Valuing Health Risks:
Monetary & Health-Utility Measures

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Valuing health
(& other non-market goods)

How do we measure welfare effects?

- People have limited experience valuing non-market goods
- Normative vs. revealed preferences (Beshears et al. 2008)
  - Normative preferences “represent the agent’s actual interests”
  - Revealed preferences “rationalize an economic agent’s observed actions”
    - Including responses to surveys, experiments

Key questions

- Do we want normative preferences for policy evaluation?
- How can we evaluate validity of estimates?
- Should we adjust (“correct”) the preferences revealed or stated by citizens?
- Should we substitute experts’ objective function?

How can we evaluate validity of estimates?

Description (revealed) v. prescription (normative)?

- For welfare & policy evaluation: prescription/normative

Consistency with theory

- Sensitive to what should matter (e.g., scope, income?)
- Insensitive to what should not matter (e.g., framing, probability v. frequency representation)

Stated preference:

- Comparison with revealed preference & experiments
  - Not practical in contexts where needed
- Are revealed-preference estimates normative?

Programs may have multiple health effects

Beneficial & adverse health effects

- Within individuals
  - Bicycling
    - Improve cardiovascular health, increase risk of crash injury
- Between individuals
  - Eating fish containing methyl mercury, dioxins
    - Reduce risk of heart disease & increase risk of cancer to mother
    - Increase risk of developmental effects to children

Criteria for evaluating valuation methods

Consistency with individuals' preferences

- Across risks of health outcomes

Consistency with social preferences

- Aggregation across people
  - How many heart attacks offset neurocognitive benefit of avoiding methyl mercury in fish?
- What standard for comparing value between people
  - Aggregate health, money, utility, …?
- Distributional effects
  - Weighted sum across individuals?
  - Compensate adverse effects on some through other means?

Some tension between these criteria

- Consistency with social preferences may conflict with individuals' preferences for own outcomes

Do people know their (normative) preferences?

Limited information about health states

- People with impairment often report it is less bad than others imagine

Misperception / limited understanding of (small) probabilities

- Which is a larger chance, 5 in 100,000 or 1 in 10,000?

Overweight qualitative attributes?

- Controllability, voluntariness, ambiguity/uncertainty, natural/synthetic chemicals?

Framing

- Risk of omission v. risk of commission, e.g., life-saving treatment with risk of fatal side effect

Hyperbolic discounting

WTP / WTA disparity

WTA / WTP ratio

(Tunçel & Hammitt 2014)

Good	Geometric mean	Geometric std error	Experi-ments	Studies
Environmental	6.2	1.2	32	13
Health & safety	5.1	1.2	41	11
Other public, non-market	3.9	1.1	66	15
Timing of receipt	2.6	1.1	6	1
Ordinary private	1.6	1.1	116	28
Lotteries	1.6	1.1	53	13
Time (leisure or travel)	1.5	1.2	7	3
All goods	3.3	1.0	337	76

Valuing health: standard metrics

Monetary measures

- Willingness to pay (WTP)
  - Widely used in environmental & transportation applications
- Willingness to accept compensation (WTA)

Health-utility measures

- Quality-adjusted life years (QALYs)
  - Widely used in public health & medical applications
- Disability-adjusted life years (DALYs)
  - Global Burden of Disease

