Valuing health & longevity

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Outline

- Principals
  - Individuals' money values of (small) changes in own health risk
- Mortality
  - Theory
  - Mortality risk v. life expectancy
  - Estimates
    - Revealed preference, stated preference
    - Value transfer
  - Recommendations
- Morbidity
  - Components: utility loss, cost of illness
  - Recommendations

Principals

- Monetary value =
  - amount of money (which can be spent as desired)
  - that has same effect on wellbeing as change in health or longevity
  - for an individual (or household)
- Monetary value often reported as rate of substitution between money and change in health risk (in period) or longevity
  - Usually value small changes
    - Relevant to many policy decisions
- Monetary values are individual-specific
  - Depend on current income, wealth, age, household structure, …
    - and on anticipated future income, health, …
  - For children: use parent's value as proxy
    - Children are not autonomous agents
    - Parents often make decisions on their behalf

Valuing mortality & longevity risk

- Mortality hazard function
  = probability of death at each age (if still living)
- Survival function
  = probability of remaining alive at each age
- Life expectancy
  = area under the survival function; average longevity

Clean city

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Polluted city

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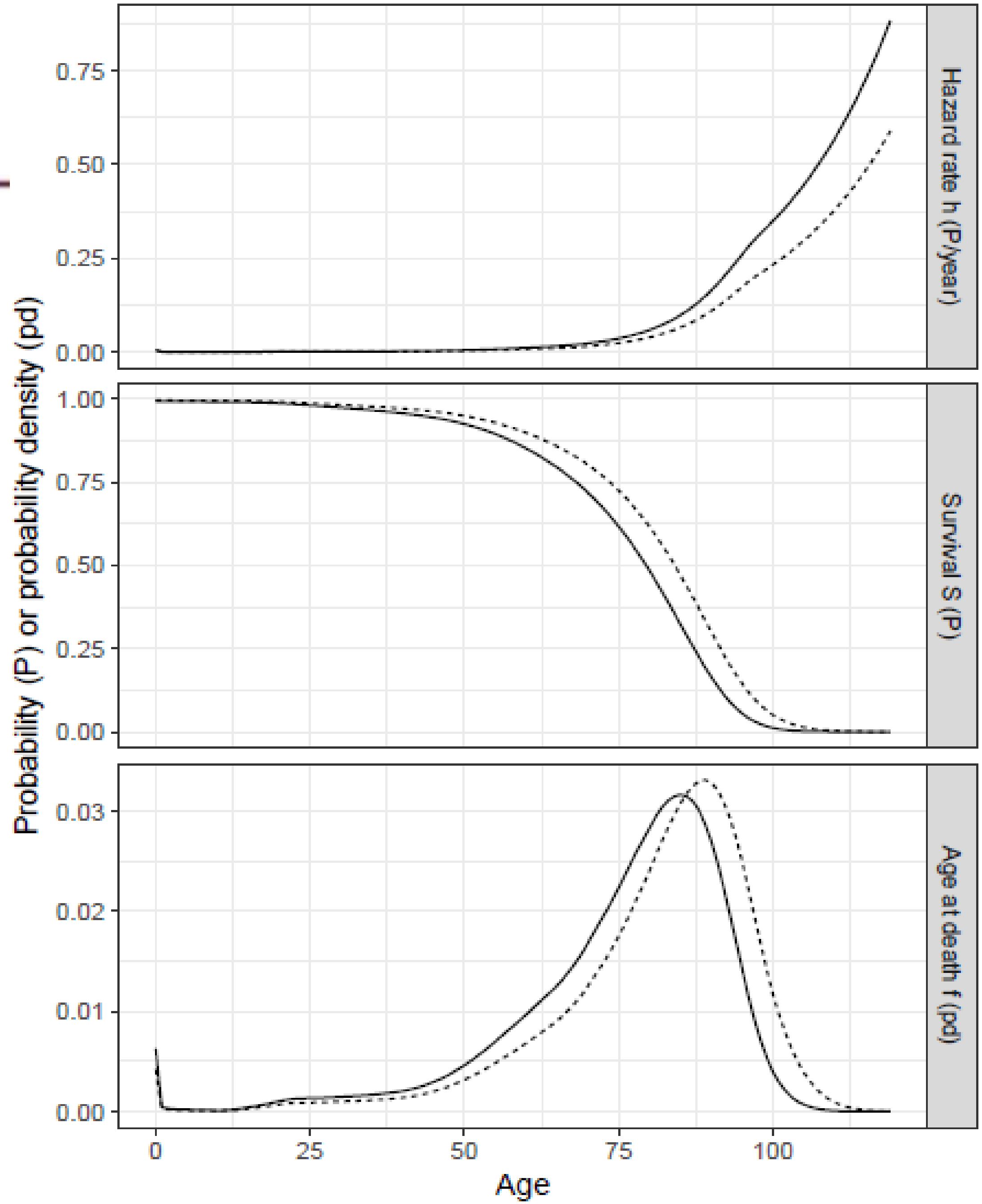


Hazard

Survival

Age of death (probability)

