HSE

Health and Safety Executive

Valuation of health and safety benefits

Dread risks

Prepared by the **University of Newcastle upon Tyne, University of East Anglia, Durham University, University of London** and **NERA Economic Consulting** for the Health and Safety Executive 2007

RR541
Research Report

First published 2007

Health and Safety Executive

Valuation of health and safety benefits

Dread risks

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It is by now well-known that people typically fear the prospect of premature death by some causes considerably more than others – see for example Slovic, Fischoff and Lichtenstein, 1981; Thomas, 1981; Mendeloff and Kaplan, 1990; McDaniels, Kamlet and Fischer, 1992; Savage, 1993; Tolley, Kenkel and Fabian, 1995; Jones-Lee and Loomes, 1995 and Sunstein 1997.

In the light of this, the UK Health and Safety Executive (HSE) commissioned a research programme comprising three separate studies.

In the first study, by the University of Newcastle upon Tyne, the focus was principally on causes that typically result in instant (or near-instant) death, such as road or rail accidents. In addition, individual attitudes were viewed primarily from the perspective of people's 'self-focused' preferences concerning personal safety.

By contrast, the second study, carried out by a team drawn from the University of East Anglia, Durham and Queen Mary, London, considered – amongst other issues – causes of death typically preceded by protracted periods of pain and discomfort, such as lung or breast cancer. In addition, the second study sought to investigate the public's attitudes to factors such as the victim's age and the question of blame or responsibility for the cause of death concerned. As a result, the focus was directed more towards people's preferences in their role as citizens, expressing their views and attitudes with respect to general principles of social decision-making concerning life-saving interventions.

Finally, the third study - carried out by Michael Spackman of National Economic Research Associates (NERA) – was aimed at summarising and evaluating the extensive body of work undertaken to date by sociologists, psychologists, philosophers and economists on the important but arguably somewhat elusive and nebulous concept of 'Societal Concerns', to which extensive reference is made by various regulatory agencies including the HSE itself.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

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Prima facie there would appear to be three primary candidates as a means of processing these data.

Approach 1 As in our earlier analysis of the matching data from the HSE/DETR/Home Office/HM Treasury study – See Chilton et al (2002) and our initial analysis in the Dread Risk Study, take the valuation ratio V^A/ V_B to be the ratio of the mean of R^A to the mean of R^B (or equivalently, the ratio of the sum of R^A scores to the sum of R^B scores).

Approach 2 Take the valuation ratio V^A/V^B to be the mean of the individual R^A/ R^B ratios.

In either of these two cases it would then seem appropriate to measure the pure "dread" effect by dividing the contextual V^A/V^B ratio by the contextless V^A/V^B ratio.

Approach 3 Under the third approach one would derive individual V^A/V^B ratios from individual R^A/R^B ratios and then compute individual contextual vs contextless ratios by dividing the individual contextual V^A/V^B ratio by the individual contextless V^A/V^B ratio and finally taking the arithmetic mean of individual contextual vs contextless ratios as the measure of the pure "dread" effect[5].

Applying each of these three approaches to the analysis of the hypothetical data for our four-person society then yields the following results:

Approach 1

Contextless $\frac{V_A}{V_B} = \frac{4.05}{4.05} = 1$

Contextual $\frac{V_A}{V_B} = 3\frac{3.025}{4.1} = 0.7379$

$\frac{\text{Contextual}}{\text{Contextless}} = \frac{0.7379}{1} = 0.7379$

Approach 2

Contextless $\frac{V_A}{V_B} = 13.675$

Contextual $\frac{V_A}{V_B} = 6.8375$

$\frac{\text{Contextual}}{\text{Contextless}} = \frac{6.8375}{13.675} = 0.5$

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[5] In fact, in a recent journal article – see Chilton et al (2006) – we focused principally on a variant of Approach 3, with overall dread effects estimated on the basis of the *geometric* (rather than the arithmetic) mean of individual contextual vs contextless ratios. We proceeded in this way a) because it transpired that the resultant estimated dread effects did not differ dramatically from those estimated under, say, Approach 1 and b) in the interests of brevity and simplicity of exposition.

then the results are:

Approach 1

Contextless $\frac{V_B}{V_A} = 1.00$

Contextual $\frac{V_B}{V_A} = 1.3554$

$\frac{\text{contextual}}{\text{contextless}} = 1.3554$

Approach 2

Contextless $\frac{V_B}{V_A} = 13.675$

Contextual $\frac{V_B}{V_A} = 27.35$

$\frac{\text{contextual}}{\text{contextless}} = \frac{27.35}{13.65} = 2.00$

Approach 3

Individual	contextual V_B / V_A ÷ contextless V_B / V_A		
1	2 ÷ 1	=	2.00
2	2 ÷ 1	=	2.00
3	0.05 ÷ 0.025	=	2.00
4	0.05 ÷ 0.025	=	2.00
5	80 ÷ 40	=	2.00
6	80 ÷ 40	=	2.00

$\frac{\text{contextual}}{\text{contextless}} = 1.975$

Hugh/Graham Approach
Subsample 1

Contextless $\frac{V_B}{V_A} = \frac{0.05}{2} = 0.025$

Contextual $\frac{V_B}{V_A} = \frac{0.1}{2} = 0.05$

$\frac{\text{contextual}}{\text{contextless}} = \frac{0.05}{0.025} = 2.00$

Subsample 2

Individual	contextual V_B / V_A ÷ contextless V_B / V_A
1	2 ÷ 1 = 2
2	2 ÷ 1 = 2
3	80 ÷ 40 = 2
4	80 ÷ 40 = 2

$$\frac{\text{contextual}}{\text{contextless}} = 2.00$$

Mean of two separate subsamples

$$\text{mean}\left(\frac{\text{contextual}}{\text{contextless}}\right) = 2.00$$

As far as the first of the two *desiderata* of the data analysis (that the overall $\frac{V_A}{V_B}$ ratio for the contextless hypothetical data set should be close to unity) is concerned it is plain that only Approach 1 comes anywhere near the mark. In particular, under Approach 2 the overall contextless $\frac{V_A}{V_B}$ ratio is 13.675 while the overall contextless $\frac{V_B}{V_A}$ ratio is 13.675, results which taken both separately and together are simply absurd. In turn, Approaches 3 and the Hugh/Graham Approach do not yield a

stand-alone contextless $\frac{V_A}{V_B}$ or $\frac{V_B}{V_A}$ ratio.

However, when we turn to the second of our two desirable features of the data analysis (namely that the pure "dread" effect for our hypothetical data set should be substantial) the picture is rather different. In this case Approach 1 produces a pure dread effect (contextual ÷ contextless) for the ratio $\frac{V_A}{V_B}$ of 0.7379 and for the ratio $\frac{V_B}{V_A}$ of 1.3554 both of which indicate a marked dread effect for context B. In turn, Approaches 2, 3 and the Hugh/Graham approach all produce a dread effect for the ratio $\frac{V_A}{V_B}$ of 0.5 and for the ratio $\frac{V_B}{V_A}$ of 2 which again indicate a marked dread effect for context B relative to context A.

or $2xyzX+2xyzY+2xyzZ>>x^2zY+x^2yZ+y^2zX+xy^2Z+yz^2X+xy^2Y$ $yzx(2x-y-z)+xzY(2y-x-z)+xyZ(2z-x-y)>>0$

A sufficient condition for this strong inequality to hold would be:

$X>>Y,Z,1$
and $x>y,z$ but $x \approx y \approx \delta$

Or (even more so):

$X>>Y>>Z,1$
and $x>y>z$ but $x \approx y$ and $y>>z$

Finally, consider Approach 1 and suppose that the basic contextless and contextual indices R^A and R^B = (all $\leq$ 1) are as follows:

Contextless Indices

Individual	R^A	R^B
1	a	d
2	b	e
3	c	f

Contextual Indices

Individual	R^A	R^B
1	A	D
2	B	E
3	C	F

Approach 1

Compute $\dfrac{\frac{A+B+C}{D+E+F}}{\frac{a+b+c}{d+e+f}}$ as "dread" effect

For this approach to produce a very large "dread" effect we would need

$$\frac{(A+B+C)(d+e+f)}{(a+b+c)(D+E+F)} >> 1$$

or $(A+B+C)(d+e+f)>> (a+b+c)(D+E+F)$

Under these circumstances, it would appear that *no* small subset of respondents could produce a very large "dread" effect by doing a major "turn around" when context is introduced and that such an effect would require that a substantial *majority* of respondents should do this.