Consistency with individual preferences

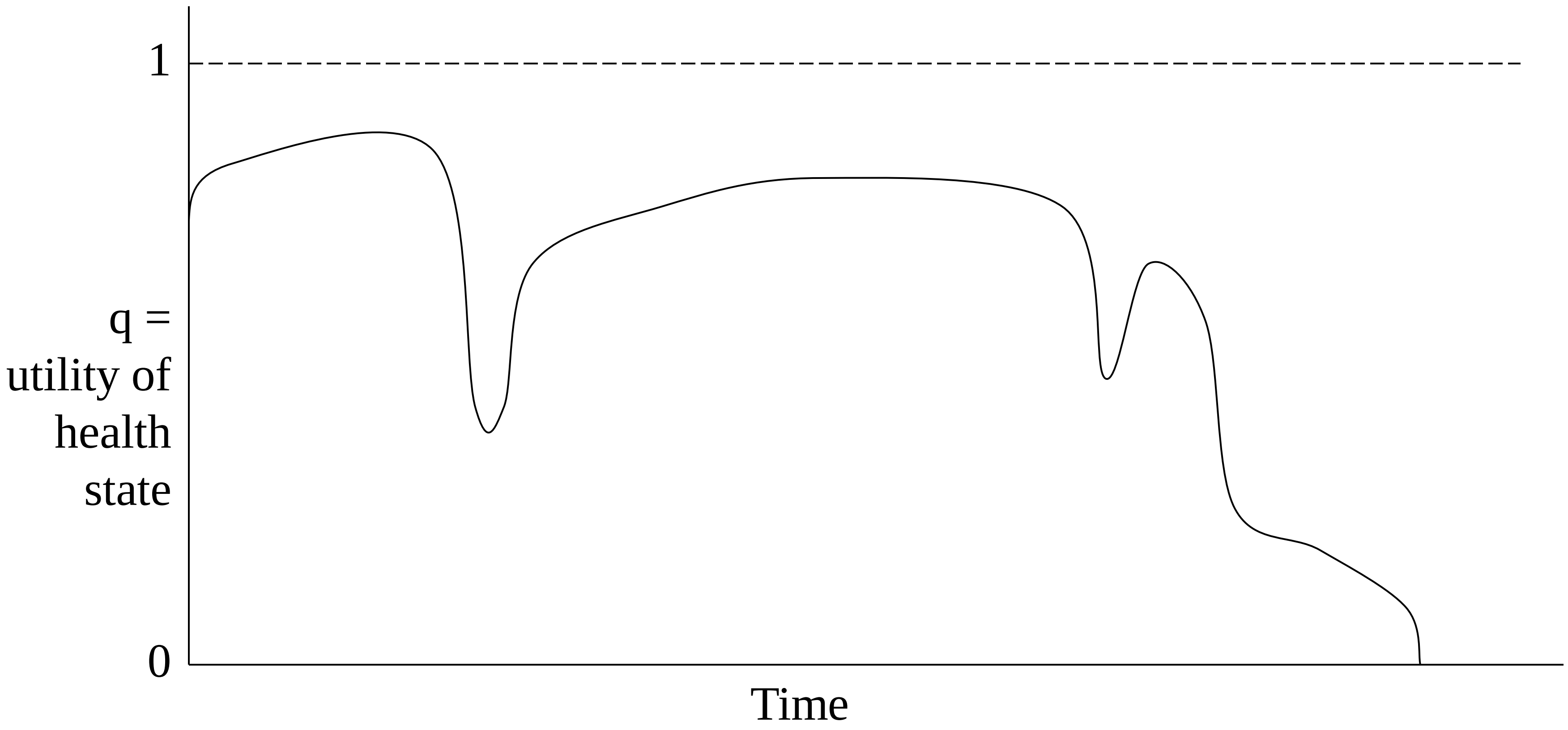
QALYs

- Structure imposed
- Several conditions – reasonable on average but often violated
  - Inconsistent with individual preferences
- Depend only on "health"

