The Benefit-Cost Analysis Reference Case:
What It Is and How to Use It

Valuing Statistical Lives

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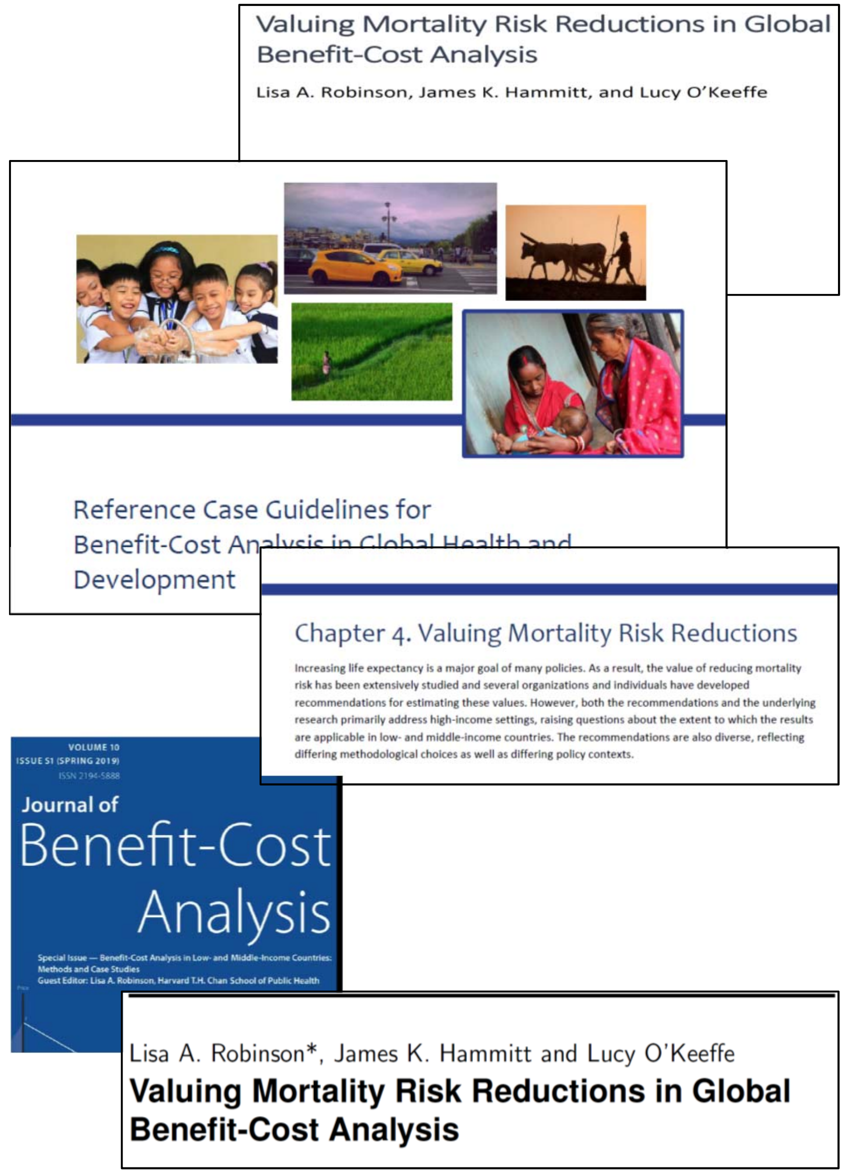

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Concepts and Definitions

What is a statistical life?

- “Statistical” = a sum of probabilities.
  - If a policy reduces the mortality risk of 10,000 individuals by 1 in 10,000 in the current year, then one fewer death (10,000 * 1/10,000) is expected in that year.
- Specific individuals who would die in the absence of the policy typically cannot be identified either before or after the policy is implemented.

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Concepts and Definitions

Value per Statistical Life (VSL) =

- Individual rate of tradeoff between small changes in own mortality risk and own spending on other goods and services, within a defined time period.

➢ ***Not*** the value that the individual, the government, the society, or the analyst places on saving a life with certainty.

Concepts and Definitions

- VSL = individual willingness to pay (WTP) for a small annual risk change divided by the risk change.
  - If $900 = individual WTP for a 1/10,000 annual change in mortality risk,
  - then VSL = $9 million ($900 ÷ 1/10,000).
- If aggregated throughout a population:
  - If $900 = average individual WTP for a 1/10,000 annual change in mortality risk,
  - 10,000 = number of individuals experiencing the risk reduction,
  - then 1 = number of statistical cases averted (1/10,000 * 10,000),
  - and value = $900 * 10,000 = $9 million.