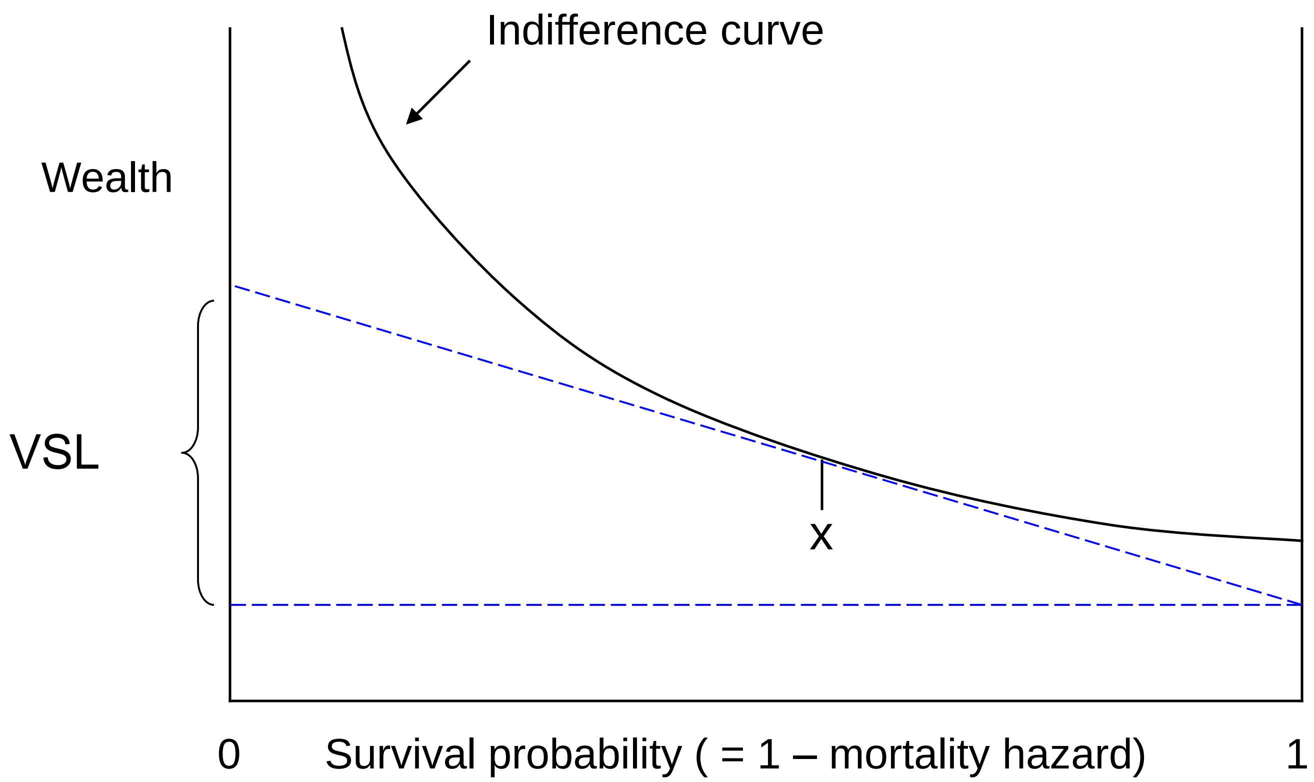
Valuing mortality & longevity risk

- Any reduction in mortality hazard
  - Increases chance of surviving to all older ages
  - Increases life expectancy
- Monetary value of a reduction in mortality hazard function can be described as
  - 'Value per statistical life' (VSL)
    - = Money value / increased chance of surviving specified period
      - Depends on specified time period (hour, year, century)
  - 'Value per statistical life year' (VSLY)
    - = Money value / increase in life expectancy
  - VSL and VSLY both depend on initial hazard function and how it changes
    - Large hazard reduction for a few years or smaller reduction for many years can produce same gain in life expectancy, may be valued differently

Value per statistical life

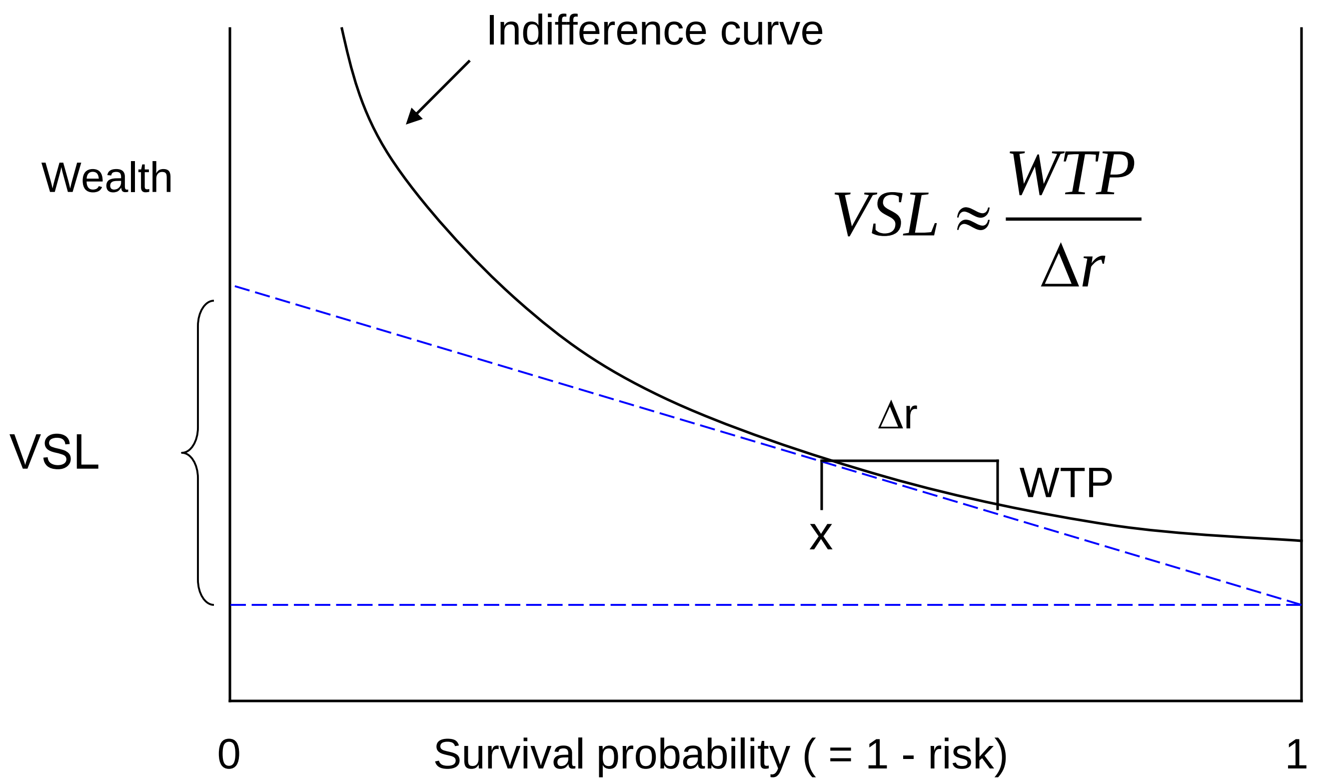
- Conventionally defined as money value of small change in current hazard (e.g., for current year)
  - WTP: willingness to pay
    - For a risk reduction
    - Or to prevent a risk increase
  - WTA: willingness to accept compensation
    - For a risk increase
    - Or to forgo a risk reduction
- Units: dollars per unit change in probability (0 to 1)
  - Alternatives:
    - Value per standardized mortality unit (VSMU, 1/10,000 change)
    - Value per micromort (1/1 million change)