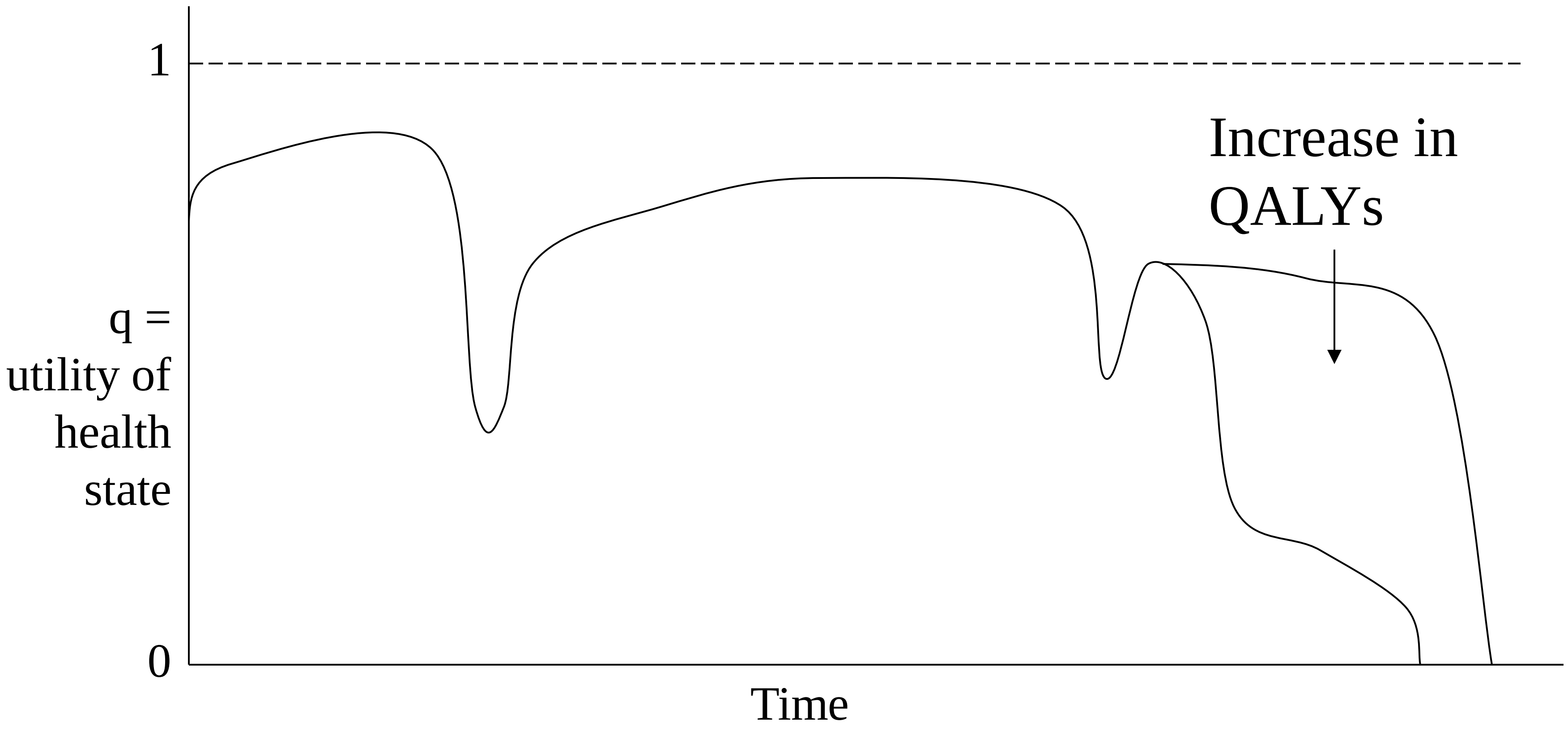
WTP

- Less structured, less constrained
- More susceptible to fuzzy thinking
- Can incorporate other effects, including qualitative attributes
  - Voluntariness, controllability, framing …

QALYs: health profile



QALYs: health profile



Quality-adjusted life years

Tradeoff between health & longevity

Value of a health profile = number of QALYs

- Area under the curve (may be discounted)

Value of change in health risk = change in E(QALYs)

Tradeoffs between health and longevity (implicitly) assumed to be independent of wealth, consumption

Does not address tradeoff between (health & longevity) and other goods

- Need to determine “threshold cost-effectiveness ratio” in some other way
- Quixotic quest for “Value of a QALY,” “WTP per QALY”
- £30,000; \$50,000 - \$100,000

Consistency with individual preferences

If QALYs represent utility, then individuals prefer

- Health profiles with more QALYs
- Lotteries with higher expected number of QALYs

Conditions on preferences

- Pliskin, Shepard & Weinstein (1980)

Quality-adjusted life years

$$QALYs = qT$$ Constant health

$$QALYs = \sum_{i=1}^{N} q_i T_i$$ Time-varying health

q = "Health-related quality of life" (HRQL)

- $q \leq 1$
  - q = 1 (full health)
    - Age dependence?
  - q = 0 (equivalent to dead)
    - q < 0 worse than dead

T = duration

Key assumptions

$$QALYs = qT \qquad QALYs = \sum_{i=1}^{N} q_i T_i$$

q (health-related quality of life)

- Independent of duration
  - If 40 yrs good health ~ 30 yrs excellent health
  - Then 4 yrs good health ~ 3 yrs excellent health
- Independent of previous & succeeding states

T (duration)

- Utility is proportional to T
- Risk neutral over lotteries on duration
  - 50/50 chance of 0 or 2 days sick ~ 1 day sick for sure

Risk neutrality on lifespan

Empirically, risk postures differ across individuals and choices

- Risk aversion for long periods (gains), risk seeking for short (losses)?
- Risk neutral on average?

