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Developing a relativities approach to valuing the prevention of non-fatal work-related accidents and ill health

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Summary

The aim of the current explorative study is to define and test a process for the valuation of the benefits associated with the prevention of non-fatal work-related accidents and ill health. A relativities approach is adopted, and monetary values for the prevention of three forms of work-related illness are estimated. The approach involves describing relevant attributes of alternative events (accidents or occurrences of ill health), their causes, the characteristics of the relevant working population, and the number of events that are avoidable, and asking respondents to make pair wise choices between alternatives options for prevention. Indirect monetary valuations are obtained against a peg event for which a reliable valuation exists (road deaths).

A series of discussion groups were held to identify relevant factors affecting potential valuations and to test the presentation of information. The predicted magnitude of responses for three-case study events (and road deaths) was estimated in a pilot study. These preliminary stages informed the final survey instrument that described five attributes in addition to a statement of the event and occupation, and the likely intervention effect, which was administered by post.

Based on a small sample, the results show that virtually all respondents passed the inserted consistency test. The median respondent altered their choice according to the number of events avoided for all three comparisons, such that the estimated valuations appear sensible. Potential amendments are suggested, but the general relativities approach warrants further investigation for the valuation of non-fatal work-related accidents and ill health.

Keywords relativities; benefit valuation; workplace health and safety

Introduction

In instances where the introduction of new legislation is an option, United Kingdom (UK) government departments are required to undertake a regulatory impact assessment that must include an assessment of the associated costs and benefits [1]. In addition, the government's recently defined 'science and innovation strategy' requires each government department to assess the impact of its actions, in order to develop a knowledge base that will inform future interventions [2].

The aim of the Health and Safety Executive (HSE) is to ensure that risks to people's health and safety from work activities are properly controlled. There are various instruments that have been used in order to improve workplace health and safety, including carrots (e.g. the argument that 'good health is good business'), sticks (the threat of prosecution), and neutral instruments that simply raise awareness of firms' legal requirements or

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good practice. The intended benefits associated with interventions implemented by HSE are reductions in the levels of work-related accidents and ill health, which cover a wide range of events.

To assess the costs and benefits of alternative health and safety interventions it is preferable to obtain a monetary value of the respective outcomes, which allows the relative efficiency of different interventions to be estimated. There is a considerable body of work aimed at the valuation of safety, though the majority of the research relating to workplace risks is concerned with fatalities [3,4]. However, most health and safety interventions are not aimed at preventing fatalities, rather non-fatal injuries and ill health. Non-fatalities have been mainly valued in the context of non-work-related events, such as road accidents [5,6]. Such valuations do not cover the breadth of variation in the types of events experienced in the workplace, but equally importantly, they do not account for the context of the event as the prefix 'work-related' could have a considerable impact on the public's valuations of similar events.

The aim of the current explorative study is to define and test a process for the valuation of the benefits associated with the prevention of non-fatal work-related accidents and ill health. The process of development includes the identification of the factors influencing respondent's valuations, and an effective means of presenting such information. An additional objective is to ensure that the final valuation process can be replicated simply and inexpensively, to enable HSE to obtain separate valuations of the specific effects of alternative health and safety interventions without great expense.

The following section provides a discussion of the context-specific merits of alternative methodologies available for the valuation of health-related benefits. Three development stages of the survey instrument for the chosen approach – the relativities method – are then described, followed by the results of the final survey. The final section discusses the merits of the relativities approach and presents ideas for further research around its application.

Background

Various approaches to the valuation of the benefits associated with health and safety interventions are considered, which are assessed on the basis of their theoretical and practical soundness, leading to the choice of methodology for the current study.

The main research effort in the health and safety field in the past has been around the monetary valuation of preventing deaths (or statistical fatalities), based on revealed preferences, willingness-to-pay (WTP), or relative valuations. Previous revealed preference approaches, based on regression models of wages, have included explanatory variables describing non-fatal risks, which enabled the estimation of a wage premium for the existence of non-fatal risks [7,8]. Arabsheibani and Marin [7] included a variable describing the excess rate of non-fatal injuries, whilst Shanmugam [8] included two such variables: 'injury' describing the average probability of injury risks and a subjective variable 'danger' that described exposure to dangerous or unhealthy conditions.

In valuing the prevention of non-fatal events the revealed preference approach is only able to value such generally specified non-fatal risks because sufficient data describing particular risks is unlikely to be available. The revealed preference approach also suffers due to the inherent difficulties in accounting for all the determinants of wage rates, and the assumption that workers are well informed about workplace risks. For these reasons, most economists appear to favour the WTP approach to valuing changes in risk [7].