In view of the possibility of "freak" results concerning "dread" effects, especially under Approaches 2 and 3 and the Hugh/Graham approach, it was decided to analyse our data using *all four* approaches.

In reporting the findings of the study we employ the following abbreviations:

fpp - fire in a public place
aih - accident in the home
cdriver - car driver/passenger accident
ped - pedestrian accident
train - train accident
dfire - domestic fire
hpp - hazardous production plant accident
drown - drowning

In answering the contextless risk – risk questions it turned out that 53 respondents employed some variant of the absolute risk equalization heuristic, 13 some variant of the incremental risk-ratio equalization heuristic and only 5 the expected utility heuristic. It is reassuring that the qualitative follow-up study (see below, Section 4) confirmed the main study interviewers' impression that the vast majority of participants employed the same heuristic in answering the contextual risk-risk questions as they had employed in answering the contextless questions.

Mean "dread" effects relative to murder were computed under each of Approaches 1, 2 and 3 and the Hugh/Graham (H/G) Approach. These effects were then normalised with respect to the dread effect for pedestrian accident relative to murder, as *prima facie*, pedestrian accident appeared to be the least dreaded context. The results are reported in Table 1, the first column of which shows the mean ranking of the contexts from 1 (least dreaded) to 5 (most dreaded). As a result of the normalization, murder does not appear in Table 1. However, focusing on the original "dread" effects relative to murder computed under Approach 1 (which, it will be recalled, is arguably the least susceptible to distortion by aberrant responses) it transpires that *none* of the other contexts has a "dread" effect greater that 1, indicating that at least under that approach murder is the most dreaded of all of the contexts considered in the study.

Table 1 : Mean “Dread” Effects Relative to Pedestrian Accidents

	Ranking	**Approach 1**	**Approach 2**	**Approach 2 (Trim 1 extreme outlier)**	**Approach 3**	**Approach 3 (Trim top and bottom 2)**	**Approach 3 (Trim top and bottom 4)**	**Approach 3 (Trim top and bottom 6)**	**H/G Approach**	**H/G Approach (Trim top and bottom 2)**
Set S										
ped	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
aih	1.00	1.00	33.07	33.07	12.14	12.20	1.69	1.45	5.46	1.00
cdriver	1.22	1.58	1.06	1.06	0.47	2.86	1.57	1.38	0.87	6.16
train	1.33	3.54	2.76	2.76	18.25	18.77	5.18	3.92	0.52	6.70
fpp	2.32	2.79	3.22	3.22	55.21	35.97	17.63	9.82	0.49	6.94
Set B										
ped	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
cdriver	1.10	1.06	2035.78	1.03	15.18	4.00	3.19	0.97	2.75	5.79
hpp	1.39	1.56	2.40	2.40	0.38	0.34	1.00	1.54	0.74	0.71
drown	1.53	1.54	3.49	3.49	2.44	1.99	2.88	2.93	0.09	0.45
dfire	2.00	1.29	1.78	1.78	0.55	0.86	1.31	1.41	0.68	1.54

group work but respondents were encouraged to make additional comments if they chose to.

Interviews were tape recorded and transcribed verbatim[8]. The transcripts were then imported into NVivo qualitative analysis software {QSR 2000 934 /id}. This software allows indexing, searching and retrieval of data for qualitative analysis.
Basic thematic analysis involved the systematic coding of all transcripts, using an evolving coding frame. (This means that as new themes emerged the coding frame was altered to incorporate them.) Themes are described and illustrated with verbatim quotation from the interviews.

Because of the small qualitative sample there is no attempt at statistical generalisation and so quantification is generally unhelpful; this is the role of the main quantitative study. The aim here is to examine, in-depth, the responses given in a small group of participants, in order to gain insight into the meaning of quantitative findings. However, where themes were common to many or all respondents, this is indicated.

Interviews

Interviews were conducted following the qualitative group sessions. During the individual interviews, reference was made to the group session, and to individuals' own responses. The interviews were organised in three main sections:

Firstly, following a brief reminder of three possible strategies (absolute risk equalisation, incremental risk ratio equalisation and expected utility maximisation), respondents were asked if each strategy in turn "made sense" to them, and whether they understood why some respondents might answer in each way (even if they had not followed the strategy themselves). They were then asked to comment, similarly, on the consideration of total risk in responses.