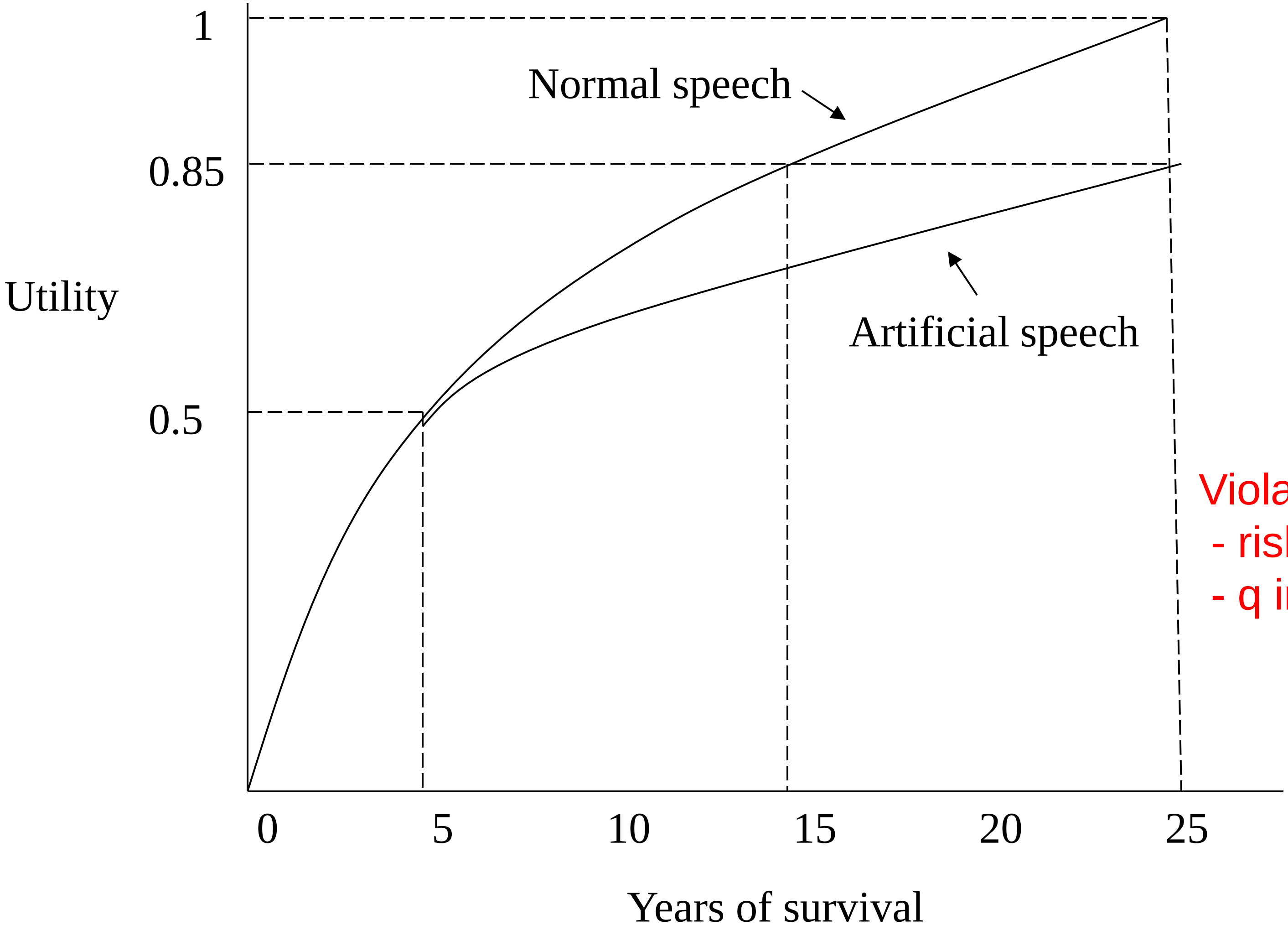
Risk-adjusted QALYs available but rarely used

- Utility a non-linear function of duration
- Unclear how to add QALYs across people

Note: discounting future QALYs ↔ risk aversion

- (Could choose discount rate and assume risk neutrality over present value of life years)

McNeil et al. (1981), "Speech and Survival:Tradeoffs between Quality and Quantity of Life in Laryngeal Cancer," NEJM



Violates:
- risk neutrality
- q independent of T

Empirical evidence on risk posture (%)

	RN	RA	RS	other
Pliskin, Shepard, Weinstein (1980) N = 10 Harvard health faculty, 1 qx	40	20	40	--
Corso & Hammitt (2001) US N = 865, 4 binary choices	0	14	11	75
N = 610, 5 binary choices	0	13	9	78