WTP studies have the advantage that respondents can be provided with sufficient information to make an informed valuation (though the provision of information does not mean that respondents will provide considered responses), as well as that researchers can (attempt to) isolate the relevant wealth/risk trade-off. As part of the process of describing a realistic contingent market it is necessary to use a realistic payment vehicle that seems reasonable to respondents, even if they do not approve of it [9]. In the context of asking the general population to pay for improvements in work-related health and safety, the two main choices appear to be indirect out-of-pocket payments (such as specifying an increase in weekly shopping bills), and additional taxation. During the deliberation over the appropriate payment vehicle, the prospective sensitivity of WTP responses to variations in the effectiveness of the proposed interventions was considered. Drawing on previous valuation work undertaken in the

health and safety field, it was noted that even the most thoroughly conducted studies using face-to-face interviews and valuing the prevention of fatalities encountered the problem of insufficient sensitivity to the size of risk reductions [10,11]. As a result, it was concluded that the likelihood of developing a WTP approach that could distinguish between alternative levels of risk for non-fatal events (that respondents are likely to have more difficulty valuing than fatal events anyway), in a format that is relatively simple to replicate, was beyond our expectations.

An alternative approach to obtaining monetary valuations for the prevention of non-fatal events is the relative valuation approach. This method estimates the value of preventing one event relative to another, rather than asking respondents to provide direct monetary valuations of alternative preventative measures. The estimated ratios for alternative events are then applied to a 'peg' monetary valuation in order to estimate the corresponding monetary values. The choice of an appropriate peg against which non-fatal work-related accidents and ill health can be valued is a key issue around the use of the relativities approach. The monetary value of the peg must be credible, and the 'peg' event itself must provide a realistic choice option compared to work-related accidents and ill health.

In line with current opinion [7], a preference for WTP-based valuations is stated in identifying a suitable peg. A recent large-scale research project obtained monetary valuations for the prevention of road deaths using an innovative four-stage WTP/standard gamble approach [10,11]. Around 90% of the responses in this study ($\frac{149}{167}$) were usable and produced estimates that were not dominated by 'extreme caution or excessive recklessness'. The estimated range for the value of preventing a statistical fatality (VPF) in a road accident (£0.75–1.25 million) also encompassed the previously estimated VPF used by the UK government (£0.9 million). It was also felt that road deaths and work-related accidents and ill health would provide a realistic choice scenario because preventative programmes in both areas are funded by the government.

The conjoint analysis approach is similar in presentation to the relative valuations approach, in that both methods ask respondents to make a series of discrete choices between pair wise comparisons describing alternative events in the context of the same set of attributes.

Defining the study population

Drawing on the use of WTP to value non-fatal events in the health care field, the most common sampling frame consists of patients [12,13]. A user valuation approach in the health and safety field would survey workers at risk of the event of interest, which would require the identification of a separate study population for every type of work-place in which alternative interventions to reduce the risk of similar events could be implemented. There may also be ethical issues regarding the use of workers at risk of work-related accidents and ill health, which may not be analogous to sampling patients who already have a condition.

In addition, workers may have strong incentives to provide biased responses, either to inflate the value of the risks they face in order to increase the value of their occupation, or workers may interpret a higher valuation as increasing the probability of the imposition of a safer working environment with the associated costs being transferred from their wages. Another problem with obtaining valuations solely from the population for whom an intervention is intended is that the characteristics of relevant populations for alternative interventions will vary greatly, which raises problems around the comparability of the respective monetary valuations.

Furthermore, as is explained below, this study involves the comparison of different health effects to different kinds of workers: for example, mental health problems in nurses and respiratory conditions in waste disposal workers. If the views of those directly affected are to be elicited, then we might recruit nurses and waste disposal workers. But since they correspond to one side of the comparison, it is not only problematic to expect them to be able to detach themselves from their direct vested interest, it is possibly unethical to ask them to do so. In other words, the exercise has a distributional element and individuals that are direct stake holders are not the best judges in such contexts.

Indeed, there is a perspective that such policy information should be obtained not from people as consumers, but from people as citizens that are based on hypothetical scenarios concerning fellow citizens. The study population is defined, therefore, as a representative sample of the general population that can provide aggregate valuations for use values, option values and externalities.

The studies

The process for estimating relative valuations for a range of work-related accidents and ill health consists of four sub-studies. The first study informed the description of the contingent market, the second study validated the attributes included in the description of the contingent market and developed a draft survey document, the third study piloted the survey document, and the final study undertook the main survey. The following sections describe the methods and results for each of the four studies sequentially.