Concepts and Definitions

- What is wrong with the following statement?
  - "The VSL is the value that the government places on my life."
- Do we need different terminology?
  - The value of prevented fatality (VPF) (e.g., UK Green Book 2011).
  - The value of a standardized mortality unit (VSMU) (Jamison et al. 2013).
  - The value of reduced mortality risk (VRMR) (Simon et al. 2019).

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Estimation Methods

- Rely on market data where possible for valuation.
  - Presumably, if an individual chooses to buy a good or service, he or she values it more than the other things the money could buy.

- For nonmarketed goods, use stated or revealed preference methods.
  - *Stated preferences* - ask respondents to indicate what they would be willing to pay under hypothetical scenarios (contingent valuation, choice experiments).
  - *Revealed preferences* – use data on market transactions or observed behavior to estimate value, controlling for other attributes statistically.

Estimation Methods: Human Capital

Economic Productivity by Age and Sex

2007 Estimates for the United States

Scott D. Grosse, PhD, Kurt V. Krueger, PhD,† and Mercy Mvundura, PhD‡*

TABLE 3. Present Value of Lifetime Production and Market Production of the US Total Population, by Discount Rate, Gender, and Age (2007 Dollars)

	Total Production			Market Production		
Gender	0%	3%	5%	0%	3%	5%
All						
0–4	4,250,131	1,180,796	568,817	2,797,829	820,892	399,300
5–9	4,053,773	1,305,510	692,331	2,668,568	907,594	486,006
10–14	3,859,627	1,440,960	841,290	2,540,763	1,001,759	590,572
15–19	3,655,929	1,568,602	999,322	2,410,700	1,095,522	706,799
20–24	3,400,833	1,641,026	1,119,137	2,247,367	1,155,188	801,954
25–29	3,066,764	1,624,222	1,164,022	2,018,593	1,143,413	836,799
30–34	2,668,817	1,521,239	1,130,428	1,740,024	1,066,036	811,878
35–39	2,255,431	1,370,828	1,051,137	1,449,007	953,402	753,219
40–44	1,848,231	1,189,228	937,939	1,155,745	811,433	663,233
45–49	1,463,947	991,366	802,484	872,584	650,305	549,054
50–54	1,108,499	783,529	648,498	604,449	474,216	412,136
55–59	793,170	578,492	486,469	367,664	299,707	[illegible]
60–64	537,375	399,419	338,632	187,398	155,629	[illegible]
65–69	359,674	271,286	230,954	81,539	66,496	[illegible]
70–74	252,923	197,093	170,533	42,140	34,404	[illegible]
75–79	175,067	140,804	123,803	22,951	16,960	[illegible]
80 and over	122,272	101,525	90,738	8921	7739	[illegible]

U.S. population-average VSL for individuals of about the same age (in the same dollar year - 2007) was around $8 million.

What are the advantages and limitations of using human capital estimates in benefit-cost analysis?

Estimation Methods

Nonmarket Valuation

- Cannot be fully valued based on market prices.
  - Human capital method focuses solely on lost productivity; ignores other factors that influence individual WTP.
- Individuals' WTP presumably encompasses all impacts of the risk change on their wellbeing:
  - Pecuniary effects, such as avoided or delayed out-of-pocket medical costs and losses in future earnings.
  - Non-pecuniary effects, such as continuing to experience the joys of life itself and delaying the pain and suffering associated with dying.
  - Spending while alive versus bequeathing money to others at death.
- Values vary across individuals and across different types of risk; there is no single value that is applicable to all contexts.

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Estimation Methods: Revealed Preferences

- **Averting behavior studies**: estimate WTP based on trade-off between money and/or time and protective measures (products or behaviors).
  - Rarely recommended for use in policy analysis; require strong assumptions.
- **Wage-risk studies** (a.k.a. hedonic wage or compensating wage differential studies): estimate WTP based on trade-off between wages and job-related risks.
  - Frequently used as basis for recommended U.S. estimates.

