Resource Economics

Pilot Study: Non-market impacts of road transport

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Overview

- Study objectives
- Previous surveys
- Choice modelling
- Pilot survey development
- Implementation
- Results
- Lessons for future work

Study Objectives

- There is a perceived need to update values in the Economic Evaluation Manual (EEM) for several non-market values, including the value of statistical life (VoSL)
- The current VoSL is based on a survey undertaken in 1989/90, updated annually using wage rates
- NZIER review suggested:
  - Need to update, including to reflect changes in underlying risk
  - NZ research needed on relativities between the value of reductions in fatal and non-fatal crashes, and between crashes and other non-market values
- This study aimed to identify a new methodology which might include several (many) non-market values, and particularly VoSL and the value of time
  - These were regarded as encapsulating a key trade-off (journey time vs safety) in transport economics

Definitions

- Value of statistical life (VoSL)
  - the value to society of reducing the risk of fatalities, eg an intervention which reduces risk by one in a hundred thousand on average across a population of 100,000 people can be described as saving one statistical life

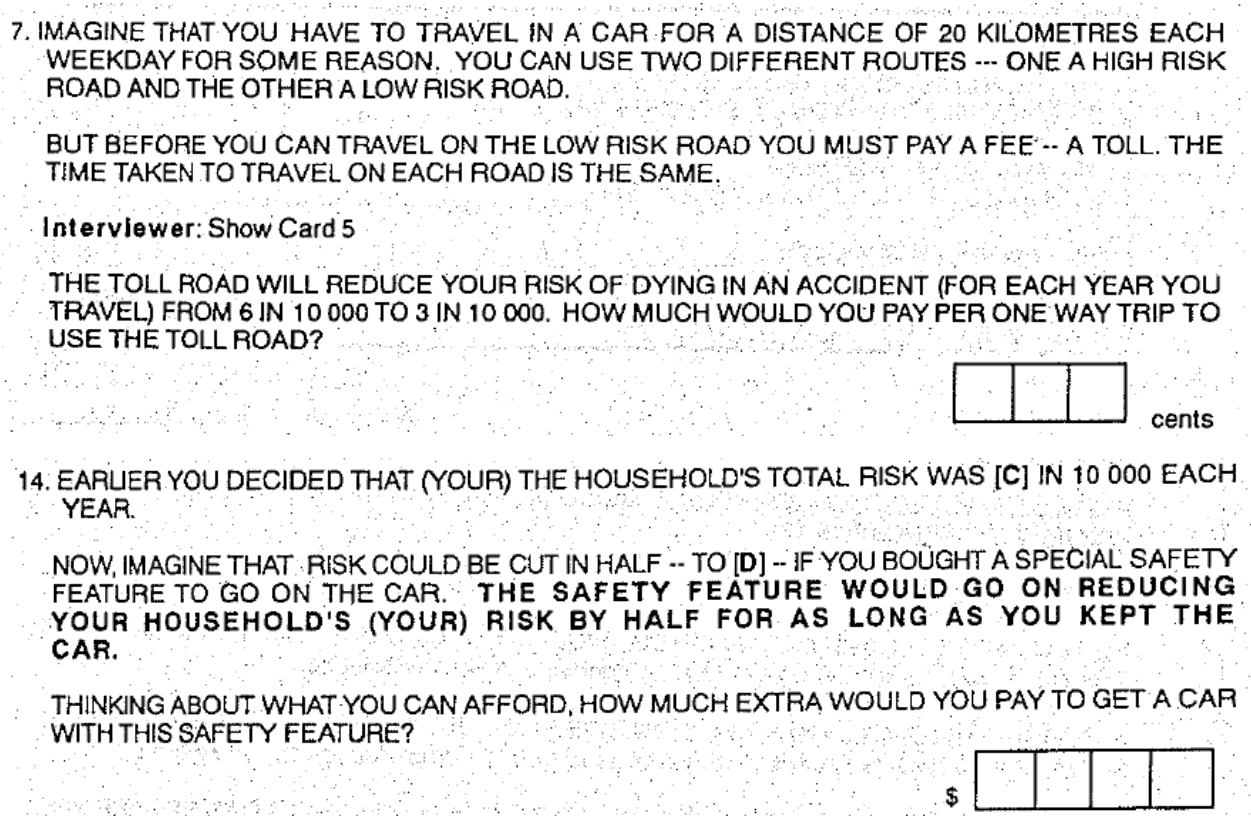
- Willingness to pay (WTP)
  - Given limited resources, any improvement in wellbeing along one dimension (eg via reduced risk of death) involves a reduction in some other dimension. WTP is the measure of how much people are willing to give up in one dimension to gain more in another.

