative frequency of occurrence, based on police statistics. Finally, an overall monetary value for a 'serious' injury can be derived by multiplying the number of lost years of functioning associated with a 'serious' injury by the value of a life year, derived from the statistical value of life at an appropriate discount rate.

3.1.1 Kruskal-Wallis Analyses

The RUL scores obtained from the rating exercise are presented in Appendix B in Tables B1-B4. Kruskal-Wallis tests were performed on all the injury states, for each of the measurement tools (VAS, Rosser, Torrance, Rosser Revisited, EuroQol) to examine whether or not there were significant differences between the scores given by the three groups (external health economists, nurses and DTP steering group members). All statistical analyses were performed on Minitab Version 2.0. On the VAS scale, the valuations given by the nurses were significantly different from the other two groups, for State R only. The valuations of the group of health economists were significantly different from the others for State N only. On the Rosser scale, a significant difference existed in the DTP valuations of State V3 compared to the other two groups (and State V4 significantly differently from those given by the DTP steering group members). Significant differences were determined at the p < 0.05 level. No significant differences existed between the three groups on any of the injury states on either the Torrance or EuroQol scales. With the Rosser Revisited/York MHV scale, State V3 was valued significantly differently by DTP steering group members in comparison to the other two groups. State V4 was also valued significantly differently by DTP in comparison to the Nurses. Given the number of comparisons (136 three way comparisons), six significant

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4 The Kruskal-Wallis one-way analysis of variance by ranks is an extremely useful test for deciding whether k independent samples are from different populations. Sample values almost invariably differ somewhat, and the question is whether the differences among the samples signify genuine population differences or whether they represent merely chance variations such as to be expected among several random samples from the same population. The Kruskal-Wallis technique tests the null hypothesis that the k samples come from the same population or from identical populations with respect to averages. The test assumes that the variable under study has an underlying continuous distribution. It requires at least ordinal measurement of that variable.
differences are to be expected by chance alone. As a result, the data was combined and analyses were performed without distinction between the different groups of raters. This does not mean that there were no differences between values given for the same injury state -- only that the difference between groups was no larger than the difference within groups. Median RULA scores are used in all subsequent calculations. The median RULA scores were considered to be the most representative due to the small sample size, although the descriptive statistics, shown in Appendix C, Tables C3-C6, illustrate that little difference exists between the mean and the median scores:

3.12 The Visual Analogue Scale

The RUL scores derived from the VA scale are presented in Table 3. VAS scores were normalised where death was given a relative utility other than 100, so that all scores for death equal 100. The relative utility loss associated with a 'serious' injury using police based data and median VAS scores is 0.42 or alternatively, 42% of the value of life. This overall RUL score is derived by weighting each of the VAS scores for F, W, X, S, V, R and N/L by their frequency of occurrence, e.g.

$$\frac{.17 \times .08}{.21 \times .16} + \frac{.34 \times .30}{.51 \times .24} + \frac{.40 \times .04}{.69 \times .16} + \frac{.90 \times .02}{.69 \times .16} = 0.42$$

From this RUL score for a 'serious' injury, a monetary value is derived by multiplying the RUL score by the DTP VOL of £620,000. The monetary value of a 'serious' injury using the VAS is thus calculated as approximately £267,000.

3.13 Calculating the Value of a Serious Injury from the four scales

RUL scores resulting from the Torrance, Rosser, Rosser-revisited and EuroQol are contained in Appendix B, Tables B1-B4 respectively. The number of lost years of functioning (LYF) for each Galasko injury state derived from the RUL scores are shown in Tables 4-7, which also illustrate the impact of different discount rates on LYF values.
Table 3: Results on the Visual Analogue Scale\(^3\)
Normalized Relative Utility Loss Scores for the Eight Galasko Injury States

<table>
<thead>
<tr>
<th>Responder</th>
<th>F</th>
<th>W</th>
<th>X</th>
<th>S</th>
<th>V</th>
<th>R</th>
<th>L</th>
<th>N Group(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.11</td>
<td>0.11</td>
<td>0.28</td>
<td>0.33</td>
<td>0.33</td>
<td>0.55</td>
<td>0.44</td>
<td>0.61 1 1</td>
</tr>
<tr>
<td>2</td>
<td>0.21</td>
<td>0.21</td>
<td>0.42</td>
<td>0.52</td>
<td>0.52</td>
<td>0.21</td>
<td>0.79</td>
<td>0.58 1 1</td>
</tr>
<tr>
<td>3</td>
<td>0.13</td>
<td>0.13</td>
<td>0.20</td>
<td>0.40</td>
<td>0.40</td>
<td>0.67</td>
<td>1.00</td>
<td>0.73 1 1</td>
</tr>
<tr>
<td>4</td>
<td>0.28</td>
<td>0.33</td>
<td>0.39</td>
<td>0.56</td>
<td>0.56</td>
<td>1.00</td>
<td>1.11</td>
<td>1.11 2 1</td>
</tr>
<tr>
<td>5</td>
<td>0.20</td>
<td>0.35</td>
<td>0.30</td>
<td>0.55</td>
<td>0.40</td>
<td>0.74</td>
<td>0.95</td>
<td>0.90 2 0</td>
</tr>
<tr>
<td>6</td>
<td>0.10</td>
<td>0.10</td>
<td>0.15</td>
<td>0.30</td>
<td>0.25</td>
<td>0.85</td>
<td>0.80</td>
<td>0.80 2 0</td>
</tr>
<tr>
<td>7</td>
<td>0.20</td>
<td>0.45</td>
<td>0.50</td>
<td>0.55</td>
<td>0.30</td>
<td>0.70</td>
<td>0.90</td>
<td>0.85 2 0</td>
</tr>
<tr>
<td>8</td>
<td>0.22</td>
<td>0.27</td>
<td>0.44</td>
<td>0.60</td>
<td>0.50</td>
<td>0.76</td>
<td>1.08</td>
<td>1.03 2 1</td>
</tr>
<tr>
<td>9</td>
<td>0.10</td>
<td>0.15</td>
<td>0.35</td>
<td>0.50</td>
<td>0.40</td>
<td>0.60</td>
<td>0.85</td>
<td>0.80 3 0</td>
</tr>
<tr>
<td>10</td>
<td>0.11</td>
<td>0.20</td>
<td>0.33</td>
<td>0.44</td>
<td>0.17</td>
<td>0.56</td>
<td>1.11</td>
<td>0.94 3 1</td>
</tr>
</tbody>
</table>

mean = \(0.17, 0.23, 0.34, 0.48, 0.39, 0.66, 0.90, 0.84\)
median = \(0.17, 0.21, 0.34, 0.51, 0.40, 0.69, 0.93, 0.83\)
SD = \(0.06, 0.12, 0.11, 0.10, 0.14, 0.21, 0.20, 0.17\)
Range = \(0.11, 0.28, 0.10, 0.45, 0.15, 0.50, 0.30, 0.6, 0.17, 0.6, 0.21, 1.0, 0.44, 1.11, 0.58, 1.11\)

\(^1\) Group - 1 = economist; 2 = nurse; 3 = DTP economist
\(^2\) Norm. - 1 = normalized; 0 = not normalized, K was directly rated 100 by the subject
\(^3\) No discounting possible with VAS.

Table 4: Lost years of functioning for Galasko health states based on median values from the Torrance matrix. The effect of various discount rates on LYF values is shown. The RUL values are taken from Appendix C3.