VSL = slope

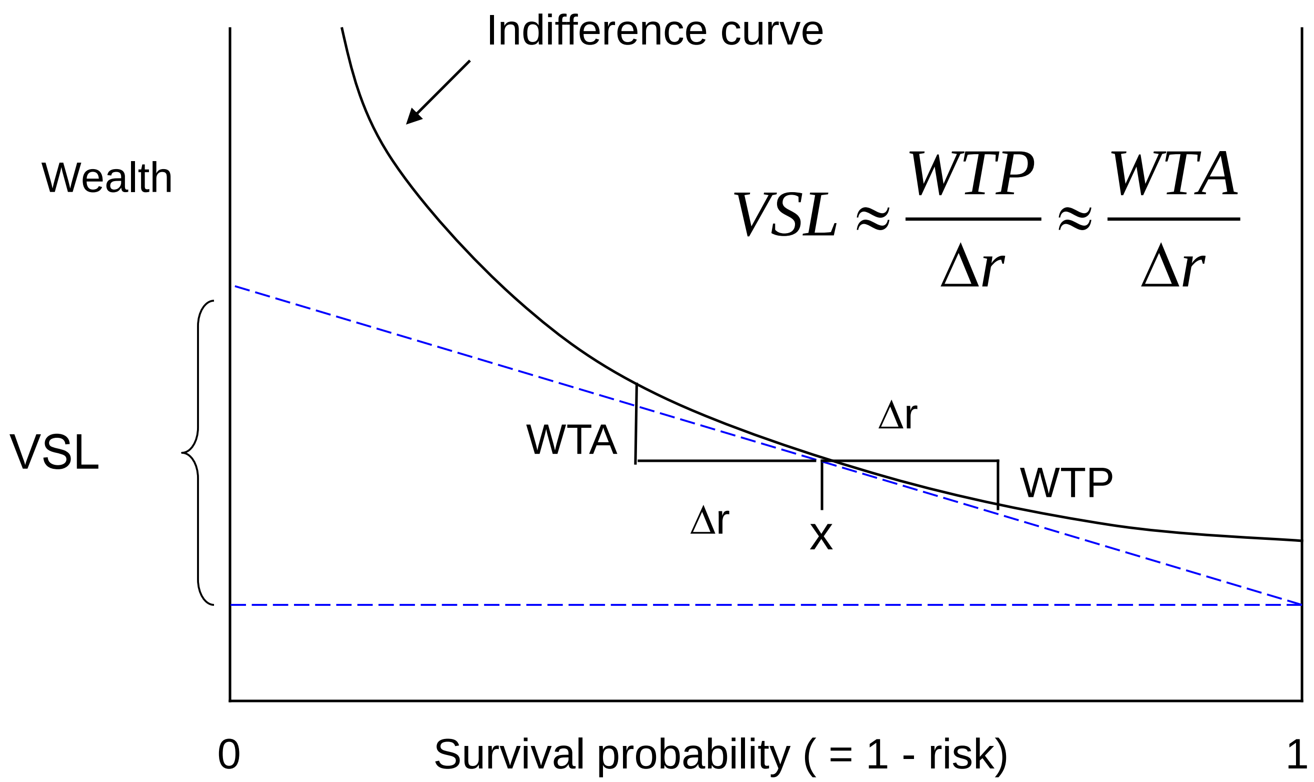


Indifference curve
Wealth
VSL
x
0
Survival probability (= 1 – mortality hazard)
1

VSL = slope


Indifference curve
Wealth
$VSL \approx \frac{WTP}{\Delta r}$
VSL
Δr
WTP
x
0
Survival probability (= 1 - risk)
1

VSL = slope



$$VSL \approx \frac{WTP}{\Delta r} \approx \frac{WTA}{\Delta r}$$

Value per statistical life year

- VSLY = money value of change in hazard / increase in life expectancy
- For reduction in current-year hazard
  - VSLY = VSL / (life expectancy if survive current year)
  - VSL = VSLY x (life expectancy if survive current year)
- If VSL not very sensitive to age
  - VSLY increases with age (as life expectancy decreases)
- If VSLY not very sensitive to age
  - VSL decreases with age (as life expectancy decreases)
- Empirically, VSL rises then falls with age
  - Suggests VSLY rises over younger ages
    - Some evidence suggests VSLY falls over older ages

Total value of a change in population risk = sum of individual values

- Total value = sum of (individual VSL x individual risk reduction)

  $= \sum_{i=1}^{n}(VSL_i \cdot \Delta r_i)$

- ≈ average VSL x sum of (individual risk reductions)

  $\approx \overline{VSL} \sum_{i=1}^{n} \Delta r_i$

  Approximation is exact if individual VSLs and risk reductions are uncorrelated

- = average VSL x expected number of 'lives saved'

  'Lives saved' = deaths postponed to later periods

  $= \overline{VSL} \cdot E(lives\ saved)$

VSL (& VSLY) depend on

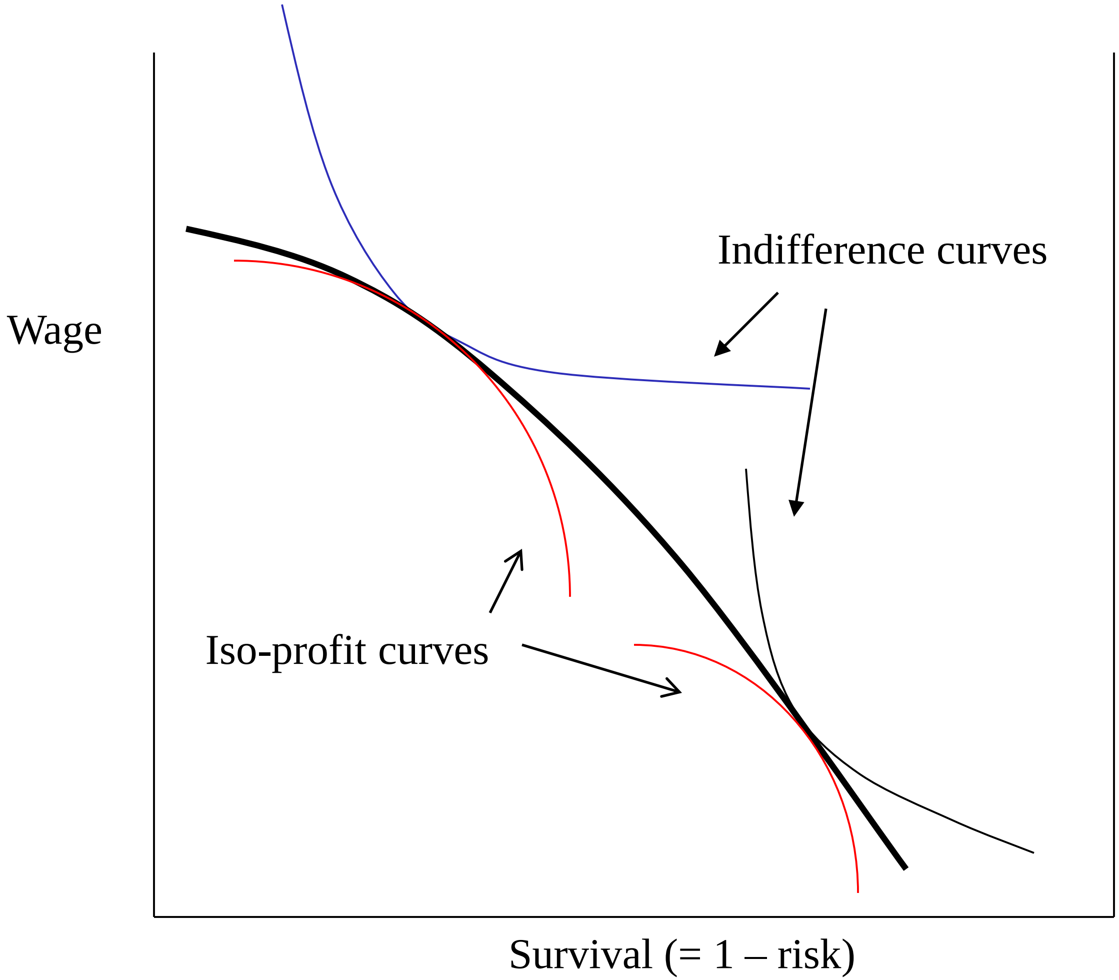
- Individual characteristics
  - Wealth & income
    - We know something about how to adjust for this
  - Age & life expectancy
    - Conflicting evidence, we suggest crude sensitivity analysis
  - Health
  - Household size & composition
- Social or cultural characteristics
  - Preferences for allocating resources to self v. family or community
- Risk characteristics
  - Traumatic injury v. chronic disease
- Other factors?