In the next section the interviewer referred directly to the exercises respondents had completed and asked about their own responses to the questions, for each of the contextless and contextual questions. Respondents were asked to explain the strategy they had adopted and how they arrived at their "switchover" point.

Contextless questions were then compared with responses to contextual questions and respondents were again asked to consider their strategies and switchover points and explain any changes either to strategy or switchover point as a result of the introduction of context. Finally, the ease of the task for both question types was discussed.

Findings

Following some brief introductory comments, the qualitative findings are presented in four main sections. Firstly, respondents' views of three possible strategies for answering the questions are described, in particular whether or not they can appreciate the rationale behind each strategy regardless of whether they themselves had adopted

[8] In one case the tape was faulty and the findings of this interview were recorded by the interviewer in brief field notes

In the light of all this, we feel reasonably confident that the study has correctly identified murder, train accidents, fires in public places and drowning as being clear dread risks in the eyes of the public, with hazardous production plants, domestic fires, car driver/passenger accidents and accidents in the home of more doubtful status and pedestrian accidents having no dread effect as such, or at least only a very minor effect in relation to the other contexts considered in the study.

6 *Policy Implications of the Newcastle Study Findings*

It will be recalled that in the pre-Ladbroke Grove study (commissioned jointly by the HSE, DETR, Home Office and HM Treasury) it was found that the value of preventing a statistical fatality (VPF) for each of rail accidents, fires in public places and domestic fires stood at a discount in relation to the roads VPF – see Chilton et al (2002). In turn, in the post-Ladbroke Grove study (commissioned by the HSE) only the rail VPF had risen to effective equality with the roads figure. These findings are also reported in Chilton et al (2002). In particular, denoting the roads VPF by VPF_{RD}, the rail figure by VPF_{RL}, the fires in public places figure by VPF_{PF} and the domestic fires figure by VPF_{DF}, the relative valuations were as follows:

Table 2: Relative Valuations

	Pre-Ladbroke Grove	Post-Ladbroke Grove
VPF_{RL}/VPF_{RD}	0.834	1.003
VPF_{PF}/VPF_{RD}	0.923	0.960
VPF_{DF}/VPF_{RD}	0.926	0.890

Given that the present study has clearly identified rail accidents and fires in public places as dread risks, at first glance it may seem puzzling that in the pre-Ladbroke Grove study both VPFs stand at a discount in relation to roads, while in the post-Ladbroke Grove study only rail has risen to effective equality with roads. However, in the focus group discussions in both the pre and post-Ladbroke Grove studies it became clear that in addition to considerations of dread *per se* many respondents were also influenced by the baseline level of risk in each of the contexts concerned and, to the extent that in the case of rail and fires in public places the baseline level of risk is substantially lower than for road accidents and in the case of domestic fires less than one third of the roads figure,, it seems clear that the baseline risk effect is to all intents and purposes cancelling out the dread effect.

With this in mind it was decided to regress the absolute VPFs implied by the relative valuations given in Table 2-together with the current absolute roads figure of £1.25 x 10^6 -on mean dread effects derived under Approach 1 and reported in Table 1, as well as mean baseline levels of risk which were as follows (though of course hazardous production plant, pedestrian, murder, drowning and accident in the home were not included in the regression analysis as we do not have VPF estimates for these contexts).

Finally, it is clear from both the original and predicted VPFs that the media attention and political reaction that followed the Ladbroke Grove accident did have a marked effect on the public's degree of dread concerning rail accidents. This suggests that it should be possible to drive the degree of dread associated with a given context in a *downward*, rather than upward, direction by appropriate emphasis on steps that have been taken to improve safety in the context concerned, as well as a more circumspect and balanced media treatment. One possible way of testing this hypothesis would be to conduct a focus-group study in which the sample was split into three subsamples, the first of which would be provided with more negative information concerning risk in a given context, the second with "neutral" information and the third with more positive information. If our hypothesis is correct then willingness –to-pay based values of safety should decline significantly as one moves from the first through to the second to the third subsample. This would appear to be a potentially fruitful subject for future research.

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Appendix B: Regression Results with Dread Effects Estimated Using Approach 3 with Top and Bottom Six Outliers Trimmed Out.