<table>
<thead>
<tr>
<th>Health State</th>
<th>RUL</th>
<th>Lost years of functioning (LYF)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>N3</td>
<td>1.14</td>
<td>44.5</td>
</tr>
<tr>
<td>L3</td>
<td>1.18</td>
<td>46.0</td>
</tr>
<tr>
<td>R5</td>
<td>0.73</td>
<td>28.5</td>
</tr>
<tr>
<td>V5</td>
<td>0.47</td>
<td>18.3</td>
</tr>
<tr>
<td>S3</td>
<td>0.47</td>
<td>18.3</td>
</tr>
<tr>
<td>X(_{\text{min}})</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>X(_{\text{max}})</td>
<td>0.34</td>
<td>1.0</td>
</tr>
<tr>
<td>W(_{\text{min}})</td>
<td>W1&amp;W3</td>
<td>0.03</td>
</tr>
<tr>
<td>W(_{\text{max}})</td>
<td>W2&amp;W4</td>
<td>0.25</td>
</tr>
<tr>
<td>F(_{\text{max}})</td>
<td>F1,F3&amp;F5</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>F2,F4&amp;F6</td>
<td>0.29</td>
</tr>
</tbody>
</table>

24
Table 5: Lost years of functioning for Galasko health states based on median values from the Rosser matrix. The effect of various discount rates on LYF values is shown. The RUL values are taken from Appendix C4.

<table>
<thead>
<tr>
<th>Health State</th>
<th>RUL</th>
<th>Lost years of functioning (LYF)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>N3</td>
<td>1.0</td>
<td>39.0</td>
</tr>
<tr>
<td>L3</td>
<td>0.31</td>
<td>12.1</td>
</tr>
<tr>
<td>R5</td>
<td>0.13</td>
<td>5.1</td>
</tr>
<tr>
<td>V5</td>
<td>0.035</td>
<td>1.4</td>
</tr>
<tr>
<td>s3</td>
<td>0.04</td>
<td>1.6</td>
</tr>
<tr>
<td>X_{\min}</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td>X_{\max}</td>
<td>\</td>
<td>0.095</td>
</tr>
<tr>
<td>V_{\min}</td>
<td>\</td>
<td>0.003</td>
</tr>
<tr>
<td>V_{\max}</td>
<td>\</td>
<td>0.021</td>
</tr>
<tr>
<td>F_{\min}</td>
<td>\</td>
<td>0.003</td>
</tr>
<tr>
<td>F_{\max}</td>
<td>\</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Table 6: Lost years of functioning for Galasko health states based on median values from the Rosser-revisited matrix. The effect of various discount rates on LYF values is shown. The RUL values are taken from Appendix C5.

<table>
<thead>
<tr>
<th>Health State</th>
<th>RUL</th>
<th>Lost years of functioning (LYF)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>N3</td>
<td>0.78</td>
<td>30.4</td>
</tr>
<tr>
<td>L3</td>
<td>0.63</td>
<td>24.6</td>
</tr>
<tr>
<td>R5</td>
<td>0.60</td>
<td>23.4</td>
</tr>
<tr>
<td>v5</td>
<td>0.40</td>
<td>15.6</td>
</tr>
<tr>
<td>s3</td>
<td>0.43</td>
<td>16.8</td>
</tr>
<tr>
<td>X_{\min}</td>
<td>0.37</td>
<td>0.37</td>
</tr>
<tr>
<td>X_{\max}</td>
<td>0.37</td>
<td>1.1</td>
</tr>
<tr>
<td>V_{\min}</td>
<td>\</td>
<td>0.037</td>
</tr>
<tr>
<td>V_{\max}</td>
<td>\</td>
<td>0.26</td>
</tr>
<tr>
<td>F_{\min}</td>
<td>\</td>
<td>0.038</td>
</tr>
<tr>
<td>F_{\max}</td>
<td>\</td>
<td>0.26</td>
</tr>
</tbody>
</table>
Table 7: Lost years of functioning for Galasko health states based on median values from the EuroQol matrix. The effect of various discount rates on LYF values is shown. The RUL values are taken from Appendix C6.

<table>
<thead>
<tr>
<th>Health State</th>
<th>RUL</th>
<th>Lost years of functioning (LYF)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>N3</td>
<td>0.96</td>
<td>37.4</td>
</tr>
<tr>
<td>L3</td>
<td>0.96</td>
<td>37.4</td>
</tr>
<tr>
<td>R5</td>
<td>0.72</td>
<td>28.1</td>
</tr>
<tr>
<td>v5</td>
<td>0.37</td>
<td>14.4</td>
</tr>
<tr>
<td>s3</td>
<td>0.37</td>
<td>14.4</td>
</tr>
<tr>
<td>X_min</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>X_max</td>
<td>X26X3</td>
<td>1.16</td>
</tr>
<tr>
<td>W_min</td>
<td>W1&amp;W3</td>
<td>0.036</td>
</tr>
<tr>
<td>W_max</td>
<td>W2&amp;W4</td>
<td>0.24</td>
</tr>
<tr>
<td>F_min</td>
<td>F1,F3&amp;F5</td>
<td>0.038</td>
</tr>
<tr>
<td>F_max</td>
<td>F2,F4&amp;F6</td>
<td>0.25</td>
</tr>
</tbody>
</table>

The relative contribution of each Galasko injury state to the overall LYF associated with a 'serious' injury for each of the four scales is shown in Tables 8-11.

Table 8: Lost years of functioning by health state and discount rate based on the Torrance matrix and weighted according to their relative contribution to a serious non-fatal road traffic injury. A mean LYF value for N3/L3 has been used since a combined frequency of occurrence has been given.

<table>
<thead>
<tr>
<th>Health state</th>
<th>Relative contribution</th>
<th>Equivalent LYF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>to serious non-fatal RTA</td>
<td>0</td>
</tr>
<tr>
<td>N3/L3</td>
<td>0.02</td>
<td>0.91</td>
</tr>
<tr>
<td>R5</td>
<td>0.16</td>
<td>4.56</td>
</tr>
<tr>
<td>V5</td>
<td>0.04</td>
<td>0.73</td>
</tr>
<tr>
<td>s3</td>
<td>0.24</td>
<td>4.39</td>
</tr>
<tr>
<td>X_min</td>
<td>0.30</td>
<td>0.10</td>
</tr>
<tr>
<td>X_max</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>W_min</td>
<td>0.16</td>
<td>0.004</td>
</tr>
<tr>
<td>W_max</td>
<td>0.16</td>
<td>0.040</td>
</tr>
<tr>
<td>F_min</td>
<td>0.08</td>
<td>0.003</td>
</tr>
<tr>
<td>F_max</td>
<td>0.08</td>
<td>0.023</td>
</tr>
</tbody>
</table>

Total (min) | 1.00 | 10.70 | 7.57 | 5.64 | 4.42 | 3.59 | 3.01 |
Total (max) | 1.00 | 10.95 | 7.82 | 5.88 | 4.66 | 3.83 | 3.24 |
Table 9: Lost years of functioning by health state and discount rate based on the Rosser matrix and weighted according to their relative contribution to a serious non-fatal road traffic injury. A mean LYF value for N3/L3 has been used since a combined frequency of occurrence has been given.