Empirical estimates of VSL (or VSLY)

- Revealed preference
  - Observe behavior, assume people prefer the choice they make
    - Alternative choices may not be observable, must be assumed
    - Need to
      - assume individuals knew attributes of alternatives
      - statistically control for other factors that differ between alternatives
    - Applicable only when preferences leave a 'behavioral trace'
  - Compensating wage differentials for occupational fatality risk
    - A few studies on choice of motor-vehicles, smoke detectors, bicycle helmets, residential location
- Stated preference
  - Survey people about behavior in hypothetical choices
    - Very flexible (context, hypothetical interventions)
    - Provide information to respondents about the alternatives
    - Respondents may have limited knowledge of how they would choose, limited incentive to answer accurately

Compensating wage differentials

- Wages depend on:
  - Productivity of worker in job
    - Worker characteristics (e.g., education, strength)
    - Type of job (e.g., capital equipment)
  - Other factors (e.g., unionization, discrimination, beauty)
- Compensation for
  - Workplace health risk
  - Other job conditions
  - "The wages of labor vary with the ease or hardship, the cleanliness or dirtiness, the honorableness or dishonorableness of the employment" (Adam Smith, 1776)
- Workers select preferred job from those available



Indifference curves
Wage
Iso-profit curves
Survival (= 1 – risk)

Compensating wage differentials

- log (wage) = constant
  + γ occupational fatality risk
  + δ occupational injury risk
  + β human capital & other factors
  + ε
- VSL = d(wage)/d(fatality risk)
  = γ x annual wage / risk increment

Fatality risk γ	0.0017	0.0032
Injury risk δ	0.2702	
VSL	$4.7 million	$8.9 million
VS Injury	$9600	
Viscusi, *Economic Inquiry* (2004)		

Stated preference

- Determine how people would behave in a hypothetical market or referendum
  - Market — purchase a good
  - Referendum — vote on a ballot proposition
  - Scenario should be credible
    - Economic good and the consequences of providing it
    - Payment mechanism
  - Extremely flexible
  - Intuitive
- Quality is controversial
  - Hypothetical choice — little incentive to choose carefully, report truthfully
  - Framing — response can be sensitive to how the question is asked
- Contingent valuation: 2 options
- Choice experiments: > 2 options

(In)sensitivity to scope

- Imagine that you have been asked to make a long coach trip in a foreign country. You have been given £200 for your travelling expenses and given the name of a coach service which will take you for exactly £200. The risk of being killed on the journey with this coach firm is 8 in 100,000.
- You can choose to travel with a safer coach service if you want to, but the fare will be higher, and you will have to pay the extra cost yourself.
  - (a) How much extra, if anything, would you be prepared to pay to use a coach service with a risk of being killed of 4 in 100,000 — that is half the risk of the one at £200?
  - (b) How much extra, if anything, would you be prepared to pay to use a coach service with a risk of being killed of 1 in 100,000 — one eighth the risk of the one at £200?
- Note: open-ended response

(In)sensitivity to scope

	(a)	(b)
Risk reduction	4/100,000	7/100,000
Mean WTP	£137	£155
VSL	£3.4 million	£2.2 million
Median WTP	£50	£50
VSL	£1.2 million	£0.7 million

42% of respondents would pay same amount for each good
(8% would pay more for the smaller benefit)

Jones-Lee, Hammerton and Philips, *Economic Journal* 1985

Insensitivity to scope can be alleviated using visual aids to explain risk change