Estimation Methods: Revealed Preferences

Averting Behavior Studies

- Trade-off between money and/or time and protective measures (products or behaviors).
  - Examples: bike helmets, seat belts, air bags, smoke detectors, driving speed.
- Need to tease out value of risk reductions from other attributes that affect price or time costs.
  - Requires assumptions about perceived risk, value of time, and other factors.
  - Intuitively attractive, but validity unclear.

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Estimation Methods: Revealed Preferences

Wage-Risk Studies*

- Estimates WTP based on trade-off between wages and job-related injuries, by industry and/or occupation.
- Uses statistical (econometric) analysis to control for other influencing factors:
  - individual characteristics (e.g., age, race, gender, education, marital status);
  - workplace characteristics (e.g., unionization, nonfatal injuries, workers’ compensation).

* Also known as compensating wage differential or hedonic wage studies.

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Estimation Methods: Stated Preferences

- **Contingent valuation**: typically elicits WTP for a particular scenario or outcome.
- **Choice experiment**: presents respondents with several scenarios involving different amenities or attributes and prices. Derives WTP from the way in which respondents rank, rate, or construct equivalent sets of alternatives.

➢ Because choices are hypothetical, require careful design and analysis to encourage and confirm validity of responses.

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Estimation Methods: Stated Preferences

Contingent Valuation

Valuing Mortality-Risk Reduction: Using Visual Aids to Improve the Validity of Contingent Valuation

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"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 [$50, $200] more per year in car payments for five years to have this device in your car?"

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Estimation Methods: Stated Preferences

Choice Experiments

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Economics and Management

journal homepage: www.elsevier.com/locate/jeem

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Demand for health risk reductions ☆

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Appendix A

Example: One of the 11,385 randomized choice sets.

Choose the program that reduces the illness that you most want to avoid. But think carefully about whether the costs are too high for you. If both programs are too expensive, then choose Neither Program.

If you choose "neither program", remember that you could die early from a number of causes, including the ones described below.

	Program A for Heart Disease	**Program B for Colon Cancer**
Symptoms/ Treatment	Get sick when 71 years old 2 weeks of hospitalization No surgery Moderate pain for remaining life	Get sick when 68 years old 1 month of hospitalization Major surgery Severe pain for 18 months Moderate Pain for 2 years
Recovery/ Life expectancy	Chronic heart condition Die at 79	Recover at 71 Die of something else at 73
Risk Reduction	5% From 40 in 1,000 to 38 in 1,000	50% From 4 in 1,000 to 2 in 1,000
Costs to you	$15 per month [= $180 per year]	$4 per month [= $48 per year]
Your choice	**Reduce my chance of heart disease**	**Reduce my chance of colon cancer**

Neither Program

Recommended Values

Benefit Transfer

(1) DESCRIBE THE POLICY OUTCOME

Identify the characteristics of the risk and the population addressed.

↓

(2) IDENTIFY POTENTIALLY RELEVANT EXISTING VALUATION RESEARCH

Search the valuation literature for primary research studies that address similar risks and populations.

↓

(3) REVIEW EXISTING STUDIES FOR QUALITY AND APPLICABILITY

(a) Assess the quality of the data and methods used in the primary research studies, considering the extent to which they follow generally accepted best practices and provide evidence of validity and reliability.

(b) Assess the applicability of the studies to the policy outcome including: (i) the similarity of the risks; (ii) the similarity of the populations experiencing the risks; and (iii) the ability to adjust for differences between the scenario studied and the policy scenario.

↓

(4) TRANSFER THE ESTIMATE(S)

Conduct the transfer, making any necessary adjustments to the primary research estimates and applying them to the policy outcome. Depending on the research available, this transfer may rely on a single study or combine the results from several studies, and may involve transferring a range of point estimates or applying a valuation function.

↓

(5) ADDRESS UNCERTAINTY

Assess uncertainties in the estimates both qualitatively and quantitatively; e.g., by conducting sensitivity or probabilistic analysis, describing the quality of the evidence, and discussing the implications for decision-making.

Recommended Values

- Preferred approach is to rely on high quality primary research that reflects the preferences of the population.
  - Often instead extrapolate due to research gaps.
- Expect WTP to decrease as income decreases.
  - Effect of other individual, societal, and risk characteristics not well-understood.
- Income represents everything one could buy.
  - If we spend more on mortality risk reductions, we will have less to spend on other things.