<table>
<thead>
<tr>
<th>Health state</th>
<th>Relative contribution to serious non-fatal RTA</th>
<th>Discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>N3/L3</td>
<td>0.02</td>
<td>0.51</td>
</tr>
<tr>
<td>R5</td>
<td>0.16</td>
<td>0.82</td>
</tr>
<tr>
<td>v5</td>
<td>0.04</td>
<td>0.056</td>
</tr>
<tr>
<td>s3</td>
<td>0.24</td>
<td>0.38</td>
</tr>
<tr>
<td>X_{min}</td>
<td>0.30</td>
<td>0.009</td>
</tr>
<tr>
<td>X_{max}</td>
<td>0.30</td>
<td>0.029</td>
</tr>
<tr>
<td>W_{min}</td>
<td>0.16</td>
<td>0.0005</td>
</tr>
<tr>
<td>W_{max}</td>
<td>0.16</td>
<td>0.003</td>
</tr>
<tr>
<td>F_{min}</td>
<td>0.08</td>
<td>0.0002</td>
</tr>
<tr>
<td>F_{max}</td>
<td>0.08</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Table 10: Lost years of functioning by health state and discount rate based on the Rosser-revisited matrix and weighted according to their relative contribution to a serious non-fatal road traffic injury. A mean LYF value for N3/L3 has been used since a combined frequency of occurrence has been given.

<table>
<thead>
<tr>
<th>Health state</th>
<th>Relative contribution to serious non-fatal RTA</th>
<th>Discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>N3/L3</td>
<td>0.02</td>
<td>0.55</td>
</tr>
<tr>
<td>R5</td>
<td>0.16</td>
<td>3.74</td>
</tr>
<tr>
<td>v5</td>
<td>0.04</td>
<td>0.62</td>
</tr>
<tr>
<td>s3</td>
<td>0.24</td>
<td>4.03</td>
</tr>
<tr>
<td>X_{min}</td>
<td>0.30</td>
<td>0.11</td>
</tr>
<tr>
<td>X_{max}</td>
<td>0.30</td>
<td>0.33</td>
</tr>
<tr>
<td>W_{min}</td>
<td>0.16</td>
<td>0.006</td>
</tr>
<tr>
<td>W_{max}</td>
<td>0.16</td>
<td>0.042</td>
</tr>
<tr>
<td>F_{min}</td>
<td>0.08</td>
<td>0.003</td>
</tr>
<tr>
<td>F_{max}</td>
<td>0.08</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Total (min) 1.00 9.06 6.42 4.79 3.74 3.05 2.56
Total (max) 1.00 9.33 6.69 5.06 3.98 3.29 2.80
Table 11: Lost years of functioning by health state and discount rate based on the EuroQol matrix and weighted according to their relative contribution to a serious non-fatal road traffic injury. A mean LYF value for N3/L3 has been used since a combined frequency of occurrence has been given.

<table>
<thead>
<tr>
<th>Health state</th>
<th>Relative contribution to serious non-fatal RTA</th>
<th>Equivalent LYF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discount rate</td>
<td>0</td>
</tr>
<tr>
<td>N3/L3</td>
<td>0.02</td>
<td>0.75</td>
</tr>
<tr>
<td>R5</td>
<td>0.16</td>
<td>4.50</td>
</tr>
<tr>
<td>V5</td>
<td>0.04</td>
<td>0.58</td>
</tr>
<tr>
<td>S3</td>
<td>0.24</td>
<td>3.46</td>
</tr>
<tr>
<td>X_min</td>
<td>0.30</td>
<td>0.11</td>
</tr>
<tr>
<td>X_max</td>
<td>0.30</td>
<td>0.35</td>
</tr>
<tr>
<td>W_min</td>
<td>0.16</td>
<td>0.006</td>
</tr>
<tr>
<td>W_max</td>
<td>0.16</td>
<td>0.038</td>
</tr>
<tr>
<td>F_min</td>
<td>0.08</td>
<td>0.003</td>
</tr>
<tr>
<td>F_max</td>
<td>0.08</td>
<td>0.020</td>
</tr>
</tbody>
</table>

LYF values for a DTp classified ‘serious’ injury, with LYF scores for each injury state weighted by the incidence of occurrence, which result from the four different scales are shown in Table 12.
Table 12: Summary of LYF values for a serious non-fatal road traffic injury according to utility loss matrix and discount rate used.

<table>
<thead>
<tr>
<th>Equivalent LYF Matrix</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosser-revisited</td>
<td>9.06</td>
<td>6.42</td>
<td>4.79</td>
<td>3.74</td>
<td>3.05</td>
<td>2.56</td>
</tr>
<tr>
<td>- min.</td>
<td>9.33</td>
<td>6.69</td>
<td>5.06</td>
<td>3.98</td>
<td>3.29</td>
<td>2.80</td>
</tr>
<tr>
<td>- max.</td>
<td>10.70</td>
<td>7.57</td>
<td>5.64</td>
<td>4.42</td>
<td>3.59</td>
<td>3.01</td>
</tr>
<tr>
<td>Torrance</td>
<td>1.78</td>
<td>1.25</td>
<td>0.94</td>
<td>0.73</td>
<td>0.59</td>
<td>0.48</td>
</tr>
<tr>
<td>- min.</td>
<td>1.80</td>
<td>1.27</td>
<td>0.96</td>
<td>0.75</td>
<td>0.61</td>
<td>0.51</td>
</tr>
<tr>
<td>- max.</td>
<td>2.8-29</td>
<td>2.96</td>
<td>2.48</td>
<td>2.04</td>
<td>1.70</td>
<td>1.36</td>
</tr>
<tr>
<td>Rosser</td>
<td>9.41</td>
<td>6.68</td>
<td>4.96</td>
<td>3.91</td>
<td>3.16</td>
<td>2.68</td>
</tr>
<tr>
<td>- min.</td>
<td>9.70</td>
<td>6.96</td>
<td>5.24</td>
<td>4.18</td>
<td>3.42</td>
<td>2.94</td>
</tr>
<tr>
<td>- max.</td>
<td>10.95</td>
<td>7.82</td>
<td>5.88</td>
<td>4.66</td>
<td>3.83</td>
<td>3.24</td>
</tr>
<tr>
<td>EuroQol</td>
<td>9.07</td>
<td>6.43</td>
<td>4.79</td>
<td>3.74</td>
<td>3.05</td>
<td>2.56</td>
</tr>
<tr>
<td>- min.</td>
<td>9.33</td>
<td>6.69</td>
<td>5.06</td>
<td>3.98</td>
<td>3.29</td>
<td>2.80</td>
</tr>
<tr>
<td>- max.</td>
<td>10.70</td>
<td>7.57</td>
<td>5.64</td>
<td>4.42</td>
<td>3.59</td>
<td>3.01</td>
</tr>
</tbody>
</table>

Finally, the monetary values of a 'serious' injury based on the Torrance, Rosser, Rosser-revisited and EuroQol LYF scores are shown in Table 13.

Table 13: Computation of the value of a serious injury, demonstrating (a) the similarity of the Rosser-revisited, Torrance and EuroQol valuations, and (b) the insensitivity of the results to discount rate.

<table>
<thead>
<tr>
<th>Discount rate (%)</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of life (VOL) £'000s</td>
<td>620</td>
<td>620</td>
<td>620</td>
<td>620</td>
<td>620</td>
<td>620</td>
</tr>
<tr>
<td>Value of a life year (VOLY) £'000s</td>
<td>15.90</td>
<td>22.59</td>
<td>30.44</td>
<td>39.12</td>
<td>48.32</td>
<td>57.78</td>
</tr>
<tr>
<td>Value of a serious injury (VOSI) £'000s</td>
<td>144-148</td>
<td>146-156</td>
<td>148-162</td>
<td>170-174</td>
<td>174-187</td>
<td>28-29</td>
</tr>
<tr>
<td>- Rosser-revisited</td>
<td>150-154</td>
<td>155-170</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Qualitative data was derived both from written comments on the questionnaires and from the round table discussion meeting. An in-depth exploration was considered a necessary part of our approach in order to understand the rationales behind consultants' ratings and to define any problems with the exercise, both in general terms and with specific reference to each utility index and to the injury descriptions themselves.