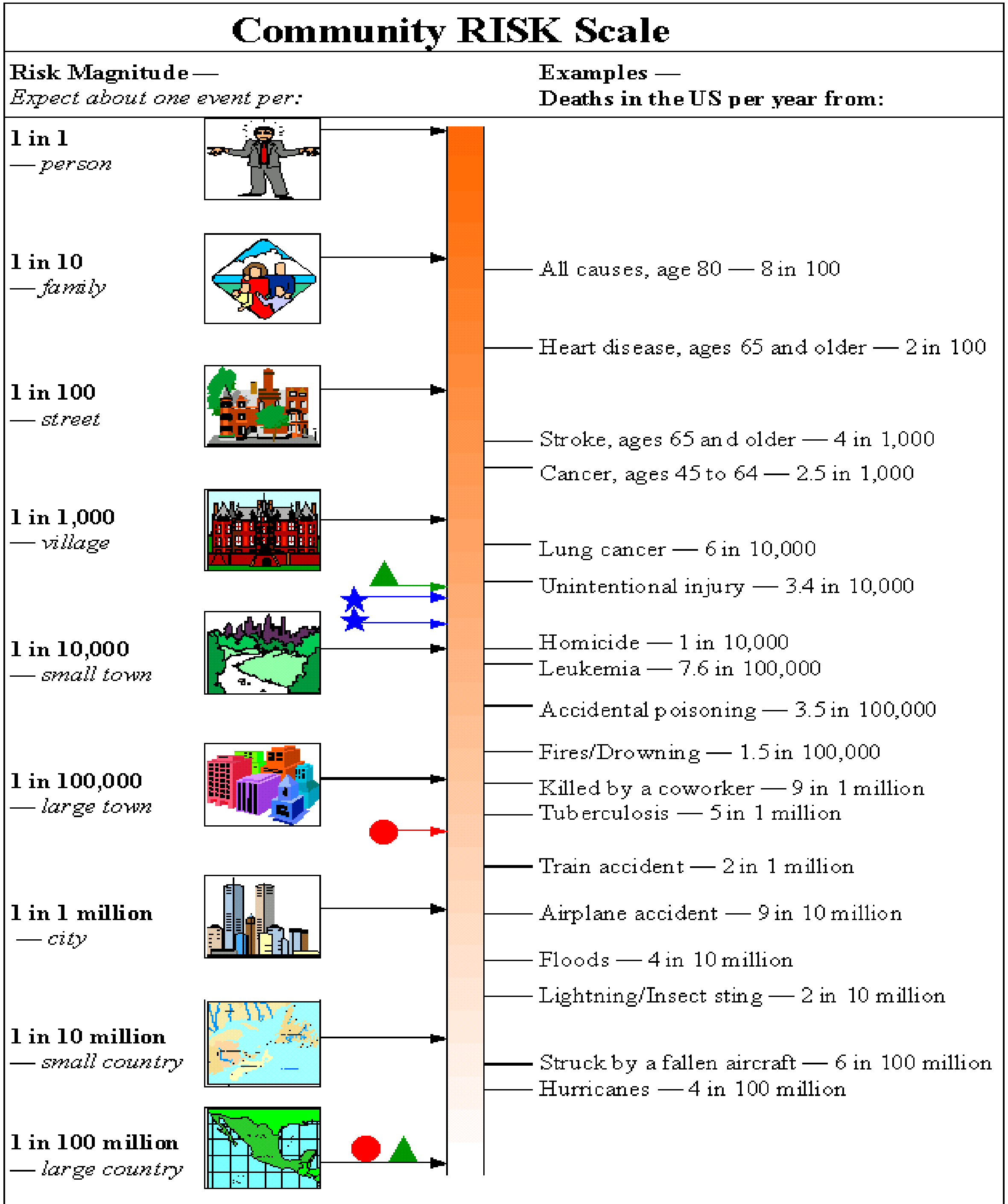
Now I would like to ask you a question about your willingness to pay money for a new safety device that can be installed in cars to protect drivers. It works like an airbag but protects drivers in a side impact rather than in a head-on crash. This device is well tested, safe and reliable. For the typical driver, this new device will reduce the yearly chance of dying in a crash from 2 in 10,000 to 1.5 in 10,000. On your visual aid, a 1.5 in 10,000 risk is equal to about 4 dots on the page. Thus, by adding a side-impact airbag, your risk is reduced from 2 in 10,000, or 5 dots on the page -- to 1.5 in 10,000, or about 4 dots on the page.

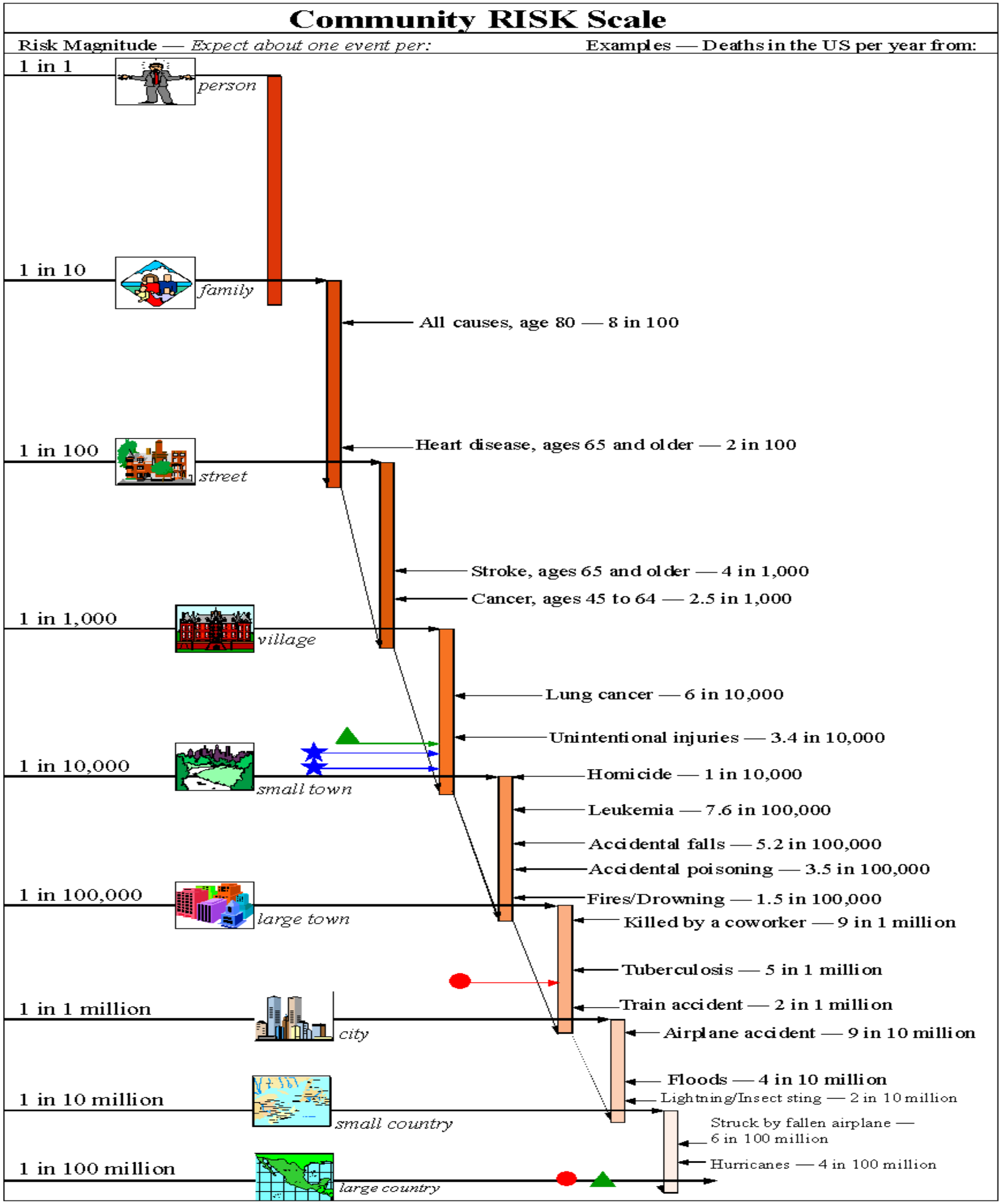
If this device were offered as an option on the next car you buy, would you be willing to pay $100 more per year in car payments for five years to have this device in your car?