Recommended Values

- Analysts generally use population-average values.
  - Adjust for income growth over time.
  - Adjust for income differences across countries.
  - Do not adjust for within country income differences.
- Perceived as promoting fairness: population-average values treat everyone similarly.
  - But what if their preferences vary?

Recommended Values

Adjusting for Income

- Requires four components:
  - A base VSL;
  - Average income for the population to which the base VSL applies;
  - Average income for the target population;
  - An estimate of the rate at which VSL changes as income changes; i.e., the average income elasticity over the relevant income range.

Recommended Values

Adjusting for Income

- Key formula:

$$VSL_B = VSL_A * (Income_B/Income_A)^{elasticity}$$

- Elasticity = 1.0; VSL changes in proportion to income.
- Elasticity < 1.0; VSL changes more slowly than income.
- Elasticity > 1.0; VSL changes more quickly than income.

Recommended Values

Illustration of Effect of Income Elasticity

	Extrapolated VSL for income = $1,025[b]	Ratio of VSL to income = $1,025	WTP for 1 in 10,000 risk change	WTP as a percent of income = $1,025
Elasticity = 0	$9.4 million	9,200	$940	92%
Elasticity = 0.5	$1.3 million	1,200	$130	12%
Elasticity = 1.0	$170,000	160	$17	1.6%[c]
Elasticity = 1.5	$22,000	22	$2.20	0.2%
Elasticity = 2.0	$2,900[d]	2.9	$0.29	0.03%

Notes:

a. Estimates are for illustration only. Results rounded to two significant digits.

b. Extrapolated from a U.S. VSL of $9.4 million and U.S. GNI per capita of $57,900 (2015 dollars)

c. An income elasticity of 1.0 means the ratio is constant; e.g., the starting point (U.S. VSL = $9.4 million) yields a WTP estimate of $940 for a 1 in 10,000 risk change, which is also 1.6 percent of U.S. GNI per capita.

d. This estimate appears implausibly low, given that it seems reasonable to expect that VSL will exceed the present value of future earnings and that the life expectancy of an average-aged adult would exceed 20 years. In such cases, the present value of future earnings should be used as a lower bound estimate of the VSL.

Recommended Values

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 same pattern.
- Given uncertainties and gaps in the research literature, analysts often either:
  - do not adjust for age, or
  - use simple assumptions to estimate the value per statistical life year (VSLY).

Recommended Values

For low- and middle-income countries, BCA Reference Case recommends:

- When high quality primary research studies are not available, recommend sensitivity analysis.
  a) VSL extrapolated from a U.S. estimate to the target country applying an income elasticity of 1.5.
  b) VSL = 100 * GNI per capita in the target country.
  c) VSL = 160 * GNI per capita in the target country.
- Option (a) generally preferred; addresses concerns about the resources available.
  – Options (b) and (c) designed to align the results with the ranges applied in other research and explore related uncertainties.

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Mortality Risk Reductions: Values

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)

Sources: Robinson, Lisa A., James K. Hammitt, and Lucy O'Keeffe. "Valuing Mortality Risk Reductions in Global Benefit-Cost Analysis." Journal of Benefit-Cost Analysis, 10(S1): 15–50. doi:10.1017/bca.2018.26.

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Recommended Values

If the policy disproportionately affects the very young or the very old:

- Conduct sensitivity analyses using VSLY estimates derived from one or more of the recommended VSL estimates as a rough proxy.
- Calculate this constant VSLY by dividing the population-average VSL by undiscounted future life expectancy at the average age of the adult population in that country.
- Multiply the resulting VSLY by the expected life year gain attributable to the policy.
- If the policy affects deaths around the age of birth, also explore the implications of assigning positive values to mortality risk reductions that occur prior to birth.

Valuing Non-Fatal Risk Reductions

- Same conceptual framework as mortality risks.
  - Value per statistical case.
  - WTP for own risk reductions.
  - Revealed and stated preference methods.
  - Use of benefit transfer.
- Issue:
  - High quality WTP studies not available for many health conditions.
- Recommendations
  - If high quality, applicable WTP studies are not available, use proxy methods:
    - averted costs (direct and indirect costs of illness - COI).
    - sensitivity analysis relying on quality-adjusted life years (QALYs), monetized using a constant.

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Thank you!

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https://sites.sph.harvard.edu/bcaguidelines/

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