Study 1: developing the contingent market

Methods. The contingent market should present all the relevant information relating to the options being valued in a sufficiently understandable, plausible and meaningful manner [14].

The first element of the contingent market is a description of the relevant commodities, i.e. the work-related accidents and ill health, the avoidance of which are to be valued. Three broad attributes may influence people's views of the priority that should be given to the prevention of alternative events: the context of the described incident (i.e. the accident or case of ill health), the standing of the defined occupation in which the incident occurs, and the traits of the workers who could potentially experience the incident.

The second element involves the appropriate description of the probability of an event occurring. Based on previous research that people are better able to deal with frequencies of occurrence, rather than probabilities [15,16], the relevant risk information was presented as the number of workers in which one case would be expected, e.g. 1 in a 1000, as well as describing the total number of events within a period and the total number of workers at risk.

The final element of the contingent market is the time period over which the described events occur. A time period of 1 year was specified as a sensible interval.

To provide a starting point for the description of the contingent market, three discussion groups consisting of university staff were held. An e-mail invitation, offering an incentive payment of £10 per attendee, was sent to the entire staff (academic and support) of the School of Health and Related Research at the University of Sheffield (c.200 people).

The format for the groups involved the provision of some background to the study followed by a general discussion of health and safety and HSE. The groups were then asked to discuss factors that should influence the prioritisation of HSE's funds. When this unprompted discussion appeared to be ending, the group were provided with the contents of Table 1 describing potential characteristics, with example scenarios, and asked for their opinions regarding factors that had not been mentioned previously. The attributes described in Table 1 are defined as event-, occupation-, worker-, or risk-based characteristics, and were based on discussions amongst the research team.

The characteristics discussed in the groups were analysed on the basis of the number of unprompted references, and the strength of agreement between the respondents within a group, as well as across the three groups. On the basis of these analyses, a set of characteristics was defined and used to inform the drafting of an initial survey document, which compared a range of commodities, including the 'peg' events.

Results. Sixteen members of staff, both academic and non-academic, attended three group meetings. On the basis of the qualitative analysis of the discussions, the following attributes were included in the first draft of the contingent market. The associated levels are presented in Table 2.

- Occupation.
- Risk of event.
- Age and sex distribution of workers.
- Worker control over risk.
- Impact of the event of the worker's life.

Other outcomes from the first set of discussion groups included the decision to describe more specific events, such as an 'arm amputation' or 'severe asthma', rather than 'amputation' or 'respiratory ill health', along with a brief description of the health-related effects of the event. Subjective characteristics, such as the social value of an occupation, and characteristics such as family circumstances that can be reasonably inferred from other presented information, were not mentioned in the draft survey document.

Table 1. Potential attributes list, with examples, distributed within first set of discussion groups

	Three example scenarios		
Event characteristics			
Event	Mental ill health	Fracture	Respiratory ill health
Time frame of injury/ill health	Short term	Immediate	Medium to long term
Temporary/permanent injury/ ill health	Temporary or permanent	Temporary	Permanent
Ability to work after injury/ ill health	Varied	Yes, in same job	Yes, in different job
Worker responsibility for injury/ ill health	Mixed employer/ worker	Mostly worker	Mostly employer
Occupation characteristics			
Occupation	Nurse	Construction worker	Waste disposal worker
Pay	£20k	£25k	£15k
Public/private sector	Public	Private	Private
Temporary/permanent contracts (affecting sick pay)	Mostly permanent	Many self-employed contractors	Mostly permanent
Visibility of risk to workers	Medium	High	Low
Worker characteristics			
Gender	Predominantly female	Predominantly male	Predominantly male
Age	Young	Middle aged	Near retirement
Skill level	Skilled	Semi-skilled	Unskilled
Risk presentation			
Risk of accident	Medium (1 in 2000 per year)	High (1 in 350 per year)	Low (1 in 10 000 per year)
Number of workers	0.5 million	2 million	50 000
Cases per year	240	5714	5

The preferred format for the presentation of risk was the number of recorded events in a particular industry and the number employed in the industry. Furthermore, the presentation of risk was not based on actual risk frequencies in the industries included in the study, rather four categories of risk that represented low risk in small industry, high risk in small industry, low risk in large industry, and high risk in large industry. Similarly, the age and sex distribution of workers was not based on real data, rather four categories describing combinations of mainly male and female workers with older and younger workforces.