Corso, Hammitt & Graham, *Journal of Risk & Uncertainty* 2001

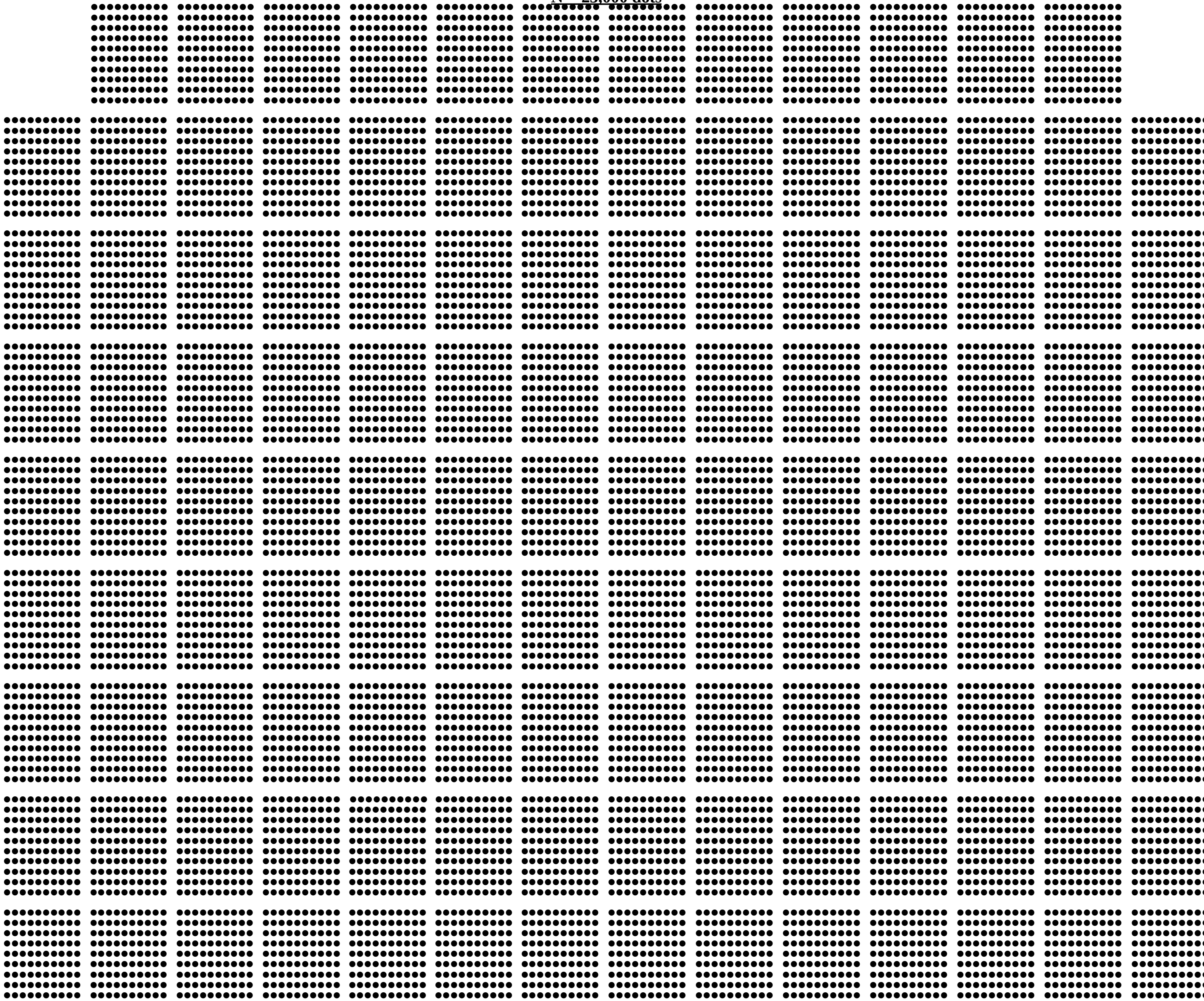
Insensitivity to scope can be alleviated using visual aids to explain risk change

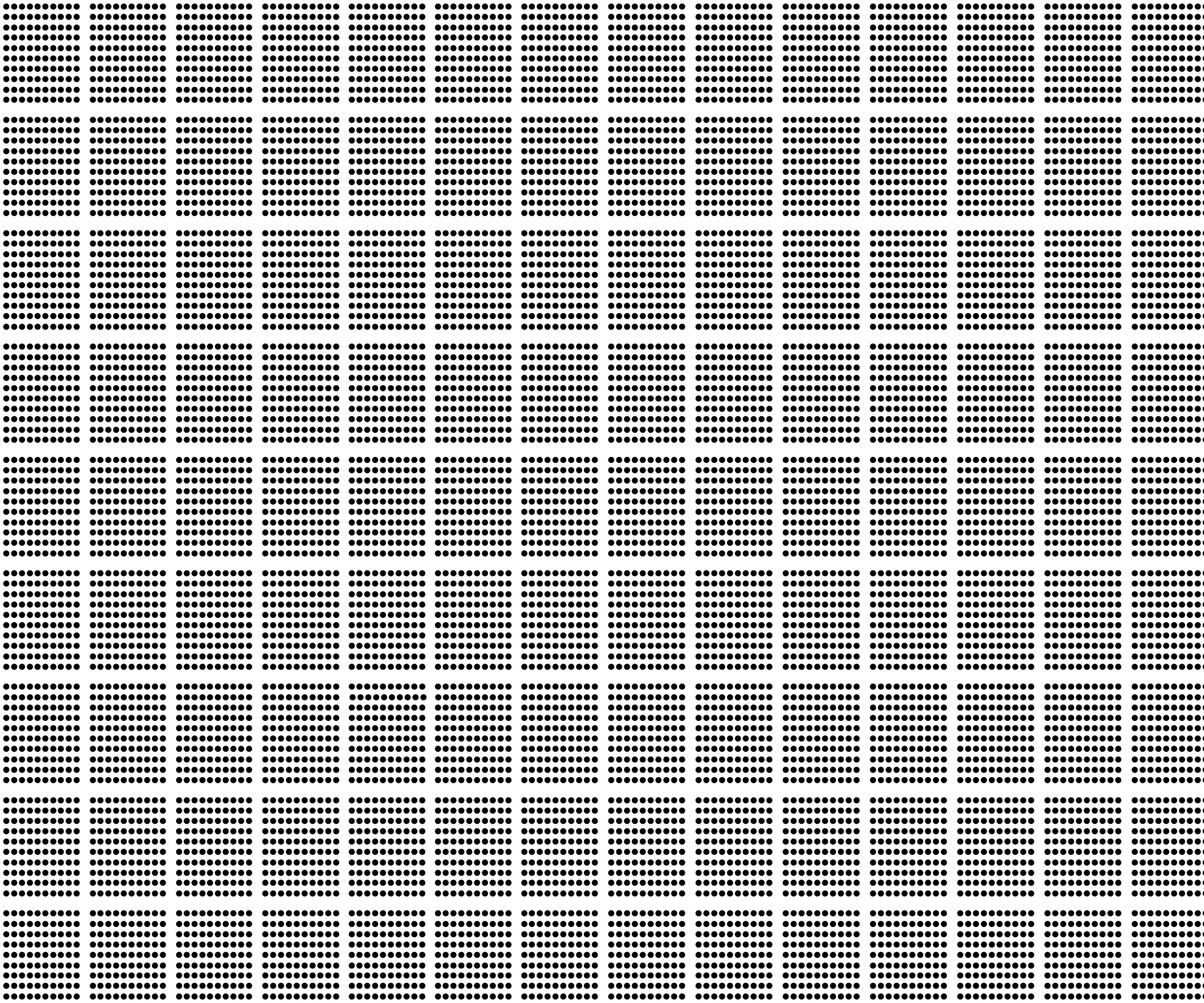
	No Aid	Linear	Log	Dots
WTP (small, large)	$235 $250	$270 $383	$195 $299	$164 $323
Ratio	1.06	1.42	1.54	1.97
VSL (millions)	$4.7 $2.5	$5.4 $3.8	$3.9 $3.0	$3.3 $3.2
Sensitive?	no	yes	yes	yes
Proportional?	no	no	yes	yes