### 3.2.1 Comments Arising from the Questionnaire

Consultants were asked to comment on the mapping of each specific injury state onto each index, and were also asked to comment generally regarding the use of each index with DTp's injury descriptors. Consultants #1-#3 are 'external' health economists, #4-#8 nurses from Professor Galaško's team, and #9-#10 'internal' economists who sit on the DTp steering group committee.

#### 3.2.1.1 General Comments about the Exercise

The general consensus appeared to be that Torrance was the most problematic scale to apply. Consultant #3 commented that Torrance was the most difficult, Rosser next, with EuroQol the easiest. Consultant #9 also found the EuroQol easiest to apply, as the descriptors were not overburdened with detailed information specific to particular circumstances. #6 felt that the sliding scale (VAS) was the easiest to use, as it was unrestrictive and enabled complex and multifaceted judgments to be reflected which could not be undertaken with the other scales. #4 found that Rosser's Classification of Illness was most appropriate to use with DTp injury descriptions, as choices under both the disability and distress headings were considered comprehensive yet precise. #5 found the Rosser Classification to fit better with the injury descriptions than the EuroQol or Torrance. #6 believed that none of the scales provided were sufficient to the task. The main criticism of the EuroQol scale was its 'all or none' dichotomy. Given a moderate, intermediate level, many consultants expressed that the EuroQol scale would be greatly improved.

The injury descriptions were criticised by several consultants as being vague, which they considered made it difficult to conceptualise the impact of the disability in question. #7 commented "In some cases, it has not been stated if it was head injury, fractures of upper or lower limbs, pulled muscles, sprained upper or lower limbs. The area affected could make the person totally immobile. With other areas, the patient could manage without assistance." #5 argued "the scenarios are not adequately detailed and leave too much to be assumed.

The adjustments for child/elderly victims were commented upon. #6 commented that the child or elderly adjustments were a bit of a 'red herring' because in such cases so much depends on the existing health and social support structures of the victims. #9 stated "Where injuries left permanent severe physical or neurological injuries, the impact would be expected to affect not only the individual, but also family and friends and has been neglected in the ratings". #7 remarked "Long term illnesses can result in financial crises within the family. whether the patient were a child, adult or elderly - someone may have to give up work to look after the dependent relative".

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32 Qualitative Data

30
The consensus appeared to be that the rating exercise was a difficult task, due to a generally poor fit between the scales and the injury descriptors and the broadness, of necessity, of the descriptors. Consultant #2 commented that the development of a specific RTA index would be ideal, but, if this were not feasible, then the rapidly developing EuroQol measure would appear to hold most promise in this area. The recent developments in the EuroQol (including intermediate categories) make it a far more sensitive tool than the version utilised in this study.

3.2.1.2 Specific Comments on the Torrance Classification  The dimensions defined by Torrance's index were criticised as being very broad and unable to pick up many real variations in health status that are evident from the RTA descriptions, as well as being insensitive to variations in injury descriptors. There was a general consensus that the 'health problems' dimension covered a restricted domain in a very partial manner and did not focus upon the sorts of problems that would arise from an RTA (needing a hearing aid; attending a special school). #9 remarked that the descriptors for 'health problems' were hard to quantify and required further breakdown. #4 commented that the health problems section was, on the whole, completely unusable. Criticism was also directed at the category of social-emotional function. The social-emotional function answers were considered inappropriate by consultant #5, especially in relation to patients suffering and the effect on friends and contacts. #4 noted that the Torrance health state classification was only able to be used, in part, with the DTp injury classification. The categories, physical function and role function could be assigned values, but the social-emotional section is too limited to allow for valid assessment. #3 criticises the scale, as it does not easily incorporate pain. Consultant #7 also comments that pain needs better categorisation.

32.13 Specific Comments on Rosser/Rosser-Revisited Classification  #2 commented that the classifications of the Rosser index are very broad. #6 noted that Distress is a subjective state which depends to a large extent on the survival strategies of the individual and the social support available to that individual. #9 stated that with the Rosser index it was difficult to distinguish between moderate and slight pain, which made it difficult to rate some of the injury states. In general, however, it was felt that the two dimensions of this index best fit the descriptions provided.

32.1.4 Specific Comments on the EuroQol Classification  The general consensus emerged that finer gradations are required in several of the categories and that the EuroQol represents only the best/worst scenarios which provide a stark dichotomy. For example, in the Self Care dimension, an enormous gulf exists between 'no problems' and 'unable to dress self' in which many injury states are found. Similarly, no category for 'slight pain' exists. In the mood dimension, a consensus existed that 'anxious/depressed' required far finer gradations of psychological well-being. In the mobility category, Level 2 is 'requiring a stick' while Level 3 is 'confined to bed'. No category exists for a wheelchair bound patient. Respondent #7 commented that anxiety should be separated from depression. Anxiety can be relieved by explanation and discussion, whereas depression may require medical treatment (e.g. drugs).

32.2 Round Table Discussion  The findings of the round table meeting are discussed in more detail in Chapter 4. In general, the respondents expressed the most confidence in their VAS scores, which were felt to most accurately express the full impact of the
injuries described. Of the three other approaches, it was felt that the Rosser dimensions best matched the way in which the injuries were described, which therefore made it the easiest to use, though not necessarily the most accurate at reflecting the full impact of the injuries. Torrance’s dimensions were considered the least appropriate for injuries resulting from RTAs and the consensus was reached that the EuroQol approach held the most promise for the future (with some revisions). Specifically, each dimension requires at least three levels, with an intermediate category between 'some' or 'none'.

The virtual concordance of the values emerging from the Torrance and Rosser-revisited matrices came as somewhat of a surprise to the consultants, considering the very different approaches of the two. Their concordance could be 'pure coincidence' of course, but when the EuroQol approach resulted in even more similar values, the respondents felt that may be considered beyond coincidence and is a very encouraging result for the RUL approach.

When shown the monetary values resulting from the indices the consultants considered them quite reasonable as representative of the pain, grief and suffering associated with a 'serious injury'. The value, they commented, was probably too low for injuries like N (quadraplegia/paraplegia) and L (severe brain damage) and too high for short term injuries like F, W and X. However, if one value for this wide range of injuries was required, the emerging values were deemed to be reasonable.

The consultants agreed that State K could not be rated using the indices provided. The utility indices used were not designed to enable a score to be assigned to death. For example, with the Rosser index, most respondents rated death a disability of 8 (unconscious), and a distress of 1 (none) which had a score of -1.028. 8,1 is the maximum score allowed by the Rosser index, as 8,2, 8,3 and 8,4 are considered void, as an unconscious patient would have no level of distress. Some of the consultants rated State K as 8,2, 8,3 or 8,4 considering the distress to the family, etc. Similar problems occurred with rating K on the Torrance and EuroQol scales. Finally, it was agreed that valuations for State K were meaningless when derived from scales not meant to assign a value to death. The scores for State K assigned by the raters in the original valuation matrix were used. In Rosser, Torrance and Rosser-revisited, death was assigned a score of zero. In EuroQol, death was not assigned a score of zero and the scores were therefore normalised.
4. DISCUSSION

4.1 Comparison of Scores from Torrance, Rosser, Rosser-revisited and EuroQol

Comparison of Tables 4-7 indicates that LYF scores from Rosser, with the exception of State N, appear to be consistently lower than LYF scores from Torrance, Rosser-revisited and EuroQol.