Again, using the specification $VPF_i = \alpha \ \beta_i + \beta D_i + u_i$ the regression results were as follows:

Regression Results

	Pre-Ladbroke Grove		Post-Ladbroke Grove	
	coefficient	P value	coefficient	P value
B_i	4.66×10^{10}	0.044	4.63×10^{10}	0.052
D_i	3,365	0.085	3,612	0.083
	Adjusted R^2 = 0.8264		Adjusted R^2 = 0.8124	

In turn, the predicted VPF were as follows:

Predicted VPFs

	Pre-Ladbroke Grove	Post-Ladbroke Grove
VPF_{RDS}	£1,3788 x 10^6	£1.3759 x 10^6
VPF_{RDB}	£1.3452 x 10^6	£1.3398 x 10^6
VPF_{RL}	£0.5319 x 10^6	£0.5687 x 10^6
VPF_{PF}	£1.3638 x 10^6	£1.4620 x 10^6
VPF_{DF}	£0.4064 x 10^6	£0.4066 x 10^6

And finally, the contribution of baseline risk and dread effects to predicted VPFs were as follows:

Contribution of Baseline Risk and Dread Effects to Predicted VPFs

	Pre-Ladbroke Grove		Post-Ladbroke Grove	
	Baseline Risk	**Dread**	**Baseline Risk**	**Dread**
VPF_{RDS}	£1,304,800 (95%)	£74,026 (5%)	£1,296,400 (94%)	£79,522 (6%)
VPF_{RDB}	£1,304,800 (97%)	£40,378 (3%)	£1,296,400 (97%)	£43,447 (3%)
VPF_{RL}	£37,280 (7%)	£494,69 (93%)	£37,040 (7%)	£531,644 (93%)
VPF_{PF}	£27,960 (2%)	£1,335,836 (98%)	£27,780 (2%)	£1,434,212 (98%)
VPF_{DF}	£372,800 (92%)	£33,648 (8%)	£370,400 (91%)	£36,186 (9%)

● It is often the case that different health or safety programmes are more likely to benefit some age groups more than others. If that were the case, how might choose between spending money on such programmes.

● DISPLAY OVERHEAD 7, UNCOVER 1ST PAIR.

● For the purposes of this exercise please assume that all programmes are deliverable and cost the same.

• Please imagine that for whatever reason safety expenditure was to be increased. So there would be more money to spend on safety programmes. Out of these fist two [INDICATE] which would YOU prefer to see carried out? Please assume, quite realistically, that the money could only be spent on one or the other in order for either to be successful. Please tick the box under the first one if you would prefer that one or the second one if you would prefer that. If you cannot decide and thus would be happy for someone else such as myself to choose then tick the middle box (note that this does not mean they both get implemented, just that you don't mind which one).

• ***ASSISTANT:* HAND OUT SHEET 4**

● OPEN DISCUSSION - HOW/WHAT THEY CHOSE.

Please do the same for questions 2 & 3. OPEN DISCUSSION AS BEFORE

MURDER/FIRE IN A PUBLIC PLACE

• Imagine first that expenditure would be cut back in one of these two areas, murder or fire in a public place.

● DISPLAY OH 11

• ***ASSISTANT:*** **HANDOUT SHEET 6(i)**

● As before, imagine the reduction in expenditure would have the effect of increasing your risk of dying in one of these accidents, but that you could choose which one.

• Before you do this please refer to Sheet 1. Fill in your risk for each of the accidents on the two lines in the boxes i.e. if you have ticked "much lower than average" write "much lower" [INDICATE] and underneath [BY THE QUESTION MARK – INDICATE] write some number that sums up for you what that means, just like in the earlier questions of this type. The sentence you have written on Sheet 1 is meant to remind you of your feelings about the risk.

● Would you choose to increase your risk by 10 in 50 million of dying in a murder incident or in a fire in a public place?