Previous work - VoSL

- Value of life has been included in transport CBAs since the 1980s
  - Originally using the human capital approach (HCA): the discounted stream of future earnings (measured at c. $235,000 in 1990 or c$400,000 today).
  - Quigley et al (1989) used US studies to derive a value of NZ$800,000 per life (c.$1.5 million currently)
  - Questions to derive willingness to pay (WTP) in the MoT Household Travel Survey (HTS) 1989/90 (Miller & Guria 1991). It recommended a VoSL of $2 million (1991$).
  - A repeated survey in 1997/98 suggested a new VOSL of $4m (NZ 1998$) but this was not adopted, partly because it would mean a shift in investment from road capacity to safety
  - Current value of VoSL is $4.21 million (2017$) based on the original $2m value scaled up using average wage rates (it would be $3.4m if updated using CPI)

1989/90 VoSL survey

- The survey included questions to understand the attitude to risk and then asked questions on WTP to reduce risk in different ways, eg different travel routes, safety training and safer vehicles, eg



7. IMAGINE THAT YOU HAVE TO TRAVEL IN A CAR FOR A DISTANCE OF 20 KILOMETRES EACH WEEKDAY FOR SOME REASON. YOU CAN USE TWO DIFFERENT ROUTES --- ONE A HIGH RISK ROAD AND THE OTHER A LOW RISK ROAD.

BUT BEFORE YOU CAN TRAVEL ON THE LOW RISK ROAD YOU MUST PAY A FEE -- A TOLL. THE TIME TAKEN TO TRAVEL ON EACH ROAD IS THE SAME.

Interviewer: Show Card 5

THE TOLL ROAD WILL REDUCE YOUR RISK OF DYING IN AN ACCIDENT (FOR EACH YEAR YOU TRAVEL) FROM 6 IN 10 000 TO 3 IN 10 000. HOW MUCH WOULD YOU PAY PER ONE WAY TRIP TO USE THE TOLL ROAD?

☐☐☐ cents

14. EARLIER YOU DECIDED THAT (YOUR) THE HOUSEHOLD'S TOTAL RISK WAS [C] IN 10 000 EACH YEAR.

NOW, IMAGINE THAT RISK COULD BE CUT IN HALF -- TO [D] -- IF YOU BOUGHT A SPECIAL SAFETY FEATURE TO GO ON THE CAR. **THE SAFETY FEATURE WOULD GO ON REDUCING YOUR HOUSEHOLD'S (YOUR) RISK BY HALF FOR AS LONG AS YOU KEPT THE CAR.**

THINKING ABOUT WHAT YOU CAN AFFORD, HOW MUCH EXTRA WOULD YOU PAY TO GET A CAR WITH THIS SAFETY FEATURE?

$ ☐☐☐☐

Previous work – value of time

- The 1989/90 VoSL survey included questions on the value of time, but this has been addressed separately in additional research.
- Current EEM values are based on a 2001 survey (Beca Carter Hollings & Ferner, 2001)
  - The values were based on SP pair-wise comparisons (preferences between two routes with different travel times and costs).
  - values are differentiated by mode, trip purpose, travel conditions (eg congestion) and comfort factors (eg standing vs seated public transport passengers).
  - From 2013 ('equity') value of time by travel purpose has been adopted across all modes.

Travel time cont.