Community RISK Scale
Risk Magnitude —
Expect about one event per:
Examples —
Deaths in the US per year from:
1 in 1
— person
1 in 10
— family
1 in 100
— street
1 in 1,000
— village
1 in 10,000
— small town
1 in 100,000
— large town
1 in 1 million
— city
1 in 10 million
— small country
1 in 100 million
— large country
All causes, age 80 — 8 in 100
Heart disease, ages 65 and older — 2 in 100
Stroke, ages 65 and older — 4 in 1,000
Cancer, ages 45 to 64 — 2.5 in 1,000
Lung cancer — 6 in 10,000
Unintentional injury — 3.4 in 10,000
Homicide — 1 in 10,000
Leukemia — 7.6 in 100,000
Accidental poisoning — 3.5 in 100,000
Fires/Drowning — 1.5 in 100,000
Killed by a coworker — 9 in 1 million
Tuberculosis — 5 in 1 million
Train accident — 2 in 1 million
Airplane accident — 9 in 10 million
Floods — 4 in 10 million
Lightning/Insect sting — 2 in 10 million
Struck by a fallen aircraft — 6 in 100 million
Hurricanes — 4 in 100 million


Community RISK Scale
Risk Magnitude — Expect about one event per:
Examples — Deaths in the US per year from:
1 in 1
person
1 in 10
family
All causes, age 80 — 8 in 100
1 in 100
street
Heart disease, ages 65 and older — 2 in 100
Stroke, ages 65 and older — 4 in 1,000
Cancer, ages 45 to 64 — 2.5 in 1,000
1 in 1,000
village
Lung cancer — 6 in 10,000
Unintentional injuries — 3.4 in 10,000
1 in 10,000
small town
Homicide — 1 in 10,000
Leukemia — 7.6 in 100,000
Accidental falls — 5.2 in 100,000
Accidental poisoning — 3.5 in 100,000
Fires/Drowning — 1.5 in 100,000
1 in 100,000
large town
Killed by a coworker — 9 in 1 million
Tuberculosis — 5 in 1 million
Train accident — 2 in 1 million
1 in 1 million
city
Airplane accident — 9 in 10 million
Floods — 4 in 10 million
Lightning/Insect sting — 2 in 10 million
1 in 10 million
small country
Struck by fallen airplane — 6 in 100 million
Hurricanes — 4 in 100 million
1 in 100 million
large country

N = 25,000 dots





Value transfer

- Extrapolate values measured in one context to different context, adjusting for relevant differences
  - Base VSL from US or other high-income countries
  - Adjust for income difference
  - Insufficient information to adjust for other factors