Four categories describing the cause of the risk were described, each of which assigned the majority of the responsibility to the particular factor. The distinction between accidental actions and (implied intentional) violent actions was specifically raised during the discussion groups. The three levels attached to the final attribute, impact on worker's life, were specified in the context of the worker's employment opportunities, but also provide an implicit description of the long-term health effects of the event.

Study 2: validation of the attributes in the defined contingent market and development of a draft survey document

Methods. A second set of discussion groups were convened to provide feedback on the draft survey document, including the set of characteristics described, the clarity of the survey instrument, and some indication of the direction and strength of preference between the presented commodities. To populate this second set of discussion groups, 100 people from the electoral ward of Netherthorpe, Sheffield, were randomly selected and invited to attend by letter. An incentive payment of £15 was offered per attendee.

The format for the second set of discussion groups again consisted of an introduction to the study, followed by a brief general discussion of health and safety and HSE. The first structured section involved the sequential presentation of five general occupations to the groups (nurses, manufacturing-, construction-, clerical and secretarial-, and waste disposal-workers). The groups were asked to describe

Table 2. Attributes and levels used in relativities questionnaire

Attribute	Levels
Event and occupation	Blindness in manufacturing workers
	Stress in clerical and secretarial workers
	Stress in nurses
	Back fractures in construction workers
	Finger amputations in agricultural workers
	Severe asthma in waste disposal workers
	Deaths in road accidents
	Deaths in rail accidents
Health effects	Single level relating to the work-related accident or case of ill health
Risk	25 cases per year, 20 000 workers at risk
	250 cases per year, 20 000 workers at risk
	25 cases per year, 1 000 000 workers at risk
	250 cases per year, 1 000 000 workers at risk
Age and sex levels	Mainly male, 50% aged under 30, 10% aged over 50
	Mainly male, 10% aged under 30, 50% aged over 50
	Mainly female, 50% aged under 30, 10% aged over 50
	Mainly female, 10% aged under 30, 50% aged over 50
Source of risk	Affected worker mainly responsible
	Employer mainly responsible
	Accidental actions of work colleagues of affected worker mainly responsible
	Violent actions of work colleagues or members of public mainly responsible
Impact of outcome	Majority of workers able to resume same job within month of accident
	Majority of workers require extended sick leave and return to different job
	Majority of workers forced into early retirement

what characteristics they associated with the occupations, with the aim of identifying any hidden attributes that respondents might apply to descriptions of general occupation within the survey instrument.

Draft questionnaires were then distributed and the groups were led through the questions and asked to comment on any aspect of the document, including their acceptance of the questions being asked and the format of the questions, as well as their actual answers. The data collected from the general population discussion groups were used to refine the first draft of the survey document.

Results. Fifteen members of the general population attended two group meetings. The groups had a balanced age and gender mix with a slight bias towards older respondents (42% aged over 60, 32% aged between 40 and 59, 26% aged between 18 and 39). Both groups accepted the need for government intervention to regulate workplace health and safety, and a number of anecdotes regarding work-related accidents were recorded.

Members of the first general population group provided sufficient evidence regarding the relevance of the chosen attributes, so a further refined survey document was presented to the second general population group. The main objective for this group was to obtain feedback on the document's suitability as a postal survey (though discussion around the choice of attributes was encouraged). Respondents were presented with a description of two events in the form of the five defined characteristics, and asked to make a choice between avoiding 100 of one event or 100 of the other event. Depending on their initial choice the respondents were guided to a separate table that provided a series of choices relating to the number of each event that could be avoided, with successively fewer numbers of the originally preferred option being avoidable. The survey was based on a previously employed design that had been used to obtain relative valuations for alternative patient groups [17].

The general consensus was that the questionnaire was far too complex and that most people would 'throw it straight in the bin'. The main reason for the confusion appeared to be the fact that the survey originally stated that an intervention could prevent a specified number of events, but the respondents were then being told that one

of the interventions could now prevent a smaller number of events.

At the end of this second set of discussion groups it was decided to ask respondents to make only a single choice with respect to each set of attributes and that an additional attribute representing the number of avoidable cases for each event should be added.

Study 3: pilot study of the survey document

Methods. Thirdly, prior to conducting the main survey, a pilot study of staff employed at the Health and Safety Laboratory (HSL) was undertaken to further inform the final survey instrument. One hundred copies of the draft questionnaire were distributed to both scientific and support staff (80:20 split). Four versions of the questionnaire (25 of each) were distributed to test two alternative presentations of the same questions, as well as two alternative forms of ordering the questions. The output from the pilot survey was analysed descriptively to inform the final survey of the direction and magnitude of the preferences between the chosen comparisons.