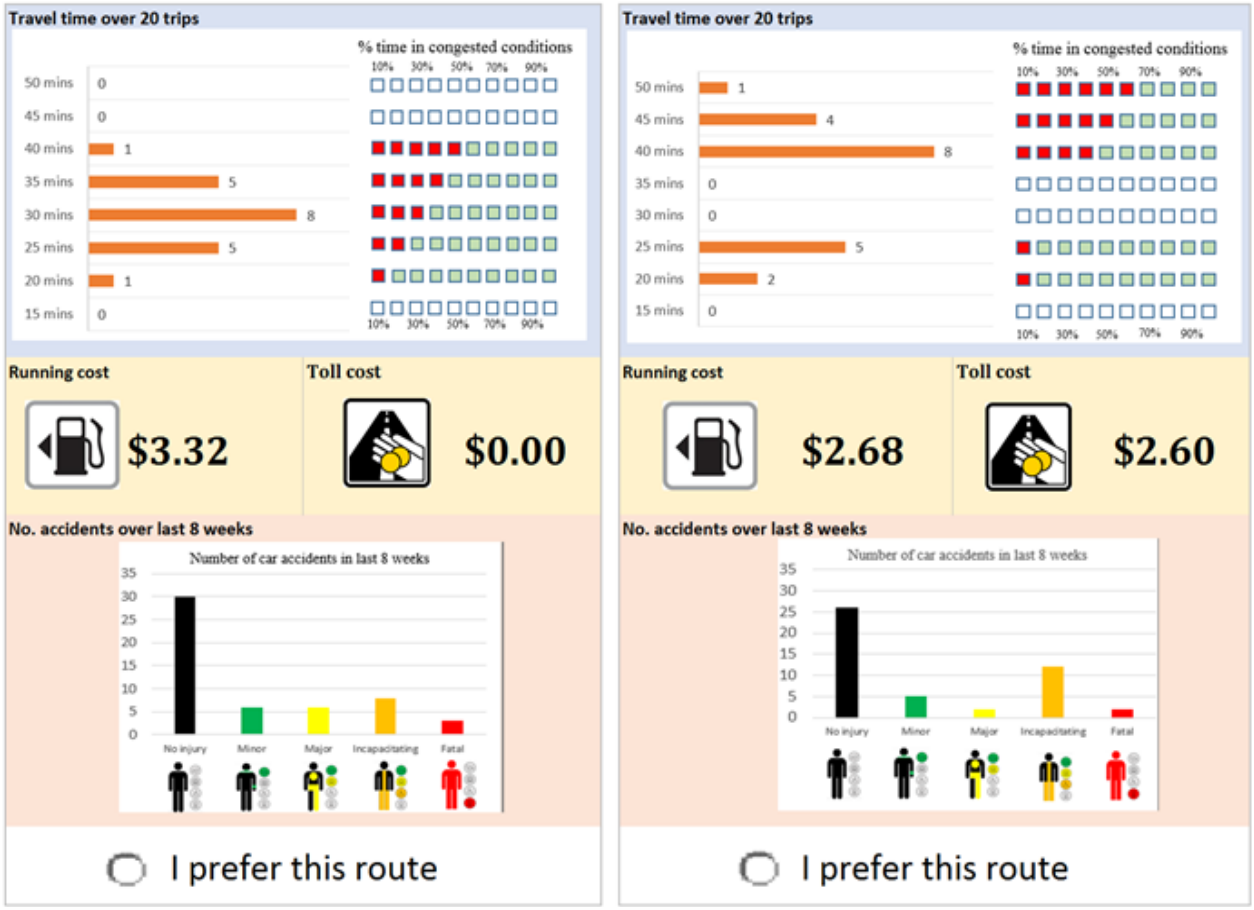
- Research suggests several complexities with the value of travel time
  - Some (commuting) travel time may be valued positively (people prefer some time over zero travel time)
  - Value of travel time savings (VTTS) may vary with total journey length, although the direction is uncertain
  - VTTS will vary with income and trip circumstances (how much of a hurry)
- People value trip time reliability separately from trip time

Choice modelling

- In simple terms, the main difference between choice modelling and contingent valuation (CV) is:
  - CV asks people to state their WTP directly
  - CM infers WTP from survey respondents' preferred option in a 'choice set' containing levels for several factors, including a monetary attribute
    - regression analysis of results used to establish values for individual attributes
- For this study, CM was seen as the best technique because
  - it allows valuation of a range of attributes at once, while explicitly addressing the trade-offs
  - It is a more realistic replica of actual choice situations.
  - It is also much more efficient than CV.