Figure 2  Lost years of functioning versus injury state as derived by four utility loss matrices. For states S to N, the vertical bar corresponds to the range of discount rates applied, from 0% (top) to 10% (bottom). For states F to X the values are barely affected, if at all, by discount rate. The range in these cases corresponds to the min/max values whose derivation is described in the text.
Figure 2 illustrates the divergence between Rosser and the other three scales. For state N, the four scales provide reasonably consistent estimates of the LYF associated with this injury state. For states F, W, S, V, R and L, Rosser-revisited, Torrance and EuroQol all exhibit a remarkable degree of convergence, whilst the Rosser estimates are consistently and quite dramatically lower. For states F, W and X in particular, the estimates of LYF from the Rosser scale are approximately an order of magnitude below the LYF estimates derived from the other three scales. Examination of Table 12, which provides a summary of LYF values for a serious non-fatal RTA according to the utility loss matrix used, further illustrates the divergence between the scores produced by Rosser and those derived from Torrance, Rosser-revisited and EuroQol.

Rosser-revisited and EuroQol exhibit markedly similar estimations of LYF for a ‘serious injury’ with a range (at a 0% discount rate) from Rosser-revisited of between 9.06 years (min) to 9.33 years (max) and EuroQol scores lying between 9.41 (min) and 9.70 (max). Torrance values are slightly higher, with a range of between 10.70 (min) and 10.95 (max). In stark contrast, estimates of the LYF associated with a serious road traffic injury using the Rosser scale range from only 1.78 (min) to 1.80 (max).

This divergence in LYF values is consequently evident in the monetary valuations for a serious non-fatal road traffic injury. Estimates from Torrance are highest, with a value of between £170,000-£174,000, with EuroQol scores showing a range from £150,000-£154,000 and Rosser-revisited a range from £144,000-£148,000. In comparison, Rosser scores yield a value for a serious injury of between £28,000-£29,000.

Possible explanations for the differences and similarities emerging from the four indices may be found in their development. As described in Section 2.3, the utility values in each of the matrices were derived by asking a certain group of people certain types of questions. In Torrance’s scale the values were derived for permanent states beginning in infancy. In contrast, the raters in Rosser’s study considered young to middle-aged adults and were first asked to consider the health states described as treatable (with no change over time if not treated), and then to consider the states as permanent and which could not or would not be treated. In the EuroQol scale, utility valuations were derived from respondents who were instructed to assume that the states would last for one year and that the victim was like himself or herself. Finally, in the Rosser-revisited study, the values given to the revised valuation matrix were based on states lasting 20 years, after which the patient would die. The influence of the different durations and ages of onset which the original utility scores are based upon, may explain differences in the scores derived from the four utility indices for the same injury descriptors. Thus, it is not unexpected that Torrance’s scores, based on permanent lifelong conditions, result in higher scores for each Galasko injury state than those resulting from Rosser, Rosser-revisited or EuroQol.

The similarity of the values resulting from Rosser-revisited and EuroQol is notable. This may also be explained by examining the development of the original matrix values. Rosser-revisited and EuroQol are both based on VAS scaling procedures, where perfect health could not receive a score higher than one. However, it should be remembered that the two scales are based on entirely different dimensions, with the Rosser-revisited scores based
on the original Rosser two-dimensional index of disability and distress in contrast to the EuroQol which is based on a six dimensional index assessing mobility, self-care, main activity, social relationships, pain and mood. In this context, it is interesting to note the relative degree of accord in the scores derived from Torrance when compared to Rosser-revisited and EuroQol. Torrance is based on a completely different set of dimensions, uses a different sample population and a scaling procedure based on TTO rather than VAS, and yet still provides very similar values to those produced by Rosser-revisited and EuroQol.

The divergence between the LYF scores emerging from the Rosser index as compared to the other three indices, which is subsequently reflected in the monetary valuations for a serious injury is also notable. The values in the Rosser matrix, although sharing the same dimensions as Rosser-revisited, are based on an magnitude estimation scaling procedure, involving one important difference from the visual analogue scaling used by the York group in Rosser-revisited and the EuroQol group. Rosser’s subjects had no upper limit to the numbers which could be used, while the York group, for both the EuroQol and Rosser-revisited study, limited perfect health to a score of 1. Furthermore, in the Rosser-revisited study, subjects rated all health states relative to a fixed marker (with a score of 1) while Rosser’s subjects started with state ‘no disability, moderate distress’, marked the second state relative to that, the third state relative to the second, and so on, with no fixed reference point. Using the ‘unbounded scaling’ methodology, Rosser derived scores for the matrix ranging between 0.25 and 812.61 (Rosser, 1989). This methodology had significant implications when the scores were transformed to a 0-1 scale.

Some concern was expressed from members of the DTp steering group that the convergence between scores from Rosser-revisited, Torrance and EuroQol was simply a reflection of the overall insensitivity of the different indices to respondents’ perceptions. In comments from the questionnaire and the round-table meeting, each of the four matrices were criticised for their insensitivity in reflecting respondents’ views. For example, EuroQol had no intermediate categories, Torrance’s health problems dimension was incomplete and difficult to rate with some of the injury descriptors and Rosser’s dimensions were criticised as being ‘too vague’, which made the Rosser scale the easiest to use but not necessarily the most accurate in reflecting consultants’ perceptions. Furthermore, the manner in which the injury descriptions were written was criticised as they were written in very broad terms and with vague qualifiers like ‘possibly’, ‘some’ and ‘several.’ It was commented, at the round table meeting, that the task involved fitting "imperfect descriptors onto imperfect tools." However, when it is remembered that the three rating tasks are based on completely different dimensions, different scaling procedures and/or using different sample populations it is unlikely that such a convergence of values would occur by chance, even if consultants' responses were restricted somewhat by the insensitivity of the scales and the vagueness of the injury descriptors. Examination of the RUL scores shows that the indices are sensitive enough to discriminate between the eight injury states.

There was also concern that the use of the median values was creating the convergence between Torrance, Rosser-revisited and EuroQol as a statistical artifact. Examination of the individual RUL scores (Appendix B, Tables B1-B4) illustrates that this is not the case. Consultants at the round table meeting expressed some surprise at the
similarity between the values resulting from the Rosser-revisited and the Torrance indices (the EuroQol scores had not, at that time, been calculated), given the great differences in methodology. It was commented that the similarity between the two could be purely coincidental but that if the EuroQol scores were to coincide as well, that would be a very encouraging sign, indeed. Convergence of the scores resulting from the use of three very different approaches, it was felt, may indicate the robustness of the RUL approach and strengthens the case for the values derived from each of them.

Further concern was expressed that the order in which the scaling exercises were completed would influence the results, in particular, whether the VAS/Rosser task was completed first. Four of the respondents completed the VAS/Rosser exercise first in their questionnaire package. Kruskal-Wallis tests were performed to compare the responses of those that completed the VAS/Rosser task first to those that did not. No significant differences in the scores were evident from the order of the rating tasks.

Despite the convergence of scores emerging from the three different approaches, it was decided to compare them with utility scores for similar injuries estimated from a variety of utility scales in a review by Miller et al. (1990). The utility scores from Miller et al.'s review were compared to the median scores for each injury state from each utility index resulting from the present study.

Miller’s scores for severe head injury range from 0.71 to 1.28, with a 'best estimate' of 1.16. The median utility loss scores for state L3 (head injury) in the present study, from three of the four utility indices are quite similar. The median from Torrance was 1.18, 0.96 from EuroQol, 0.63 from Rosser-revisited and, the outlier, 0.31 from Rosser. Miller’s review also provides utility loss estimates for quadriplegia, with a range from 0.49-1.14 and for paraplegia with a range of between 0.29-0.81. State N3, the equivalent state in the present RULA study, received a median score on the Torrance scale of 1.15, a score on the Rosser scale of 1.00, a score on the Rosser-revisited scale of 0.78 and a score from the EuroQol scale of 0.96.