Results. The response rate was 31% (31/100), though this included four partially completed returns and six uncompleted returns. The survey consisted of six questions, two of which related to the 'peg' event of deaths in road accidents (vs stress in nurses and severe asthma in waste disposal workers). The other descriptors related to blindness in manufacturing workers, stress in clerical and secretarial workers, back fractures in construction workers, and finger amputations in agricultural workers. The results of the pilot study are presented in Table 3.

An additional aspect of the pilot survey was the specification of attribute sets designed to test for the impact of the non-health-related attributes, for example, one question compared stress-related ill health in nurses that was due to the nurses' own actions with stress in clerical and secretarial workers that was caused by violent actions of the public. The expectation being that, *ceteris paribus*, most respondents would choose to prevent ill health in nurses. Whilst the majority of respondents did choose nurses, a substantial minority of respondents (34%) opted for a preventative intervention aimed at clerical and secretarial workers.

The pilot questionnaire also asked respondents to comment on the survey, which most respondents did. One area in which the questionnaire was altered, as a result of the pilot study, was in the description of the 'worker control over risk' attribute. Some comments criticised the lack of realism in the statement that 'the affected worker is mainly responsible for the risk of stress' in nurses, which was changed to 'the nature and conditions of the work are mainly responsible for causing of stress'.

The vast majority of the comments related to the complexity of the task asked of respondents, which reconfirmed our decision to simplify the final survey, but also persuaded us to reduce the number of comparative questions asked. The final survey consisted of seven questions describing four different combinations of attributes. The chosen questions are presented in Table 4. The final question provides a test of consistency for the responses as the prevention of both asthma in waste disposal workers and stress in nurses are also included in questions 1,2 and 3,4, respectively, where they are compared against alternative numbers of back fractures.

Table 3. Results of pilot study of HSL staff

(Prevention of) Blindness in manufacturing workers	Strongly preferred to	Asthma in waste disposal workers
Asthma in waste disposal workers	Strongly preferred to	Finger amputation in agricultural workers
Back fractures in construction workers	Very strongly preferred to	Stress in nurses
Stress in nurses	Weakly preferred to	Stress in secretarial/clerical workers
Road deaths	Very strongly preferred to	Stress in nurses
Road deaths	Very strongly preferred to	Asthma in waste disposal workers

Table 4. Comparison questions included in final questionnaire

Event 1	Event 2
Incidents resulting in back fractures in construction workers	Cases of severe asthma in waste disposal workers
Accident is traumatic, victims unable to do heavy work	Unpredictable and severe asthma attacks despite treatment
Mainly male, 50% aged under 30, 10% aged over 50	Mainly male, 10% aged under 30, 50% aged over 50
250 cases per year, 1 000 000 workers at risk	25 cases per year, 20 000 workers at risk
Accidental actions of work colleagues responsible for accident	Employer mainly responsible for not controlling cause of ill health
Majority of workers forced into early retirement	Majority take extended sick leave and return to different job
Action can prevent 75/25 events[a]	Action can prevent 100 events
Incidents resulting in back fractures in construction workers	Cases of stress-related ill health in nurses
Accident is traumatic, victims unable to do heavy work	Find stressful situations 'anxiety producing' and 'depressing'
Mainly male, 50% aged under 30, 10% aged over 50	Mainly female, 10% aged under 30, 50% aged over 50
250 cases per year, 1 000 000 workers at risk	250 cases per year, 20 000 workers at risk
Accidental actions of work colleagues responsible for accident	Nature and condition of work responsible for cause of stress
Majority of workers forced into early retirement	Majority take extended sick leave and return to different job
Action can prevent 75/25 events[a]	Action can prevent 100 events
Deaths in road accidents	Incidents resulting in back fractures in construction workers
Mainly male, 50% aged under 30	Accident is traumatic, victims unable to do heavy work
3500 cases per year	Mainly male, 50% aged under 30, 10% aged over 50
Action can prevent 20/1 deaths[a]	250 cases per year, 1 000 000 workers at risk
	Accidental actions of work colleagues responsible for accident
	Majority of workers forced into early retirement
	Action can prevent 100 events
Cases of severe asthma in waste disposal workers	Cases of stress-related ill health in nurses
Unpredictable and severe asthma attacks despite treatment	Find stressful situations 'anxiety producing' and 'depressing'
Mainly male, 10% aged under 30, 50% aged over 50	Mainly female, 10% aged under 30, 50% aged over 50
25 cases per year, 20 000 workers at risk	250 cases per year, 20 000 workers at risk
Employer mainly responsible for not controlling cause of ill health	Nature and condition of work responsible for cause of stress
Majority take extended sick leave and return to different job	Majority take extended sick leave and return to different job
Action can prevent 100 events	Action can prevent 100 events

[a] These questions were asked twice with alternative numbers of preventable cases in for Event 1 (the ordering of the comparisons was varied in the survey).