3 pairwise choices among 3 shifts to survival curve (same life expectancy)

	RN	RA	RS	other
Nielsen et al. (2010) N = 129 40 year olds in Newcastle UK	6	22	23	49
Hammitt & Tunçel (2014) N = 1024 French general population	23	14	16	47

Willingness to Pay

Rate of substitution between (health & longevity) and wealth / income

Value changes in

- Health profiles (time paths of health)
- Risk over health profiles
- Not used to determine the total value of a health profile (e.g., a life)

Willingness to Pay / Willingness to Accept

For minor illness (or small risk change), WTA ≈ WTP

For serious illness or fatality (or large risk change), WTA may be much greater than WTP

- WTP limited by wealth
- WTA larger, could be infinite?

Interpersonal aggregation

Evaluate policy by summing individual changes in QALYs or WTP

- Could weight by effect type or beneficiary

To add utility across people, need some method to standardize it

- Who benefits more from
  - an extra year of life?
  - an extra € 10 000?

Neoclassical economics assumes utility cannot be compared between people

- Who suffers more from pain?

Any standard we choose is arbitrary

- QALYs: healthy year of life
- WTP: purchasing power

Integrating WTP & QALYs (Hammitt 2013)

Assume (for any level of wealth)

- Preferences for health and longevity are consistent with (generalized) QALYs
  - $Q(h, T) = Q[q(h), T]$
  - Health-related quality of life $q(h)$ is independent of wealth w

Then (future) lifetime utility

$$u(h, T, w) = [Q(h, T)]\, a(w) + b(w)$$

where $a(w) > 0$

Marginal utility of wealth

u(h, T, w) = [Q(h, T)] a(w) + b(w)

$$\frac{\partial U}{\partial w} = Qa'(w) + b'(w)$$

b' ≥ 0 (standard, marginal utility of bequest)

a' > 0 ↔ marginal utility of wealth greater if alive than dead (standard)

→ marginal utility of wealth increasing with

Health (standard)

Longevity (plausible)

Marginal WTP per QALY (v)

u(h, T, w) = [Q(h , T)] a(w) + b(w)

$$v = -\frac{dw}{dQ} = \underbrace{\frac{a(w)}{Qa'(w) + b'(w)}}_{\text{Marginal value of QALY}} + \underbrace{\frac{\partial w}{\partial Q}}_{\text{Effect of health \& longevity on wealth (neglect)}}$$

v is independent of Q (future health & longevity) iff a' = 0

→ marginal utility of wealth independent of survival, health, & longevity

a' > 0 → v decreases with Q

Diminishing marginal WTP with severity & duration of potential illness

WTP increases with age and chronic/future illness

Empirical estimates: WTP & ΔQALY

Individual preferences for self

- Own money, own health risk

Two stated-preference studies

- Knowledge Networks internet panel (US, nationally representative)

Acute illness (food-borne, N ≈ 2900)

- Describe symptoms
  - Duration = 1, 3, 7 days
- Elicit q (health-related quality of life)
- Elicit WTP

Chronic illness (environmental, N ≈ 2200)

- Describe illness by EQ-5D profile
  - Duration = 1 month, 1 year, lifetime
- Elicit WTP

Empirical model

$WTP = \Delta r^{\delta}\, \Delta q^{\alpha}\, T^{\beta}\, m$

$\log(WTP) = \delta \log(\Delta r) + \alpha \log(\Delta q) + \beta \log(T) + [m_0 + \Sigma\, x_i\, \gamma_i + \varepsilon]$

Δr = risk reduction (= $p_0 - p_1$)

Δq = loss in HRQL while ill (= $q_0 - q_s$)

T = duration of illness

m_0 = WTP per QALY (when all $x_i = 0$)

x_i = covariates that affect WTP per QALY

ε = error term (normal)

Constant WTP per E(ΔQALY) $\rightarrow \delta = \alpha = \beta = 1$

Acute illness
(Hammitt & Haninger 2007 Haninger & Hammitt 2011)

WTP to reduce risk of short-term illness from microbial contaminants on food

Choose between two food types

- Conventional
- “Superior safety system”
  - Uses safer (to humans) pesticides
  - Not organic, irradiated, etc.