• Please circle the one you would choose. If you do not mind and are happy for the government to choose, put an equal sign between them

● ***ASSISTANT:*** **HAND OUT RISK-RISK TRADE OFF SHEET 6(ii) (DO NOT HAND OUT A SHEET TO ANYONE INDICATING EQUALITY)**

● Please complete the table in the same way as you did in the previous exercises when you compared two accidents. So if you preferred to increase the risk of dying in a murder incident by 10 in 50 million write I in the first sentence and column as well as your personal risk and the information for fire in a public place in the second column. Then write I in the first row. Then compare the two risk increases and indicate when, if at all, you would switch to fire in a public place (J). Likewise, if you chose to increase the risk of dying in a fire in a public place by 10 in 50 million write J in the first sentence and column as well as your personal risk and the information for murder in the second column. Then write J in the first row. Then compare the two risk increases and indicate when, if at all, you would switch to murder (I).

● DISPLAY OVERHEAD 12. QUICK RECAP ON HOW TO FILL IN IF NECESSARY.

MURDER/ACCIDENT - HOME

• This time please compare murder with an accident in the home.

● DISPLAY OH 12

• ***ASSISTANT:*** **HANDOUT SHEET 7(i)**

● As before, imagine the reduction in expenditure would have the effect of increasing <u>your</u> risk of dying in one of these accidents, but that you could choose which one.

• Before you do this please refer to Sheet 1. Fill in your risk for each of the accidents on the two lines in the boxes i.e. if you have ticked “much lower than average” write “much lower” [INDICATE] and underneath [BY THE QUESTION MARK – INDICATE] write some number that sums up for you what that means, just like in the earlier questions of this type. The sentence you have written on Sheet 1 is meant to remind you of your feelings about the risk.

● Would you choose to increase your risk by 10 in 50 million of dying in a murder incident or in an accident in the home?

• Please circle the one you would choose. If you do not mind and are happy for the government to choose, put an equal sign between them

● ***ASSISTANT:*** **HAND OUT RISK-RISK TRADE OFF SHEET 7(ii) (DO NOT HAND OUT A SHEET TO ANYONE INDICATING EQUALITY)**

● Please complete the table in the same way as you did in the previous exercises when you compared two accidents.

MURDER/CAR DRIVER/PASSENGER

• This time please compare murder with a car driver/passenger road accident.

● DISPLAY OH 13

• ***ASSISTANT:*** **HANDOUT SHEET 8(i)**

● As before, imagine the reduction in expenditure would have the effect of increasing <u>your</u> risk of dying in one of these accidents, but that you could choose which one.

• Before you do this please refer to Sheet 1. Fill in your risk for each of the accidents on the two lines in the boxes i.e. if you have ticked “much lower than average” write “much lower” [INDICATE] and underneath [BY THE QUESTION MARK – INDICATE] write some number that sums up for you what that means, just like in the earlier questions of this type. The sentence you have written on Sheet 1 is meant to remind you of your feelings about the accident.

● Would you choose to increase your risk by 10 in 50 million of dying in a murder incident or as a car driver/passenger in a road accident?

• Please circle the one you would choose. If you do not mind and are happy for the government to choose, put an equal sign between them

● ***ASSISTANT:*** **HAND OUT RISK-RISK TRADE OFF SHEET 8(ii) (DO NOT HAND OUT A SHEET TO ANYONE INDICATING EQUALITY)**

● Please complete the table in the same way as you did in the previous exercises when you compared two accidents.

MURDER/PEDESTRIAN

• This time please compare murder with a pedestrian in a road accident.

● DISPLAY OH 14

• ***ASSISTANT:*** **HANDOUT SHEET 9(i)**

● As before, imagine the reduction in expenditure would have the effect of increasing <u>your</u> risk of dying in one of these accidents, but that you could choose which one.

• Before you do this please refer to Sheet 1. Fill in your risk for each of the accidents on the two lines in the boxes i.e. if you have ticked “much lower than average” write “much lower” [INDICATE] and underneath [BY THE QUESTION MARK – INDICATE] write some number that sums up for you what that means, just like in the earlier questions of this type. The sentence you have written on Sheet 1 is meant to remind you of your feelings about the accident.

● Would you choose to increase your risk by 10 in 50 million of dying in a murder incident or as a pedestrain in a road accident?

• Please circle the one you would choose. If you do not mind and are happy for the government to choose, put an equal sign between them

● ***ASSISTANT:*** **HAND OUT RISK-RISK TRADE OFF SHEET 9(ii) (DO NOT HAND OUT A SHEET TO ANYONE INDICATING EQUALITY)**

● Please complete the table in the same way as you did in the previous exercises when you compared two accidents.