Transport applications

- Recent Australian example
  - Route choice used as the only choice task
  - Attributes = Journey time distribution, cost, accident risk



Designing a NZ survey

- Response mechanism
  1. binary choice
  2. single preferred option from three or more choices
  3. ranking all of three or more choices
  4. Best/worst of 3 or more choices

- Dimensions

Dimension	Description
Choice tasks	The number of choice questions offered, eg one choice question would be do you prefer route A or route B
Alternatives	The number of options to select from in each choice task. In this study, each choice offers two alternatives (route A or B)
Attributes	The number of characteristics for each alternative, eg average travel time, lateness, congestion
Attribute levels	Variations in the measure of an attribute offered across the alternatives

- Emphasis on efficient design rather than covering all possible options

- Survey design issues, eg realism, complexity, length (# questions), face-to-face or on-line etc

Prior decisions

- Focus on risk to individual decision maker and not societal (eg WTP to reduce average risk) or household risk.
  - Wider focus will include individual and risk to others in a way that can't be differentiated
  - More difficult to focus survey on an individual's unavoidable risk (they may think they can always avoid it – I'm a better driver than the average etc)
- Desire to include many attributes, but no inclusion of environmental values in route choices – these are regarded more as externalities to decisions

Three rounds of testing

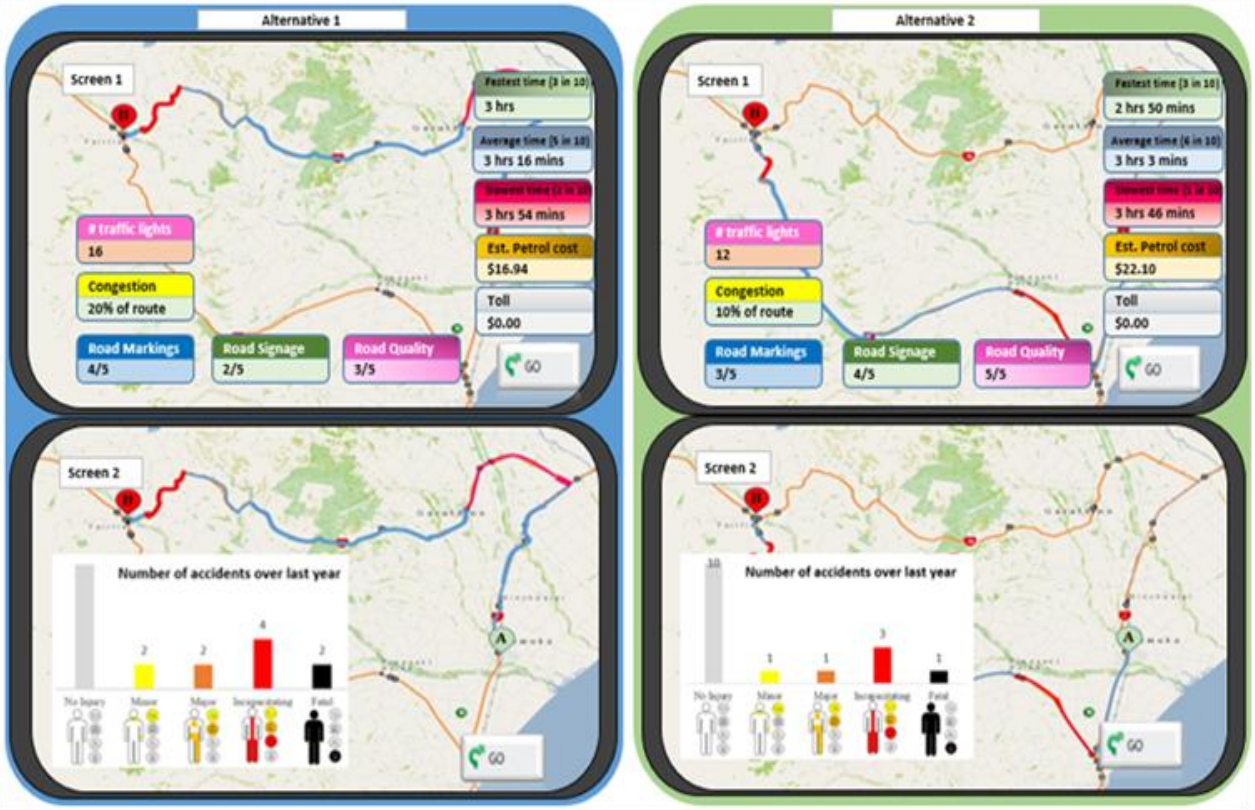
- Two initial survey rounds of semi-structured interviews with a small number of selected participants. People did the survey and were asked about how they made decisions etc
  - Alpha test - an initial evaluation of questionnaire performance (15 face-to-face)
  - Beta test – revised survey following feedback (15 face-to-face and 25 on-line)
- A Pilot test