Risk change & cost presented per meal or per month

Risk attributes

Risk reduction: [4 or 2] to 1 per 10,000 per meal

- Risk reduction = [3 or 1] per 10,000
- Visual aid: white square with fraction colored red

Duration: 1, 3, 7 days

Severity: mild, moderate, severe

- Mortality risk conditional on illness: 0, 1/10,000, 1/1,000

Food: chicken, ground beef, packaged deli meat

Initial bid: between $0.04 & $4.00 per meal

- Follow-up bids half and twice as large

Per month framing: risk and bid presented using respondent-reported consumption frequency

Severity

1. You will have an upset stomach and will feel tired, but these symptoms will not prevent you from going to work or from doing most of your regular activities.

2. You will have an upset stomach, fever, and will need to lie down most of the time. You will be tired and will not feel like eating or drinking much. Occasionally, you will have painful cramps in your stomach. In addition, you will have some diarrhea and will need to stay close to a bathroom. While you are sick, you will not be able to go to work or do most of your regular activities.

3. You will have to be admitted to a hospital. You will have painful cramps in your stomach, fever, and will need to spend most of your time lying in bed. You will need to vomit and will have severe diarrhea that will leave you seriously dehydrated. Because you will be unable to eat or drink much, you will need to have intravenous tubes put in your arm to provide nourishment.

HRQL by severity
(mean, std dev)

	Health Utilitities Index	Decrement	Visual analog scale	Decrement
Current health	0.80 (0.21)		0.76 (0.17)	
Mild	0.51 (0.27)	0.29	0.58 (0.21)	0.18
Moderate	0.26 (0.31)	0.54	0.47 (0.23)	0.29
Severe	0.12 (0.31)	0.68	0.42 (0.25)	0.34

Regression (log WTP, std err)

	Pooled (4851)	Per meal (2135)	Per month (2035)
Intercept	**5.2 (0.4)**	**5.0 (0.7)**	**6.4 (0.5)**
Log Δr	**0.52 (0.05)**	**0.49 (0.08)**	**0.54 (0.06)**
Log ΔHRQL	**0.20 (0.05)**	**0.17 (0.06)**	**0.26 (0.08)**
Log duration	**0.11 (0.05)**	**0.11 (0.06)**	**0.11 (0.08)**
Ground beef	**-0.45 (0.11)**	**-0.57 (0.13)**	**-0.14 (0.20)**
Deli meat	**-0.49 (0.14)**	**-0.45 (0.16)**	**-0.56 (0.27)**
Monthly version	**1.12 (0.10)**		
		$p < 0.01$	**$p < 0.10$**

Chronic illness
(Hammitt & Haninger 2014)

Illness caused by environmental contaminants

Reduce by participation in government program of annual screening & preventive medicine

- Initial risk = [3 or 4] per 10,000 per year
- Reduction = [1 or 2] per 10,000 per year
- Initial bid: between $10 & $2,000 per year

Illness described by EQ-5D profile & duration

- Plus disease name for half of respondents

Elicit health conditional on illness (TTO, VAS)

- Encourage respondent attention to illness description
- Elicit current health (EQ-5D, TTO, VAS) to calculate health loss

EQ-5D

5 attributes

- Mobility
- Self care
- Usual activities
- Pain/discomfort
- Anxiety/depression

3 levels

- No problems
- Some problems
- Severe problems

HRQL calculated using scoring function for US population (Shaw et al. 2005)

Health conditions

10 EQ-5D profiles

- HRQL ranges from 0.086 to 0.827

11 disease names

- Provided to half the sample
- EQ-5D profiles representative of these diseases in Medical Expenditure Panel Survey

Duration = 1 month, 1 year, or lifetime

- Implausible [disease name / duration] pairs excluded

Totals

- 22 [EQ-5D profile – disease name] pairs
- 38 [EQ-5D profile – disease name – duration] triples

Regression (log WTP, std err)

	(N = 2339)	(N = 2343)
Intercept	**16.1 (2.1)**	**15.4 (2.1)**
Baseline risk	0.12 (0.12)	0.12 (0.16)
Log Δr	**1.02 (0.22)**	**1.01 (0.23)**
Log ΔHRQL	**0.35 (0.09)**	
Log duration	**0.12 (0.03)**	
Log ΔQALY		**0.17 (0.03)**
Named illness	**-0.65 (0.16)**	**-0.72 (0.16)**
Current HRQL	**-1.76 (0.53)**	**-1.41 (0.52)**
ΔHRQL = 0	**0.54 (0.39)**	-0.03 (0.30)
		$p < 0.01$