Who is most to blame	Nobody in particular	The individuals themselves

The interventions cost the same amount of money

Which is better?	A	B
	☐	☐

However, further piloting showed that an uncomfortably large minority of respondents were liable to be confused by this framing. The expectation had been that people would identify the scenario they regarded as worse and nominate the intervention which would prevent that scenario as the better intervention. Unfortunately, too many respondents simply considered which scenario was less unpleasant and selected that. So respondents who thought the 10 deaths described in B above did not constitute as bad a prospect as the 15 described in A were too often liable to put a tick in box B to indicate that the *scenario* was better, rather than putting a tick in A to signify that the *intervention to prevent that scenario* should receive greater priority.

It was therefore decided to ask the questions in the form that people found easier to answer: that is, to describe two scenarios and ask them to say which of the two they considered to be worse, and *how much worse* they considered it to be.

Thus the two scenarios shown above would have appeared in the final format as follows:

Which is worse?

	A	**B**
Number of people who die	15 deaths	10 deaths
Age-group	Under 17 year olds	17-40 year olds
Quality of life in period leading up to death	A lot worse than normal for last 3-5 years of their lives	A bit worse than normal for last 1-2 years of their lives
Who is most to blame	Nobody in particular	The individuals themselves

What do YOU think? (tick one)	A is <u>much</u> worse than B	A is <u>slightly</u> worse than B	B is <u>slightly</u> worse than A	B is <u>much</u> worse than A
	☐	☐	☐	☐

	vs 10 rail passengers	vs 10 rail passengers	vs 10 rail passengers
Q25	50 smoking cancer vs 25 asbestos cancer	25 CO poisoning vs 15 accidents at work	15 smoking cancer vs 10 asbestos cancer
Q26	25 car drivers vs 15 pedestrians	10 accidents at work vs 15 car drivers	25 accidents at work vs 50 car drivers
Q27	15 pedestrians vs 25 breast cancer	25 pedestrians vs 15 breast cancer	15 CO poisoning vs 25 accidents at work
Q28	10 work-related cancer vs 15 car drivers	25 work-related cancer vs 50 car drivers	15 car drivers vs 25 pedestrians

The rationale behind the various elements of this part of the design was as follows.

A comparison of responses to Q24 across the three Versions was intended to see to what extent there was a weighting in favour of preventing a rail passenger fatality over a car driver fatality: while we might not be surprised to find a majority favouring rail in Version 1, where the number of deaths was the same, would this persist in Version 2 where there were 50% more car driver deaths? And if so, was the premium such that rail passenger deaths would receive priority even against two-and-a-half times as many car driver deaths, as in Version 3?

In fact, it became apparent that the 'blame' attribute was doing a great deal of work in these questions, so part way through the study we added an extra question – referred to in the analysis below as Q29 – which was the same as Q24 except that car drivers were replaced by car passengers, and those mostly to blame became 'other individuals' rather than 'the individuals themselves'.

Questions 25-28 inclusive can be thought of as falling into one of two categories. In some cases, evidence from piloting suggested which way a weighting would go, and the objective was to get some indication of the strength of that weighting. For example, we knew from piloting that deaths from asbestos-related cancer would be given more weight than deaths from lung cancer attributed to the individuals themselves being smokers. So the numbers in the Questions 25 in both Versions 1 and 3 were both pointed in the same direction, in one case in the ratio 1.5:1 and in the other case in the ratio 2:1; likewise for work-related cancers vs car drivers (Questions 28 in Versions 1 and 2) and for accidents at work vs car drivers (Q26 in Versions 2 and 3). However, for pedestrians vs breast cancer (Q27 in Versions 1 and 2), CO poisoning vs accidents at work (Q25 in V2 and Q27 in V3) and pedestrians vs car drivers (Q26 in V1 and Q28 in V3) the numbers were counterbalanced in each direction because we had no strong priors[10].

[10] It might be thought that pedestrians would receive more weight than drivers. That was our intuition; but the Newcastle data suggested that dying as a pedestrian was weighted lower than dying as a driver, so we thought we should not prejudge the direction in this case.