Study 4: the main survey

Methods. In line with the objective of the study to create an inexpensive valuation process, and because the development stage for the survey instrument indicated that the required valuations could be obtained using a postal questionnaire, the main study was conducted as a postal survey. The sample for the survey was again randomly selected from the electoral ward of Netherthorpe. Two

hundred and forty copies of the survey were distributed over a 3-week period, 150 without incentives and 90 with the offer of entry into a prize draw (three prizes of £50 each, with respondents informed that the expected number of responses was 100). No reminders were sent out.

The data collected from the main postal survey were analysed descriptively to show the responses to the specific choices included in the final questionnaire. The data were also analysed using logistic regressions, where the dependent variable is the percentage of respondents choosing the event for which the number of avoided events varies (Event 1 in Table 4), and the number of events avoided is the explanatory variable (the number of comparator events avoided is held constant at 100 – Event 2 in Table 4).

The primary output from the regressions were the relative valuations for the median respondents, which provided the baseline relativity that was applied to the peg event to estimate the monetary value for the avoidance of each event. The number of events avoided (x) of Event 1 required to compensate for 100 avoided events of Event 2, such that a given proportion of respondents chooses Event 1 was calculated by

$$x = \frac{\log(y/1-y) - \alpha}{\beta}$$

where y is the proportion of interest, α is the coefficient for the constant and β is the coefficient for the comparator.

The proportion of respondents choosing Event 1 when equal numbers of Events 1 and 2 were avoidable was calculated by

$$y = \frac{\exp(\alpha + \beta x)}{1 + \exp(\alpha + \beta x)}$$

Results. At the time of the final analysis 45 completed responses had been received from a distribution of 230 questionnaires (10 were returned 'addressee unknown') – a response rate of 19.6%. The response rate for the section of the survey that included the offer of entry into a prize draw was 31.4% (27/86), whilst the rate for the non-prize draw section was 12.5% (18/144) [$p < 0.06$].

Table 5 presents the descriptive analysis of the data. The results show that similar proportions of respondents chose to prevent 25 back fractures in construction workers as opposed to 100 cases of either severe asthma in waste disposal workers or stress-related ill health in nurses. However, a higher proportion would prefer to prevent 100 cases of stress compared to 75 back fractures, than 100 cases of asthma compared to 75 back fractures. This result is consistent with the direct comparison of stress with asthma, which shows that 55% of respondents would prefer to prevent 100 cases of stress than 100 cases of severe asthma.

The descriptive results also show that, for the three comparisons involving two choices, e.g. avoiding 1 or 20 road deaths compared to 100 back fractures in construction workers, the median

Table 5. Descriptive analyses of responses to main survey

Prefer to[a]	Mean	Lower 95% CI	Upper 95% CI
Prevent 100 asthma cases to 25 back fractures	0.289	0.23	0.35
Prevent 75 back fractures to 100 asthma cases, but 100 asthma cases to 25 back fractures	0.244	0.19	0.30
Prevent 25 back fractures to 100 asthma cases	0.467	0.39	0.54
Prevent 100 stress cases to 25 back fractures	0.333	0.27	0.40
Prevent 75 back fractures to 100 stress cases, but 100 stress cases to 25 back fractures	0.178	0.13	0.22
Prevent 25 back fractures to 100 stress cases	0.489	0.42	0.56
Prevent 100 back fractures to 1 road death	0.422	0.35	0.49
Prevent 20 road deaths to 100 back fractures, but 100 back fractures to 1 road death	0.244	0.19	0.30
Prevent 1 road death to 100 back fractures	0.333	0.27	0.40
Prevent 100 stress cases to 100 asthma cases	0.556	0.48	0.63
Prevent 100 asthma cases to 100 stress cases	0.444	0.37	0.52

[a] See Table 4 for full description of comparisons.

respondent altered their choice according to the number of events avoided for all three comparisons.

Separate logistic regression analyses of the three 2-level comparisons were performed with the dependent variable in each case describing whether a respondent had opted for the prevention of the assumed worst-case event (the stimulus, e.g. road deaths). The single explanatory variable was the level of the stimulus, i.e. either 75 or 25. Table 6 presents the results for each of the comparisons. The first column shows that a large majority of respondents would prefer to prevent the stimulus event when compared against equal numbers of the comparator event, though 8% fewer respondents would choose back fractures in construction workers over stress in nurses, than would choose such back fractures over asthma in waste disposal workers.