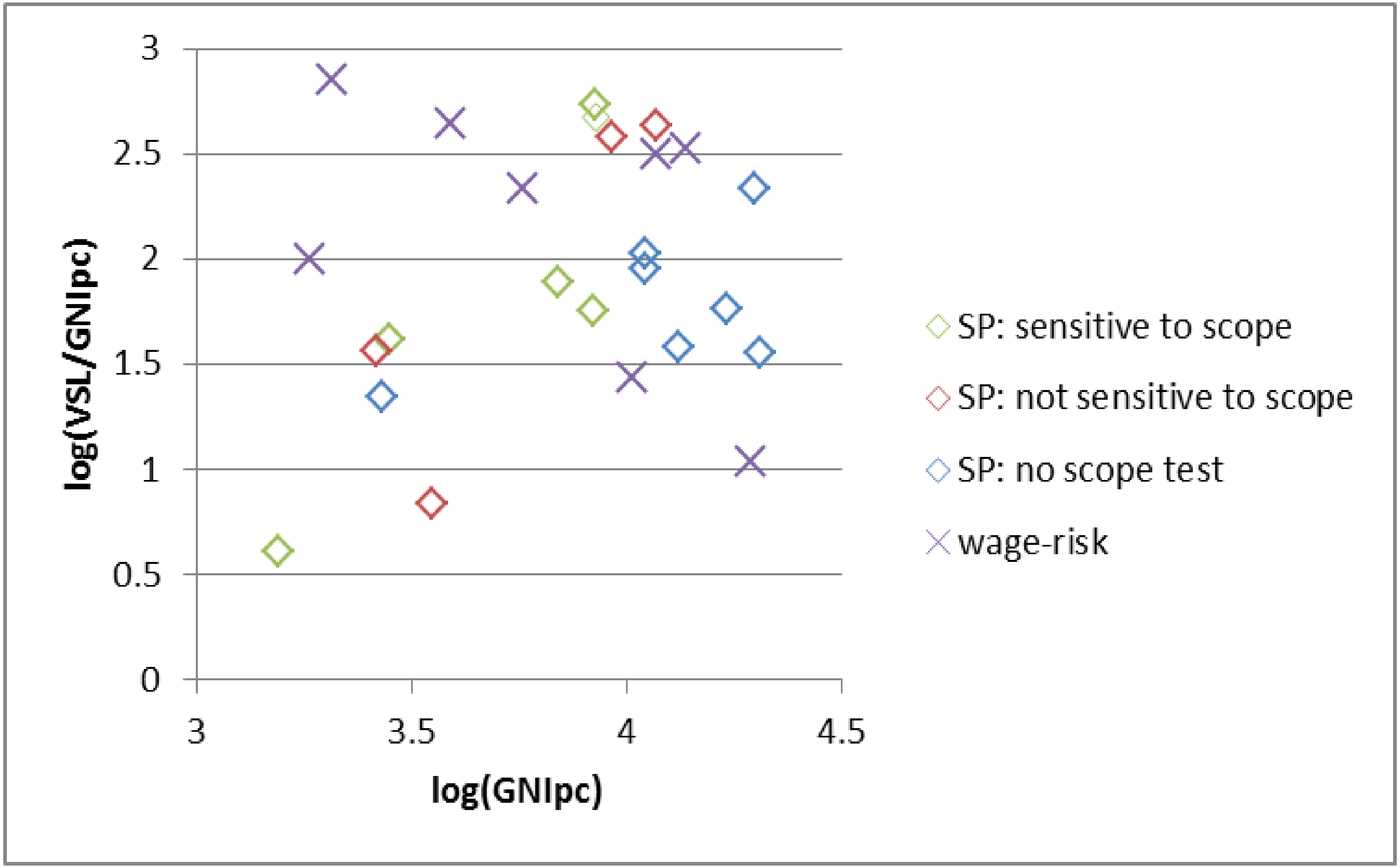
Adjusting for income

- $VSL_1/VSL_0 = (Income_1/Income_0)^{elasticity}$
- $VSL_1/income_1 = (VSL_0/Income_0)^{(elasticity - 1)}$
  - Elasticity = 1
    - VSL changes in proportion to income
    - VSL/income is independent of income
  - Elasticity < 1
    - VSL changes more slowly than income
    - VSL/income increases as income falls
  - Elasticity > 1
    - VSL changes more quickly than income
    - VSL/income decreases as income falls
- Empirically, elasticity ≥ 1

Direct estimates in LMICs

- Searched for studies conducted in LMICs
  - General adult population
    - Probabilistic (not convenience) sample
    - WTP to reduce own risk
  - Data collected in past 20 years (1997 – present)
  - Written in English
- 25 studies
  - 8 revealed preference (wage differential)
  - 17 stated preference studies (18 estimates)
    - 9 of 18 tested whether willingness to pay increases with risk reduction
    - 5 of 9 found a statistically significant increase

VSL / GNIpc vs. GNIpc
(not adjusted to common year)



Recommendations: level of VSL

- If high-quality direct estimates exist, use them
  - Requires multiple high-quality studies
- Otherwise (or as sensitivity analysis) extrapolate from high-quality estimates (in high-income country)
  - Adjust for income, using GNI per capita as measure
    - GNI per capita is broad measure, available for all countries
    - PPP (value of risk reduction relative to other costs of living)
  - a) VSL extrapolated from a U.S. estimate to the target country applying an income elasticity of 1.5
    - a) Bound result to VSL / GNI per capita ≥ 20
  - b) VSL = 100 * GNI per capita in the target country.
  - c) VSL = 160 * GNI per capita in the target country.
- Option (a) preferred; elasticity > 1 more plausible
  - Options (b) and (c) designed to align results with ranges applied in other research and for sensitivity analysis

Examples of extrapolated VSL estimates

Approach	GNI per Capita (2015 international dollars)					
	$1,000	$5,000	$10,000	$15,000	$20,000	$25,000
a) Reference ratio=160 Elasticity=1.5	$0.021 million (21*GNI per capita)	$0.24 million (48*GNI per capita)	$0.67 million (67*GNI per capita)	$1.2 million (83*GNI per capita)	$1.9 million (95*GNI per capita)	$2.7 million (110*GNI per capita)
b) Reference ratio=100 Elasticity=1.0	$0.10 million (100*GNI per capita)	$0.50 million (100*GNI per capita)	$1.0 million (100*GNI per capita)	$1.5 million (100*GNI per capita)	$2.0 million (100*GNI per capita)	$2.5 million (100*GNI per capita)
c) Reference ratio=160 Elasticity=1.0	$0.16 million (160*GNI per capita)	$0.80 million (160*GNI per capita)	$1.6 million (160*GNI per capita)	$2.4 million (160*GNI per capita)	$3.2 million (160*GNI per capita)	$4.0 million (160*GNI per capita)

Adjusting for age or life-expectancy

- Evidence from high-income countries suggests:
  - Values for children may be as much as 2x values for average-aged adults
  - Values for working age adults may follow an inverse-U pattern, peaking in middle age
  - Values for older adults may remain the same or decline
- Little is known about the extent to which values in low- or middle-income countries follow this pattern

Recommendation: adjusting for age

- If policy disproportionately affects very young or very old
  - Conduct sensitivity analyses using constant VSLY
  - Calculate constant VSLY by dividing the population-average VSL by life expectancy at the average age of adult population
  - Multiply the resulting VSLY by the expected life year gain attributable to the policy
    - VSL proportional to life expectancy, declines with age
- If policy affects stillbirths, miscarriages, etc., explore the implications of assigning positive values to reducing prenatal risk

Nonfatal health risks

- Analogous to fatal risks, except three loss components
  1. Pure utility loss (pain & suffering)
  2. Lost productivity
     - Labor force or household
     - Born by individual, employer, insurer (government)
  3. Health-care resources consumed
     - Medical costs (doctors, nurses, medicines, etc.)
     - Caregivers costs (other household members)

  — For fatal risks, 1 and 2 included in VSL, 3 assumed negligible
- Cost of illness approach quantifies 2 & 3, omits 1

Recommendation: nonfatal risks

- If high-quality direct estimates exist, use them
  - Very unlikely:
    - Non-fatal health effects are extremely diverse
    - Few high-quality estimates exist for high-income countries
  - Add costs born by others (e.g., medical cost, wage insurance)
- Otherwise, use cost of illness
  - Costs of care, productivity loss
  - As sensitivity analysis, estimate utility loss using quality-adjusted life years (loss of health quality x duration) multiplied by a constant value per QALY (or VSLY)
    - Be careful of double counting: treatment or productivity costs born by individual may be included in estimates of utility loss