Alpha test

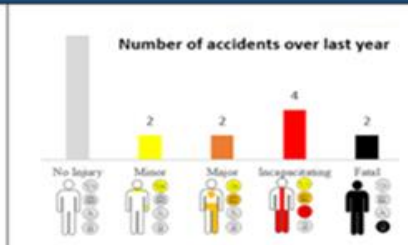
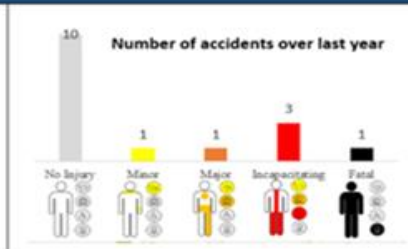
- Real or hypothetical journey – a hypothetical journey used, anchored to a real trip type, eg a regular commute or a regular trip to the next main centre.
- Number of choice tasks – versions with five and eight choice tasks used.
- Number of attributes. Those examined were:
  - travel time – average journey length
  - time reliability – fastest and slowest times (simpler than Australian distribution)
  - traffic:
    - number of traffic lights
    - % of route in congestion
  - road condition and quality
    - signage (score out of 5)
    - road quality (score out of 5)
    - markings (score out of 5)
  - cost – fuel and tolls
  - crashes – number of crashes by injury type (no injury, minor, major, fatal)

Alpha test- GPS layout

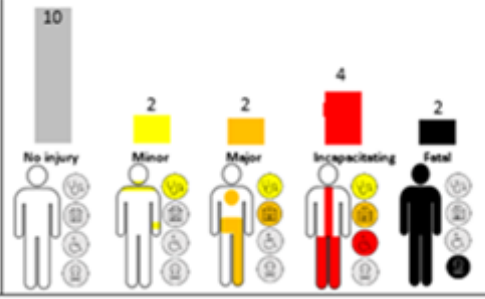
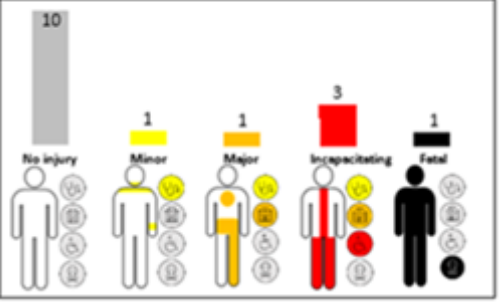
- Simpler form of the Australian design



Alpha test- map/grid layout

	Alternative one	Alternative two
Route Map		
Travel Time		
Fastest	3 hrs (3 in 10)	2 hrs 50 mins (3 in 10)
Average	3 hrs 16 mins (5 in 10)	3 hrs 3 mins (6 in 10)
Slowest	3 hrs 54 mins (2 in 10)	3 hrs 56 mins (1 in 10)
Traffic		
Traffic lights	16	12
Congestion	20% of route	10% of route
Road quality		
Signage	4/5	3/5
Quality	2/5	4/5
Markings	3/5	5/5
Cost		
Petrol	$16.94	$22.10
Tolls	$0.00	$0.00
Accidents		
Total accidents per year		