Moreover, Miller provides utility loss estimates for a broken lower leg (with a duration of a year), which can be roughly compared to the non-permanent states F, W and X in the RULA study. Miller’s estimates for a temporary injury range from 0.30-0.54. Estimates for State F (no inpatient - recover 3-4 months) range from 0.28-0.43 on the Torrance scale, 0.28-0.40 on the Rosser-revisited scale, 0.36-0.37 on the EuroQol scale and 0.02-0.04 on the Rosser scale. Estimates for State W (recover 3-4 months) range from between 0.26-0.36 on the Torrance scale, 0.34-0.50 on the Rosser-revisited scale, 0.36-0.76 on the EuroQol scale and 0.03-0.07 on the Rosser scale. Finally for State X (recover 1-3 years) utility loss estimates range from between 0.36-0.42 on the Torrance scale, 0.37-0.50 on the Rosser-revisited scale and 0.37-0.76 on the EuroQol scale 0.03-0.07 on the Rosser scale.

For both states with permanent residual disability (L and N) and for the temporary states (F, W and X) there appears to be a high level of concurrence between estimates from Miller’s review and estimates provided by the consultants in the present study.
accident, and is an alternative measure to LTP.

Where, total time is defined as any portion of time in which the vehicle cannot perform normal activities as a consequence of a motor vehicle

utility and duration,

expected to be considered implicitly in consultant’s findings. However, may not characterize the relationship between

utility by duration in a general fashion to derive LTP scores. With the Rasch, however, where duration may be

higher than those from Rasch with the Torrance, Ross-Register and EnrootO RUL values were

predominantly lower than those from Torrance. Rass-Register and EnrootO, though they are predominantly

However, if the new RUL Scores are compared between the VAS and the other four scales, the VAS RUL

with the other four scales.

classification system which describes the dimensions which should be considered in the evaluation, as was the case

multifaceted informed concerning the RUL of the different injury scores and did not confine them to a rectitude

caring were considered in the results on the VAS. It was computed that the VAS allowed them in their RUL scores. For example, the opportunity costs of

respondents were considering those wider costs in their VAS scores. For example, the opportunity costs of

incomparable. Indeed, comments from the stakeholders and the road safety discussion indicated that many of the

influenced that many of the indirect impacts on the family and friends of an injured person might implicitly be

Primfacie the RUL Scores from the VAS were expected to be higher than those from the other scales. We had

shown in Table 13.

value of a section, injury derived using VAS scores is higher than those derived by any of the RUL matrices. As

this enhances to a value of a section that the relative injury of approximately 267.900. The overall monetary

injury values and weighted by the relative frequency of occurrence is 0.2 of 0.5 of the VAS. In monetary terms,

The relative utility loss associated with a section injury derived from the median VAS scores for each of the eight

4.2 The Visual Analogic Scale

Injuries (L-associated AIS 4 and 5 of the body, W and X) are very similar.

estimates of LTP for scores L and N do not appear to be excessively higher, and the non-permanent but sessions

estimates of AIS LTP values range from 12.4 to 46.7 years lost. In comparison to estimates from LTP, our

estimation (LTP) from the four utility scales range from 20.4 years to 4.5 years at a 0% discount rate. For scale L,

RUL all studies are quite similar again with the estimates of LTP associated with scale L associated with columns

and all AIS 4 injuries are estimated at 20.4 years, and AIS 5 injuries at 14.5 loss days of productivity. A LTP of 28 LTP, a

injuries with total disability is 4.5 loss years. For a severe head injury with partial disability, it is 12.6 loss years

LTP. (1987) estimates lost time per injured victim for AIS 4 and AIS 5 injuries. His estimate for a severe
For example, on the VAS, consultants have given greater weight to the utility loss associated with short term non-permanent states than that which results when we multiply the RUL of a non-permanent state by its duration, (perhaps because they wanted to reflect their own perceptions of the relative importance of the immediate future compared to the distant future). This had the effect of increasing the overall monetary value of a serious injury. With the scores from the other four scales, the RUL scores are explicitly weighted by duration, which consequently reduces the impact of the short term injury states such as F, W and X, which may have been given relatively high utility loss scores. The calculation thus reduces the relative contribution of the temporary injuries to the overall value of a non-fatal serious road traffic injury.

4.3 Duration

There is evidence that the LYF approach taken here may involve the 'double-counting' of duration. This may be shown by examining the divergence in the respondents' ratings of sub-states that are effectively equivalent and which, it could be argued, should therefore be rated the same. States X2 and S1 are described identically ('in hospital 1-4 weeks experiencing moderate pain'), as are V1 and F2 ('No overnight stay in hospital, but seen as an outpatient experiencing moderate pain'), W3 and F5 (Experiencing some pain/discomfort and some restrictions to work and/or leisure activities for several weeks, after which return to normal health') and V5 and S3 ('Experiencing some pain which gradually reduces, but may recur when taking part in some activities; some permanent restrictions to leisure and possibly some work activities') and W4 and F6 ('Experiencing some pain/discomfort for several weeks with some restrictions to work and/or leisure activities lasting several months, after which return to normal health with no permanent disability').

Only respondent #3 consistently rated these equivalent states the same. This respondent indicated at the round table meeting his concern that our approach double-counted duration. He also commented that he thought that the parenthetical information provided at the end of each of the descriptions (eg. [as state S1], written at the end of State X2's description) was provided as an aid to consistency. All other respondents rated the identical descriptions differently from a minimum of at least once on the three indices to a maximum of 14 out of 15 times, so it appears that, in general, most respondents did not use the information in this way. These inconsistencies may be a result of our instructions that respondents were to rate each sub-state "in context of the complete injury" which was provided at the top of the page.

The overall description was retained at the top of the page for specific reasons. If the sub-components of each of the injury states were rated in isolation from the total state, there was concern that the sub-components would not 'add-up' to give a RUL score representative of the whole injury state. Furthermore, the injury descriptors provided information on the extent of pain and disability. From this, respondents were expected to estimate the quality of social-emotional functioning (Torrance), mood and social-relationships (EuroQol) and distress (Rosser, Rosser-revisited). The effect of any level of pain or disability in the victim's functioning on these psychosocial dimensions,
it was thought, might be dependent on the prognosis. For this reason, respondents may have rated, say, "four weeks in hospital in severe pain" differently with respect to mood or social relationships when it was followed by a return to normal health than when it was followed by permanent disability. In this way, it appears that the duration of the injuries may be, to some extent, double-counted, as we explicitly multiply the RUL score given by its duration to obtain the LYF scores and ultimately the monetary value of a serious injury.

The effect of duration on utility estimates is one of the major outstanding areas of uncertainty in the relative utility loss approach. Insufficient research has so far been undertaken to determine whether the assumption of linearity is erroneous or to suggest the form of the actual function between utility and duration.

To summarise, the LYF calculations are dependent on the assumption of a direct proportional relationship with utility and duration. However, the influence of duration, in the form of prognosis, may also be incorporated in the rating exercise itself. In the present study, respondents undertook rating of the utility of each phase of the injury path in context of the entire injury description or prognosis. Some respondents did rate identical states (such as W4 and F6) differently if they were followed by a phase of permanent disability or followed by a phase of recovery, as discussed above. In these cases the influence of duration may be accounted for twice in the overall exercise—implicitly in the consultants' ratings of the sub-states, and explicitly in the aggregation procedure.

