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# An investigation into procedural (in)variance in the valuation of mortality risk reductions

Trine Kjær <sup>a, \*</sup>, Jytte Seested Nielsen <sup>b</sup>, Arne Risa Hole <sup>c</sup>

<sup>a</sup> DaCHE, Department of Public Health, University of Southern Denmark, J.B. Winsløvsvej 9B, 1., DK-5000, Odense C, Denmark

<sup>b</sup> Newcastle University Business School, UK

<sup>c</sup> Department of Economics, University of Sheffield, UK

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## ABSTRACT

This study investigates whether elicited preferences are affected by the presentation of mortality risks in a stated preference survey. We elicited willingness to pay for public risk reducing initiatives under three different but outcome equivalent presentation format. Results from a discrete choice experiment demonstrate that presentation format influences the valuation of mortality risk reductions, which to varying degrees depends on the respondent's level of concern and numeracy. Marginal willingness to pay for a risk reduction increases significantly when framed in terms of avoided fatalities compared to corresponding frequencies. Furthermore, we find that less numerate respondents are more influenced by the inclusion of the number of fatalities in the presentation format. The same pattern is observed for respondents who express a higher degree of concern for a traffic accident.

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## 1. Introduction

Valuation of mortality risk reductions constitutes an important input to cost-benefit analysis of many environmental policies such as air pollution reducing initiatives. The welfare economic approach to valuing reductions in mortality risk requires an estimate of the individual's rate of substitution between wealth and risk (Jones-Lee et al., 1985). Several methods can be used to estimate this trade off including stated preference (SP) methods such as contingent valuation and choice experiments. The estimated absolute value of a marginal risk reduction, defined as the Value of Statistical life (VSL) is obtained by dividing the estimated willingness to pay (WTP) by the corresponding risk reduction. While some SP studies have investigated (in)sensitivity to the magnitude of risk reduction (see e.g. Andersson et al., 2016), studies on the effect of different but outcome equivalent presentation formats are scarce. Gyrd-Hansen et al. (2003) and others have found individuals to be sensitive to whether risk information is presented as absolute or relative risk reductions, and Zhai and Suzuki (2008) have found that the larger the denominator of the fraction (e.g. 1/100 versus 10/1000), the less the WTP for a given risk reduction.

\* Corresponding author.

E-mail addresses: [tkj@sdu.dk](mailto:tkj@sdu.dk) (T. Kjær), [jytte.nielsen@ncl.ac.uk](mailto:jytte.nielsen@ncl.ac.uk) (J.S. Nielsen), [a.r.hole@sheffield.ac.uk](mailto:a.r.hole@sheffield.ac.uk) (A.R. Hole).

The benefit of public risk reducing initiatives can either be presented as a change in the risk of dying (expressed as frequencies or probabilities), or as the equivalent expected total number of fatalities avoided/lives saved over a given population.<sup>1</sup> The latter has also been termed the ‘community analogy’ (Calman and Royston, 1997). To illustrate, a reduction in risk from 2 in 10,000 to 1 in 10,000 in a community with 500,000 individuals can be presented as either a standard frequency (1 in 10,000) or a relative risk reduction (50%), or presented as a ‘community analogy’ frequency based on the number of individuals in the community (50 fatalities avoided). According to the assumption of *procedural invariance* (Tversky and Thaler, 1990), presentation format should not matter as long as the expected outcome is the same. The risk reduction format (frequency and/or relative risk reduction) has been used in previous SP studies, see eg. Jones-Lee et al. (1985) and Alberini and Scasny (2011), whereas the community analogy has been used for estimating WTP in eg. Andersson et al. (2016) and Rheinberger (2011). No study has so far attempted to systematically compare the effect of these different presentation formats on the implied valuations of outcomes, and the choice of presentation format appears to be rather idiosyncratic.

There is a large literature showing that risks and risk changes are not always perceived correctly by individuals, and that individuals have difficulties understanding how probabilities influence risk assessments. It has been proposed that affect (i.e. risk as feelings) may serve as a cue for many important judgments involving risk, and that different representations of risks are associated with affect to varying degrees (Finucane et al., 2000). Studies by Slovic and colleagues have showed that presentation of risks in the form of frequencies (e.g. 1 out of 100) created more frightening images than probabilities (Slovic et al., 2002). In addition, Rottenstreich and Hsee (2001) found a more pronounced overweighting of small probabilities relating to affect-rich outcomes compared to affect-poor outcomes. According to Slovic et al. (2002) affective responses occur rapidly and automatically and reliance on such feelings can be characterized as an ‘affect heuristic’.

Furthermore, research in psychology has demonstrated that numeracy skills have important consequences for judgement and decision making, and that inadequate numeracy may be an important barrier to an individual's understanding of risks. There is evidence that numerate individuals are likely to pay more attention to numbers associated with a risk as they comprehend them better and use them in decisions. On the other hand, the less numerate are likely to be informed more by other sources of information such as emotions, implying that they are more susceptible to how messages are framed and how numbers are formatted (Peters et al., 2006; Reyna et al., 2009).

We extend the current literature on valuation of mortality risk reductions by systematically investigating the potential influence that different presentation formats have on the elicited values. For this purpose, a three-way split sample discrete choice experiment (DCE) was conducted that include two types of risk information presented either separately or jointly. Respondents were asked to express their WTP for risk reducing initiatives keeping the size of the outcomes constant across splits (all in the context of traffic). To further our understanding of the underlying causes of variation across formats, we investigate whether numerical abilities and affective feelings can explain some of the observed discrepancies in marginal WTP. As a proxy for the former we use subjective numerical skills whereas for the latter, we use survey responses relating to level of concern for traffic accidents.

We find that presentation format significantly affects preferences and that marginal willingness to pay for a risk reduction increases significantly when framed in terms of avoided fatalities compared to corresponding frequencies. Furthermore, we find evidence that the sensitivity to format is impacted by the numerical ability of the respondents as well as their affective reaction.

## 2. Materials and methods

### 2.1. Data

The sample was obtained from the Nielsen Company's online panel database in May 2013. The survey sample was representative of the adult Danish population with respect to gender and age. 3600 individuals were invited (by email) to participate in the survey. The response rate in the survey was 17% resulting in a sample of 600 equally split across three treatment groups. For those who started the survey, the completion rate was 77%. Prior to the actual data collection, the survey was tested in an online pilot study ( $n = 200$ ).

The first part of the final questionnaire contained socio-demographic questions as well as questions related to respondents own traffic behaviour including the following question; ‘I am very concerned of being in a car accident’, measured on a 1–5 point Likert scale ranging from highly disagree (1) to highly agree (5). Information about annual baseline traffic mortality risk was then provided followed by risk communication explaining the corresponding number of lives lost out of 100,000 randomly selected Danish citizens. The full risk communication text can be found in the accompanying online Appendix.

The risk reducing initiative was described as a mandatory public 10-year traffic safety intervention with annual payments and annual risk reductions. The DCE comprised of two attributes; the annual mortality risk reduction and a price attribute (framed as extra taxation). The attributes and levels are shown in Table 1 below. A D-efficient Bayesian design was developed using Ngene software (ChoiceMetrics, 2009) with priors from the pilot study. This led to a final design with a total of 10 choice sets consisting of two hypothetical alternatives (A and B) and one opt-out (i.e. no initiative). Respondents were randomly

<sup>1</sup> Strictly speaking, a life cannot be saved but can be extended. On the other hand, a fatality can be avoided.

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