Alpha test – no map layout

	Alternative one	Alternative two
Fastest Trip Average Trip Slowest Trip	3 hrs (3 in 10) 3 hrs 16 mins (5 in 10) 3 hr 54 mins (2 in 10)	2 hrs 50 mins (3 in 10) 3 hrs 3 mins (6 in 10) 3 hrs 46 mins (1 in 10)
Traffic lights Congestion	16 lights 20% of route	12 lights 10% of route
Road signage Road quality Road markings	4/5 2/5 3/5	3/5 4/5 5/5
Est. Petrol Cost Toll	$16.94 $0.00	$22.10 $0.00
Accidents per year		

Alpha test feedback

- **Maps** are useful but influenced decisions, eg congestion (in un-controlled way)
- **Choice tasks** – started with 5 but increased to 8
- **Realism** – some people just use GPS normally. Trip purpose attribute added part way – was useful.
- **Attributes:**
  - too many (some ignored)
  - journey time the most important
  - costs and crash risk often ignored (they said)
  - road markings, signs etc are least important
  - Some people made it clear the type of vehicle they owned affected their risk response

Beta test

- Fewer attributes
  - travel time – average trip duration
  - trip time reliability/variability – probability and lateness
  - congestion levels – % of trip moving slowly/stopped
  - costs –fuel, other running costs and possibly tolls
  - injury-risk: no. of injuries and fatalities (2 attributes) + version with no. of crashes in past year by injury level (no injury, minor, major) + no. of fatalities.

Choice presentation

- Persisted with map
- Crash risk – explained as beyond their control
- Respondents choose option + extent of preference.

Imagine this trip is **to visit friends**

	Route one	Route two
		
Average travel time	24 mins	26 mins
Likelihood of arriving late	20% arrive 7 mins late	50% arrive 3 min late
Congestion	30% of route	10% of route
Trip cost	$7	$4
Crashes per year	30 crashes (with 2 fatalities)	10 crashes (with 5 fatalities)

Strongly prefer route one	Moderately prefer route one	Slightly prefer route one	Slightly prefer route two	Moderately prefer route two	Strongly prefer route two

Beta test feedback

- Maps – simplified helped but uncontrolled attributes still used
- Choice tasks – none thought 8 too many
- Realism – some did not usually experience congestion and other were never late (left early)
- Attributes
  - Number is manageable as those irrelevant were ignored
  - Journey time most important
  - Reliability more visible but not very important
  - Costs higher and considered more
  - Crash risks – some were thinking about impacts on delays.
  - Some needed more info on whether crash rate was high or low.

Attribute levels

- Discussion on whether to increase the levels of crash and injury/fatality risk to ensure people react
  - There is an argument for doing so as respondents will take more account of it. Crash risks are very low.
  - Risk is of “hypothetical bias” – if levels presented deviate too much from reality (including relativity to other attributes), respondent choices are likely to be biased

Pilot test

- 22 face-to-face + 50 on-line
- Choice tasks increased to 10
- Map removed because of the extent to which people were using the map information as an input to their decision.
- The lateness attribute has a standardised % of trips which are late, but the extent of lateness (minutes) varies. Rather than varying both.
- Heavy traffic (congestion) is presented in minutes rather than as a percentage of the trip.
- Crash impacts are presented in terms of
  - the number of fatalities, major and minor injuries on the road per billion kilometres and
  - the comparison in percentage terms to the New Zealand average (for fatalities).

Pilot test presentation

Out of the two alternatives shown, which one would you prefer to take?