4.4 Discounting

Discount rate has a marginal effect upon the LYF scores for states F, W, and X because they have no long-term consequences and even at a very high discount rate, say, 10%, one year is still worth 0.91 years, for example. Discounting has a significant effect, however, upon the LYF associated with a permanent injury. For example, 39 years at a discount rate of only 4%, is worth only 20.37 years. This effect washes out, however, upon calculating a monetary value, for three reasons. First, the value of a serious injury is calculated by weighting each of the LYF values at a specified discount rate for each Galasko state by its relative frequency of occurrence and multiplying the sum by the value of a life year. For consistency, the same discount rate should be adopted in the calculation of the LYF values and the value of a life year. The consequence of this, in the case of road traffic injuries, is that discount rate has little effect upon the monetary value of a serious injury. Second, this is because the dominant contributors to the value of serious injury are the long-term impairments with a constant utility loss over remaining life span. The discounting of such impairments exactly compensates for the increasing value of a life year as the discount rate is increased. Third, as depicted in Figure 3, this balancing out of the discount rate is also a consequence of the anchoring of the value of a life year to a predetermined VOL.

In effect, the area under the curve of value of a life year versus time must remain constant and equal to the chosen VOL. Thus, if the length along the horizontal axis (duration) is shortened, the length along the vertical axis (value of a life year) must lengthen proportionately. It is also salient to note that, while there may be an implied discount rate in the current £620K VOL, it is not known by the Department.
Figure 3: Illustration of the 'balancing out' of the discount rate on VOLY and duration of impairment as a result of the anchoring of the methodology to a predetermined VOL.

4.5 The monetary value of a 'serious' injury

In comparison to the current value of a serious injury used by DTp, the values which emerge from the RUL study are higher. This does not necessarily imply that the values emerging here are inappropriate, but may imply instead that the current values used are too low. The monetary values derived from RULA were presented to the expert consultants at the round-table meeting and were considered acceptable and in accord with the intuitive estimation from the consultants of what the value of the pain, grief and suffering associated with a serious road traffic injury ought to be. When presented with the value that the Department currently uses, the consultants considered it far too low. It was commented that the values emerging from the RUL approach were actually still too low to reflect the seriousness of states like N (quadriplegia/paraplegia) and L (severe brain damage) but too high for states like F, W, and possible X. If one value for this wide range of injuries is required, however, the emerging values were considered quite reasonable.

An explanation for the relatively high monetary values can be obtained by referring back to Tables 8-11 which show the relative contribution of each injury state, at different discount rates, to a serious non-fatal road traffic injury.
For each of the four scales (Torrance, Rosser, Rosser-revisited and EuroQol) the major contribution to the value of a serious injury is clearly due to the contribution of states R5 and S3. State R5 is defined as 'Experience continuing permanent pain/discomfort, possibly requiring frequent medication; substantial and permanent restrictions to work and leisure activities; possible some prominent scarring'. State S3 is defined as 'Experiencing some pain which gradually reduces, but may recur when taking part in some activities; some permanent restrictions to leisure and possibly work activities'. With the Torrance matrix, R5 comprises 42% and S3 41% of the total LYF associated with a serious injury. With the Rosser index R5 is 46% and S3 is 21% of the total LYF. For Rosser-revisited R5 is 41% and S3 45%. With the EuroQol matrix, R5 and S3 again dominate the total contribution to LYF for a serious injury, with R5 48% and S3 39% of the total LYF.

Both R5 and S3 have high relative utility loss scores and both involve permanent residual disability (39 years duration), the combination of which yields relatively high lost years of functioning scores. States R5 and S3 also have a relatively high incidence rate, therefore their combined impact on the LYF values for a serious non-fatal road traffic injury, weighted by incidence (Table 12) is a major determinant of the overall LYF score. As a result, the LYF scores for states R5 and S3 have the most significant impact on the overall monetary value of a serious injury.

Clearly, the final numbers depend heavily on the probabilities associated with different injury states and these may need to be revised when better data becomes available.

4.6 The Monetary Value of a 'Slight' Injury

A value for slight non-fatal injuries has been arrived at by the Newcastle-upon-Tyne/York universities team, using the CVM approach. A best value of £102 (mean) and £50 (median) was arrived at for an injury involving minor cuts and bruises and from which there would be a very quick and complete recovery. These are thought to constitute about 80 per cent of the slight injuries. However, there is in addition a further group of injuries involving whiplash which make up the remainder. Whiplash injuries are generally more serious and, in terms of utility loss, are thought to be between States W and X, but much closer to X. If it were assumed that whiplash injuries lay four-fifths of the way between W and X, the equivalent lost years of functioning would be approximately 0.5. The value of a slight injury, excluding the costs of lost output, medical and police services, would therefore be given by the following equation:

\[
\text{Value of slight injury} = 0.5 \times \text{VOLY} \times 0.2 + (\text{£102 or £50}) \times 0.8
\]

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6 This is computed using the data in Figure 1. The mean LYF values for states X and W are 0.6 and 0.1 according to Rosser-revisited, Torrance and EuroQol scales. 0.5 is four-fifths of the way between 0.1 and 0.6.
For slight injuries, VOLY is dependent on the discount rate. The values of the first term in the above equation are £1.59K (0% DR), £2.26K (2% DR), £3.04K (4% DR), £3.91K (6% DR), £4.83K (8% DR) and £5.78K (10% DR). To these values should be added either a further €80 or £40 depending on whether the mean or median valuation of minor cuts and bruises is applied. Whichever is chosen makes little difference to the answer.
5. CONCLUSIONS and RECOMMENDATIONS

5.1 Summary of Main Points

A striking accord emerges between the LYF scores for all eight injury states and therefore the monetary value for a serious injury derived using the EuroQol, Rosser-revisited and Torrance indices (Figure 2). The slightly higher scores which emerge from the Torrance index with permanent disability may be attributable to the fact that the utility values in this matrix are based on infants, whose longer life expectancy might lead to high utility loss scores in the case of permanent impairment.

The main divergence in LYF scores emerges from the Rosser utility loss index. It is suggested that this divergence might be attributable to the unbounded magnitude estimation methodology used by Rosser, which is distinct from that used by Rosser-revisited, EuroQol and Torrance.

Discount rate has a marginal effect upon states F, W and X, which have no long-term consequences. The value of a serious road traffic injury is calculated by weighting each of the LYF values for each Galasko state by its relative frequency of occurrence, and multiplying the sum by the value of a life year. For consistency, the same discount rate should be adopted in the calculation of the LYF values and the value of a life year. As a consequence the discount rate has very little effect upon the value of a serious injury. This is due to the fact that the dominant contributors to the value of a serious injury are the long-term impairments with a constant utility loss over remaining lifespan. The discounting of impairments with these dual characteristics exactly compensates for the increasing value of a life year as the discount rate is increased. This balancing out of the discount rate is also a consequence of the anchoring of the value of a life year to the predetermined VOL. In effect, the area under the curve value of a life year versus time must remain constant and equal to the chosen VOL.

The resultant values of a serious injury are £144-£148 (Rosser-revisited); £150-£154 (EuroQol); £170-£174 (Torrance); and £28-£29 (Rosser). Which of these values might ultimately influence the selection of a value of a serious injury is, in itself, a political question. The near convergence of the values does not, by itself, guarantee validity, although it is probably an important indicator of the mainstream of current thinking and research in this sector. The values are also not dissimilar from those arrived at by other researchers in the United States, and from some of the studies carried out by Professor Jones-Lee and colleagues in the UK.

In the case of the VAS, consultants rated each of the complete injury descriptors on a scale from 0 (worst imaginable injury) to 100 (no accident or injury). Such a scale allowed for the incorporation of states perceived as 'fates worse than death'. For the VAS, where duration was rated implicitly, the RUL of a serious injury need only be multiplied by the VOL. This results in a RUL value of 0.43 and a value of a serious injury of approximately £267,000. This value is somewhat higher than those emerging from the other indices which utilised a LYF approach.
Respondents indicated that their responses were 'multifaceted', allowing more freedom of judgment to be used, and enabling factors to be considered, such as the wider impacts to family and friends, which were not considered in the other scales.