	A	B
Number of people who die	10 deaths	10 deaths
Age-group	17-40 year olds	17-40 year olds
Quality of life in period leading up to death	A bit worse than normal for last few minutes of their lives	A lot worse than normal for last few minutes of their lives
Who is most to blame	The individuals themselves	Business or government

Because it seemed possible that respondents' judgments might evolve somewhat as they worked through the questions, the first question they were presented with after the five practice questions was later repeated as Q21. The question as it appeared in Version 1 was as follows (Versions 2 and 3 were the same, except that the numbers of deaths in A was 15 in Version 2 and 25 in Version 3):

The three Tables below show the patterns of choice in each Version of the questionnaire. In all cases A>>B indicates the response 'A is much worse than B', while A>B denotes 'A is slightly worse than B'; A<B and A<<B are the corresponding statements in the opposite direction.

The three Tables tell somewhat different stories. In Version 1 (Table 2), the split between A and B is fairly stable – 15:86 in Q6, 14:87 in Q21 – but those identifying B as worse become less extreme in their view: 61 regarded B as much worse in Q6, but this number falls to 49 in Q21.

Table 2
Repeated Question in Version 1 (10:10)

	Q6				
Q21	A>>B	A>B	A<B	A<<B	Total
A>>B	1	2	1	1	5
A>B	2	4	2	1	9
A<B	2	2	13	21	38
A<<B	1	1	9	38	49
Total	6	9	25	61	101

In Version 2 (Table 3), the A:B split changed from 30:78 to 18:90, a difference which is just significant at the 5% level.

Table 3
Repeated Question in Version 2 (15:10)

	Q6				
Q21	A>>B	A>B	A<B	A<<B	Total
A>>B	2	2			4
A>B	4	3	5	2	14

As above, standard utility theory entails that respondents ought to be multiplying the disutility of a particular type of death by the number of those deaths. Standard DCE estimation procedures, however, rely on taking *absolute differences* of attribute levels. We therefore estimated a model that was multiplicative in the number of deaths as follows:

$$P(B) = f\{(N^{\alpha}_{B}-N^{\alpha}_{A}) + \gamma_a(N^{\alpha}_{B}*age_B-N^{\alpha}_{A}*age_A) + \gamma_s(N^{\alpha}_{B}*severity_B-N^{\alpha}_{A}*severity_A) + \gamma_d(N^{\alpha}_{B}*duration_B-N^{\alpha}_{A}*duration_A) + \gamma_b(N^{\alpha}_{B}*blame_B-N^{\alpha}_{A}*blame_A) + e\}$$

where P(B) is the probability that a respondent will consider scenario B to be worse than A, N^{α}_{A} and N^{α}_{B} are the number of deaths in scenarios A & B respectively raised to power α, and γ_i is the coefficient on the i^{th} attribute. When α is set equal to one, all deaths are given equal weight. Values of α less than 1 indicate a declining marginal disutility of deaths, so that 50 deaths would be given less than five times the weight of 10 deaths; while values of α greater than 1 indicate an increasing marginal disutility of deaths. The remaining attributes enter the model as dummy variables with the omitted dummies representing the following base case: Age = over 60's, Severity = *bit* worse than normal, Duration = for last *few minutes* of their lives, Blame = nobody in particular

The disutility of this 'base type' of death was accorded a value of 1. We first estimated the model with $\alpha = 1$, but a number of the coefficients appeared to have the 'wrong' sign and did not fit the data at all well. It seemed that setting $\alpha = 1$ imposed a restriction on the weight placed on the number of deaths which diverged from what respondents actually did to such an extent that it distorted many of the other parameter estimates.

We then explored other values of α. A grid-search showed that the log-likelihood function was minimized (i.e. the model fitted best) when $\alpha = 0.2$. The results of estimating the model on this basis are shown in Table 14. Observations were not independent (as each respondent contributed 12 observations), so standard errors were adjusted to allow for clustering by respondent. The parameter estimates and their respective levels of significance are given in Table 14.

Table 14: Model 1: α = 0.2

Variable	**Coefficient**	**Robust Std Error**	**Significance**
Deaths	(offset)		
Dage(<17)	.817	.065	0.000
Dage(17-40)	.605	.055	0.000
Dage(40-60)	.355	.049	0.000
Dsev(lot)	.331	.035	0.000
Ddur(weeks)	.152	.045	0.001
Ddur(1-2 yrs)	.276	.047	0.000