Please select one only

	Route one	Route two
 **Average travel time**	20 minutes	40 minutes
 **Lateness**	10% of trips are delayed by 5 minutes	10% of trips are delayed by 10 minutes
 **Heavy traffic**	0%	20%
 **Trip cost**	$9	$3
 **Deaths** (per 100 billion kms travelled)	6 deaths (11% higher than an average NZ highway)	6 deaths (11% higher than an average NZ highway)
 **Serious injuries** (per 100 billion kms travelled)	30	30
 **Minor injuries** (per 100 billion kms travelled)	210	210

Strongly prefer route one	Moderately prefer route one	Slightly prefer route one	Slightly prefer route two	Moderately prefer route two	Strongly prefer route two

Results: Respondent burden

22 face-to-face + 50 online responses

No respondent said:

- Too many attributes
- Too many choice events

No face to face participants lost focus

Conclude: 7 attributes and 10 choice events is acceptable

Results: attribute non-attendance

Attribute not considered	Count
Minor injury	30
Cost	21
Serious injury	20
Fatalities	18
Lateness	15
Heavy traffic	10
Travel time	8

26% considered all attributes when choosing between routes

Reasons for non-attendance

- Too difficult
  - They told us it wasn't
- Don't believe it applies to them (e.g. I'm a safe driver)
  - Address this through improved wording
- Don't care about the attribute (people told us that ignored attributes were not important to them)
  - Manage this through data analysis with an adequate sample and debriefing questions

Crash rates

- Included as “per 100 billion kilometres travelled”
- Many wanted explanation
- Some wanted deaths per year
- Poor comprehension

- Tussle between how people process information and technical requirements to interpret exposure rates.

Benefit estimation

- We developed a novel “split sample” approach to
  - Reduce participant burden

    (because serious and minor injury rates occur in fixed ratios relative to fatalities they do not need to be separate attributes)
  - Simplify the experimental design

Split 1: 1 fatality = 5 serious injuries and 35 minor injuries

Split 2: 1 fatality = 9 serious injuries and 63 minor injuries

The ratio $\frac{\text{Minor}}{\text{Serious}}$ is 7 in both cases

Statistical modelling

Random parameters models

1. Full sample (N=83) and Restricted sample (N=72)
   11 excluded completed in under 5 minutes
2. With and without question order effects

$\Rightarrow$ 4 models estimated

We did not model non-attendance

Willingness to pay estimates
(standard errors in parentheses)

	Full sample with order effects
Travel time ($/hour)	20.34 (3.24)
Lateness ($/hour)	12.00 (2.40)
Heavy traffic ($/percent)	0.174 (0.037)
Statistical life ($m/life)	8.75 (3.01)
Statistical life 95% confidence interval	2.86 ~ 14.64

Disclaimer:
This was a pilot test on a small, non-representative sample.
Do not interpret these results as the NZ VOSL, or use them for policy purposes.

Willingness to pay estimates

(standard errors in parentheses)

	Full sample with order effects	Reduced sample with order effects
Travel time ($/hour)	20.34 (3.24)	20.70 (3.66)
Lateness ($/hour)	12.00 (2.40)	15.36 (2.76)
Heavy traffic ($/percent)	0.174 (0.037)	0.189 (0.044)
Statistical life ($m/life)	8.75 (3.01)	8.29 (4.14)
Statistical life 95% confidence interval	2.86 ~ 14.64	0.16 ~ 16.42

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Willingness to pay estimates
(standard errors in parentheses)

	Full sample with order effects	Reduced sample with order effects	Full sample	Reduced sample
Travel time ($/hour)	20.34 (3.24)	20.70 (3.66)	20.70 (3.42)	20.64 (3.78)
Lateness ($/hour)	12.00 (2.40)	15.36 (2.76)	11.52 (2.52)	14.88 (2.82)
Heavy traffic ($/percent)	0.174 (0.037)	0.189 (0.044)	0.176 (0.039)	0.190 (0.047)
Statistical life ($m/life)	8.75 (3.01)	8.29 (4.14)	8.82 (3.07)	9.76 (3.65)
Statistical life 95% confidence interval	2.86 ~ 14.64	0.16 ~ 16.42	2.80 ~ 14.85	2.61 ~ 16.91