5.2 Recommendations

States F, W and X are qualitatively and quantitatively different from the other injury states. LYF scores of these non-permanent injuries are significantly different from those of the permanent injuries, as depicted in Figure 2. Our results, buttressed by the comments of the experts at the round table meeting, indicate that the Department of Transport should seriously consider adding a 'moderate' category to their catalogue of injuries.

Going beyond our own results, this could help them in revaluing 'slight' injuries. If whiplash, described by State X in the present study, is considered a 'slight' injury, yet has a description identical to a number of 'serious injuries (described by State X), there is evidently a problem in the 'serious-slight' dichotomy. Our results indicate that States F, W and X, including whiplash, would constitute an appropriate 5 moderate' category. Their associated LYFs are approximately an order of magnitude below the LYF estimates for States S, V, R, L and N. 'Slight' injuries then, primarily comprised of scratches and bruises, could appropriately be valued by their direct costs alone, given that their long term impact and therefore their RUL value, would be insignificant.

Regardless of which approach is taken, it would be important to examine States R5 and S3 very closely, as they represent the largest contribution to the value of a serious injury. It may be appropriate to break these states down. For example, perhaps very few 'R-type' injuries have 'some prominent scarring'. If that component of the description is having a large impact on the RUL scores given, the majority of R-type injuries will be over-valued.

A focus group survey, as recommended in the Stage 1 report (Ives and Kemp, 1991) would help improve the reliability of, and confidence in, the estimates provided by this preliminary survey of expert opinion. As mentioned before, RULA is a novel approach to the valuation of non-fatal injuries and a wider-scale focus group survey would thus enable the Department to examine further the strengths and weaknesses of the methodology, and to subsequently place more faith in the monetary values of injury which emerge.

5.3 Conclusions

The results of the RULA study for valuing injuries from road traffic accidents is very encouraging. Expert consultants who undertook the mapping task, found the exercise manageable although admittedly difficult. The RUL values emerging from four of the five approaches were strikingly similar and similar also to the RUL values obtained by other researchers for similar injuries. The monetary values, although significantly higher than DTp's
current value for a serious injury, are not unreasonable given the duration and severity of the sorts of injuries being considered. Finally, our results provide a clear indication of the way ahead - a 'moderate' category can be ascertained from the data (Figure 2), and a monetary value could easily be ascertained for that category.

Finally, the prevention of serious injuries from road traffic accidents is an important factor in decisions about road developments. It should receive an appropriate value in the COBA model, relative to the values of other costs and benefits being considered, to reflect its importance to the population.
REFERENCES


POSTSCRIPT

1. Injury distribution
Since this Report was written, Professor Charles Galasko’s research team has revised its estimates of the proportionate breakdown of injuries within the Police reported ‘serious’ injury category in the light of new data. The updated annual risks for the various injury subcategories are shown below, with those used in the main study analysis shown in brackets:

<table>
<thead>
<tr>
<th></th>
<th>19 in 100,000</th>
<th>(8 in 100,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>15 in 100,000</td>
<td>(16 in 100,000)</td>
</tr>
<tr>
<td>W</td>
<td>31.5 in 100,000</td>
<td>(30 in 100,000)</td>
</tr>
<tr>
<td>X</td>
<td>6 in 100,000</td>
<td>(4 in 100,000)</td>
</tr>
<tr>
<td>V</td>
<td>13 in 100,000</td>
<td>(24 in 100,000)</td>
</tr>
<tr>
<td>S</td>
<td>14 in 100,000</td>
<td>(16 in 100,000)</td>
</tr>
<tr>
<td>R</td>
<td>1.5 in 100,000</td>
<td>(2 in 100,000)</td>
</tr>
<tr>
<td>Overall annual risk</td>
<td>100 in 100,000</td>
<td>(100 in 100,000)</td>
</tr>
</tbody>
</table>

The main difference in the two distributions is in injury states F and S. Injury state F is typically regarded as the least severe injury state and its relative frequency of occurrence has been doubled. The proportion of serious injuries in injury state S, i.e. some permanent disability, has fallen from 24 in 100 to 13 in 100. It was noted in the report that injuries R and S had contributed a high proportion of the costs due to their element of permanent injury and their relative frequency of occurrence.

2. Lost output
In addition, to the revised injury distribution it has been possible to refine the value of lost output resulting from road traffic casualties (O’Reilly, 1992). The revised value of lost output results in a minor change in the implied pure willingness to pay element of the value of a fatality currently used by the Department of Transport. The latest value of net lost output is £46,828, assuming a 2% growth rate and a 6% discount rate (O’Reilly, 1993). The resulting pure WTP element of the value of a fatality is £617,672. This is a refinement of the rounded figure of £620,000 given to the authors of the report in the absence of better data.

WTP element of current 1990 value of a fatality:
- Total Fatal £664,935
- medical & ambulance £435
- TRL latest lost output £46,828
- total resource cost £47,263
- pure WTP cost(Mk) £617,672

3. Updated calculations
3.1 Serious
The values below are the updated values corresponding to those in Table 13, on page 29, of this report, summarising the minimum and maximum monetary values
derived from the health indices in 1990 prices. Obviously tables 8-12 will also have been affected as these are based on the relative frequency of occurrence of each injury type, they have been amended accordingly and are available from UEA.

<table>
<thead>
<tr>
<th>Value of life (VOL) £'000s</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>617</td>
<td>617</td>
<td>617</td>
<td>617</td>
<td>617</td>
<td>617</td>
</tr>
<tr>
<td>Value of a life year (VOLY) £'000s</td>
<td>15.8</td>
<td>22.5</td>
<td>30.3</td>
<td>38.9</td>
<td>48.1</td>
<td>57.6</td>
</tr>
<tr>
<td>Value of serious injury (VOSI) £'000s</td>
<td>110-114</td>
<td>111-128</td>
<td>115-131</td>
<td>131-135</td>
<td>135-151</td>
<td>132-148</td>
</tr>
<tr>
<td>-Rosser-revisited</td>
<td>22</td>
<td>22-24</td>
<td>23-25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Rosser</td>
<td>116-121</td>
<td>118-134</td>
<td>122-139</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The calculation of the Visual Analogue Scale scores must also be updated according to the new data. Thus the calculation on page 23 of the report should now read;

\[
F \times W \times X \times S \times V \times R \times N + L = RUL (0.17 \times 0.19) + (0.21 \times 0.15) + (0.34 \times 0.315) + (0.51 \times 0.13) + (0.40 \times 0.06) + (0.69 \times 0.14) + (0.90 \times 0.015) = 0.37
\]

and, \(0.37 \times £617,672 = £228,539\)

3.2 Slight
The values below are updated revisions of values produced in section 4.6 of this report, pages 41-42. Where the value of a slight injury is

\[= 0.5 \times \text{VOLY} \times 0.2 + (102 \text{ or } 50) \times 0.8\]

To be consistent with the willingness to pay method use £102 in the above formula to give a value of £81.60. Add £81.60 to each of the following values of a life year:

- £1,583 at 0% discount rate + £81.60 = £1,665
- £2,251 at 2% " + £81.60 = £2,333
- £3,032 at 4% " + £81.60 = £3,114
- £3,897 at 6% " + £81.60 = £3,979
- £4,814 at 8% " + £81.60 = £4,896
- £5,756 at 10% " + £81.60 = £5,838

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