The second column shows the point at which the median respondent is indifferent between the numbers of events that can be prevented for either event offered. At this level there is only a small difference between the respondents with respect to the prevention of asthma in waste disposal workers and stress-related ill health in nurses. The median respondent was a lot less likely to trade off road deaths against back fractures in construction workers.

The final column applies the relative valuations presented in the previous column to the mid-point of the published range for the valuation of the prevention of a road death, which was £1 000 000 [10,11], showing that the prevention of the scenarios describing asthma in waste disposal workers and stress-related ill health in nurses are valued similarly at around £40 000, whilst the avoidance of back fractures in construction workers is valued at £132 000.

Discussion

The objective of this explorative study was to design and evaluate a method for the monetary valuation of non-fatal work-related accidents and ill health, which explored the impact of characteristics of the work undertaken and the process by which the accident or ill health occurred. Revealed preference techniques were excluded due to the lack of reliable data describing occupational choices with respect to non-fatal work-related events.

It is recognised that the valuations obtained in an expressed preference study may vary according to whether the study population is at risk of an event, or is a general population sample. The current study chose to obtain valuations from a general population sample on both theoretical and practical grounds. The theoretical basis is around the intended use of the valuations obtained from the reported study, which is to inform cost benefit analyses of interventions aimed at improving health and safety in the workplace. Such analyses are primarily undertaken from the societal perspective, and as such it is legitimate to incorporate a societal valuation of the prevention of injuries that result from the assessed interventions. At one level, the choice of worker or public as the source of the valuations is analogous to the choice of patient or public as the source of utilities to inform the estimation of QALYs in a health technology

Table 6. Results from logistic regression and implied monetary valuations for the non-fatal work-related accidents and ill health

Comparison[a]	% choosing stimulus if preventable numbers are equal[b]	Median respondent: 100 comparator = x stimulus[b]	Implied value of comparator[c]
Asthma in waste disposal workers vs back fractures in construction workers	0.82	29.24	£38 602
Stress in nurses vs back fractures in construction workers	0.74	31.06	£41 004
Back fractures in construction workers vs road deaths	0.99	13.20	£132 000

[a] See Table 4 for full description of comparisons.
[b] The latter event in each of the comparisons is the stimulus.
[c] Based on a value of preventing a road death of £1 000 000 (HSE, 2000).

economic evaluation. Current guidelines in the health care field favour the use of public valuations, which provide a stable source for the comparison of values across different areas. At a further level, since the exercise elicits the value of health problems to different worker groups, there is an element of distributional concerns, and obviously, workers, who are directly affected by particular risks but not others, are not the best judges of how to distribute these risks across different worker groups.

From a practical viewpoint, the use of public valuations is necessary in order to facilitate the wide range of valuations that may be required to inform a cost benefit analysis of a health and safety intervention, for example, government regulations aimed at reducing back injuries will impact on a wide range of industries, and on a range of severities of back injury. The task of obtaining separate valuations from a sufficiently large sample of workers in each affected industry would likely be unfeasible in many evaluations. Furthermore, even if the above approach were taken, because the elicitation exercises involved comparisons of different health problems to different worker groups, each respondent would only be relevant to one group, not to the whole comparison exercise *per se*.

General population samples have been used in previous WTP studies for risk reduction interventions, but these studies have valued either fatal events [18] or non-fatal events for which everyone is at risk (road injuries) [5]. All these studies, to a greater or lesser degree, reported inconsistencies in the valuations obtained. The current study aimed to value non-fatal events that the majority of respondents would never be at risk of experiencing. The process of estimating a monetary value for the certainty of preventing a number of such events, let alone a reduction in the risk of an event, was thought to be cognitively infeasible for most respondents – especially in the format of a postal questionnaire.

The relative valuations technique was chosen because it does not require the identification of monetary estimates for the avoidance of specified events, rather respondents make discrete choices between pair wise comparisons describing alternative numbers of each event that are avoidable. The relativities approach avoids the cognitive demands of attaching monetary values to the prevention of events, but rather asks respondents to concentrate their efforts on making the choice between the prevention of alternative numbers of two defined events. Though respondents in the discussion groups commented on the inherent difficulties in making such choices, they were mainly able to make considered responses that reflected their preferences. Also, whilst the relative valuations were not uniformly accepted, as demonstrated by comments received during all stages of the study, they may be more acceptable than questions asking respondents to place a monetary value on the prevention of an event.