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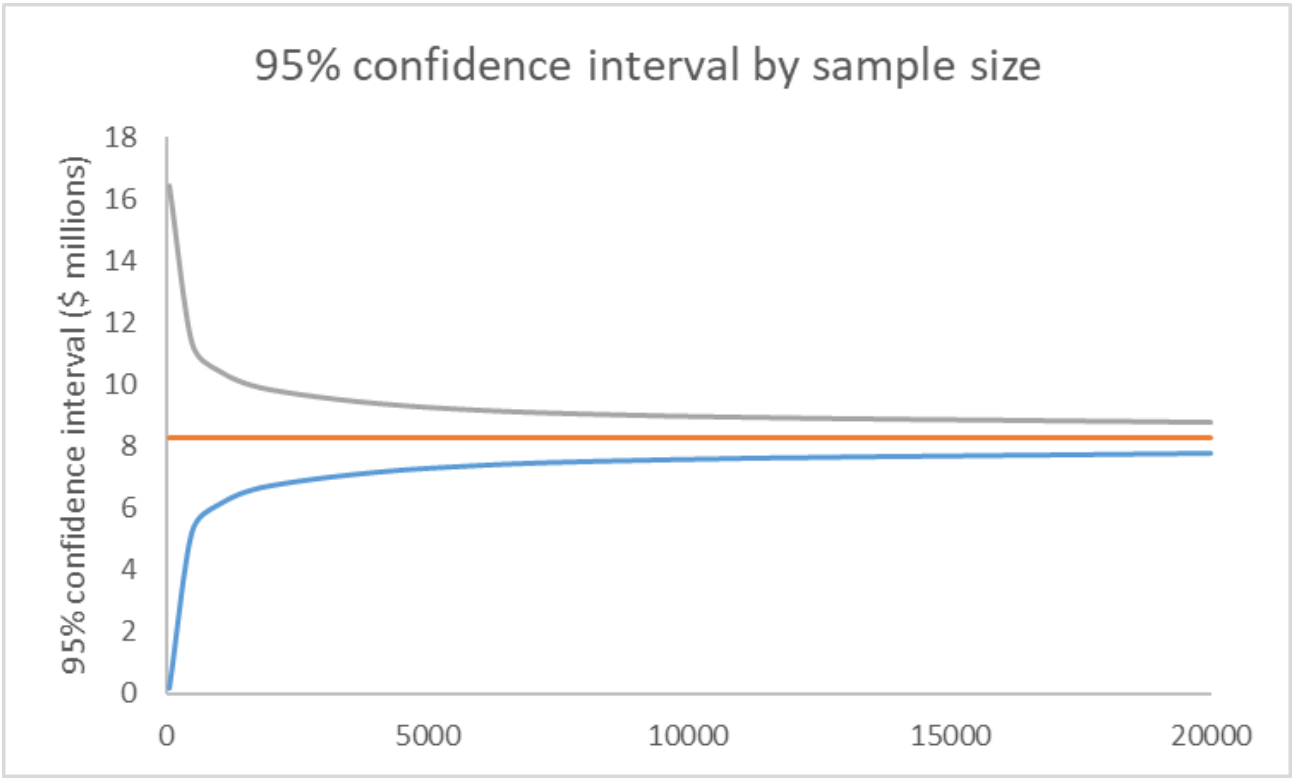
Sample size

Increasing the sample size improves precision

For model 2: Mean VOSL = $8.29m

N	72	500	1000	2000	5000	10000	20000
SEM ($m)	$4.15	$1.57	$1.11	$0.79	$0.50	$0.35	$0.25
CV	50%	19%	13%	10%	6%	4%	3%



Conclusions

An overall success

- Survey design worked well
- The experimental design was effective
- The split sample method was a success
- Insensitive to model assumptions
- Needs work on attribute level acceptance and risk communication

Areas requiring further consideration in future survey

- Valuation of changes to very low risk events – issues with realism and comprehension
- Improving survey context setting (eg trip characteristics, purposes and types)
- Valuation of individual vs societal preferences (eg risk to self versus risk to household, others in vehicle or society)
- Face-to-face vs on-line.
  - Face-to-face better enables explanation of complex issues but costs are orders of magnitude higher.
  - Hybrid options may be possible, eg phone + online or online plus video