The survey document presented information describing the type and number of injuries with characteristics of the injured, including summary descriptions of the age and sex distributions within each working population. This approach was adopted in order to better inform the respondents, and in order to get more relevant valuations for injuries in alternative industries. The categories of characteristics described in each scenario were chosen on the basis of the developmental work informing the final survey instrument (e.g. the focus groups) and so are the most relevant from the perspective of the public who are valuing the injuries. The specification of these characteristics is based on the general population of workers within each specified working population.

A key component of the relativities approach is the use of a relevant and valid monetary peg to obtain relative valuations for other events. The identified 'peg' event in the current study, deaths in road accidents, has been valued by a thorough and extensive WTP study, which reinforced previous estimates of the monetary value of preventing such events. Thus, there is sufficient confidence in the peg value.

The development of the relativities survey document through the discussion groups and a pilot survey provided the necessary data to refine the original list of potential characteristics to those that appeared to have the greatest impact on people's choices between alternative work-related accidents or cases of ill health. The development stage was also crucial in terms of informing the format of the survey document, including the realisation that the estimation of each respondent's precise trade-off was unlikely to succeed in the form of a postal survey.

Despite the simplification of the survey instrument, the response rate to an 'unincentivised' sample population was low, whilst the response rate improved when the offer of entry into a prize draw was included the resulting rate was still

below 30%. One factor influencing the low rate may have been the general appearance of the questionnaire, which was printed on standard A4 paper and fastened together with two staples down the left-hand side. Despite the fact that the questionnaires were posted out in HSE envelopes (with logo), one respondent phoned up to enquire about the validity of the survey, citing the appearance of the questionnaire as the reason for his call.

Future surveys testing the relativities approach would likely obtain a higher response rate through the use of a more professionally designed and implemented survey, but also perhaps by using an alternative method of contacting potential respondents. The current study posted the survey documents with no accompanying contact either before or after delivery. Without incurring the additional costs required to obtain valuations in person, some additional contact may have increased the response rate.

It must be appreciated that the presented results are based on only 45 observations, so they only provide a guide to the relative valuations placed on the work-related accidents and occupational ill health described by the general population. Moreover, the sample population was derived from a single electoral ward and a more representative sample would be required to validate the estimated valuations. The preliminary results obtained do endorse the chosen structure of the comparisons, with the back fracture in construction workers scenario being deemed a significantly worse event than either the asthma in waste disposal workers or stress-related ill health in nurses. The magnitude of the comparisons (75 and 25 back fractures, and 20 and 1 road deaths) also appear to have been well-informed by the earlier discussion groups and pilot studies, as the median respondent always chose the 'worse' event for the higher number of 'worse' events preventable, whilst switching to the comparator event when the number of 'worse' events decreased. Despite the position of the median respondent, there remains uncertainty as to whether the specification of only two response options for each stated comparison provides an adequate data set on which to estimate the required relativities.

The approach described in this study meets the objective of creating a survey instrument that can be replicated simply and inexpensively. As the more intensive approach of obtaining valuations from the workers facing particular risks is discounted on theoretical grounds, the options for implementing a more complete (and expensive) valuation process include the use of individual interviews or group sessions to derive relative valuations. These alternatives could be argued to provide more informed responses through the provision of additional information on the causes and effects of injuries, as well as on the characteristics of the working population. The additional benefit of these options could be further explored in a subsequent (and more expensive) research study.

If further work in this area were to be pursued, there are a number of interesting issues that could be developed, for example, the prevention of similar events in different populations could be explored either directly or indirectly to determine the extent to which other factors influence respondents choice. Furthermore, such scenarios could be compared against a less informed scenario that excluded the information relating to the occupation of the affected population. The difference in the monetary valuations obtained for the specific and generic populations could then inform relative weights that could be applied to other conditions.

The presented results do not provide an off-the-shelf estimator of monetary valuations for the prevention of events because the decision was taken to describe events, such as stress-related ill health and back fracture, specifically and not as varying levels of morbidity. As such the valuations presented are specific to the events and attributes described for each valuation, and the trade-offs between each of the attributes included in the study are not estimated (because the trade-offs will vary by the characteristics of the event and events are not described as attributes).

The applied objective of the methodology developed in this paper is to provide a usable method for estimating the value of preventing specific accidents and forms of ill health, to inform cost benefit analyses of work-related health and safety interventions. For a particular cost benefit analysis, the range of accidents and ill health affected by the evaluated intervention, and the associated attribute levels, could be described and valuations obtained using the relativities approach described in this paper.

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