Named Illness

	Pooled (9103)
Influenza	**-1.10 (0.26)**
Resp infect	**-0.52 (0.29)**
Bronchitis	**-0.59 (0.24)**
Migraine	**-0.81 (0.20)**
Parkinson's	-0.16 (0.20)
Heart disease	0.02 (0.22)
Hepatitis	**-0.72 (0.25)**
Liver disease	-0.34 (0.26)
Liver cancer	-0.17 (0.24)
Skin cancer	**-1.35 (0.28)**
Lung cancer	0.35 (0.25)
	p < 0.01

WTP/QALY inferred from VSL

Assume WTP to reduce health risk proportional to E(ΔQALY)

$$WTP = \omega \cdot \Delta r \cdot \Delta Q$$

where ω = WTP/QALY

$$\rightarrow \omega = \frac{WTP/_{\Delta r}}{\Delta Q} = \frac{VSL}{\Delta Q}$$

VSL = $9.3 million, LE = 40 yrs, avg HRQL by age

- Disc rate = 0 → ω = $280 000
- Disc rate = 3% → ω = $480 000

WTP/QALY inferred from VSL

Problem: VSL not proportional to E(ΔQALY) or life expectancy

- Theory: Average WTP/QALY decreases w/ Q

VSL increases then decreases with age

- Not monotone in Q
- Utility discount rate < interest rate →
  - Optimal to save, defer consumption to older ages
  - Opportunity cost of spending decreases with age

Wage differential

Aldy & Viscusi 2008

FIGURE 1.—COHORT-ADJUSTED AND CROSS-SECTION VALUE OF STATISTICAL LIFE, 1993–2000

VSL

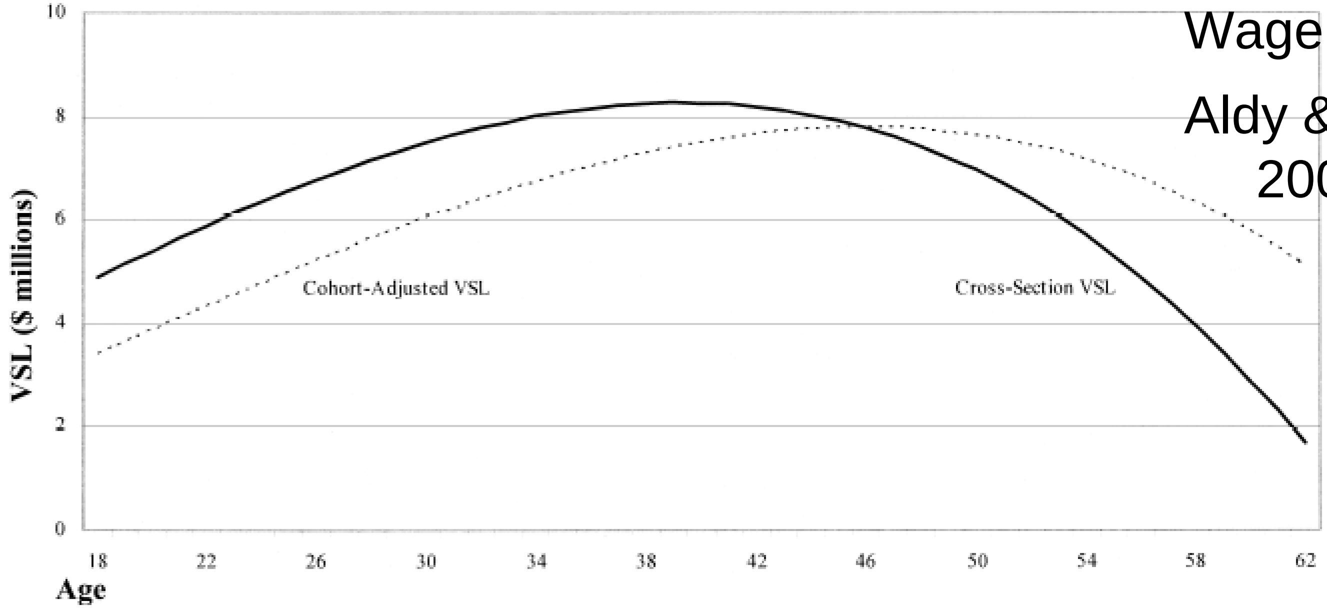
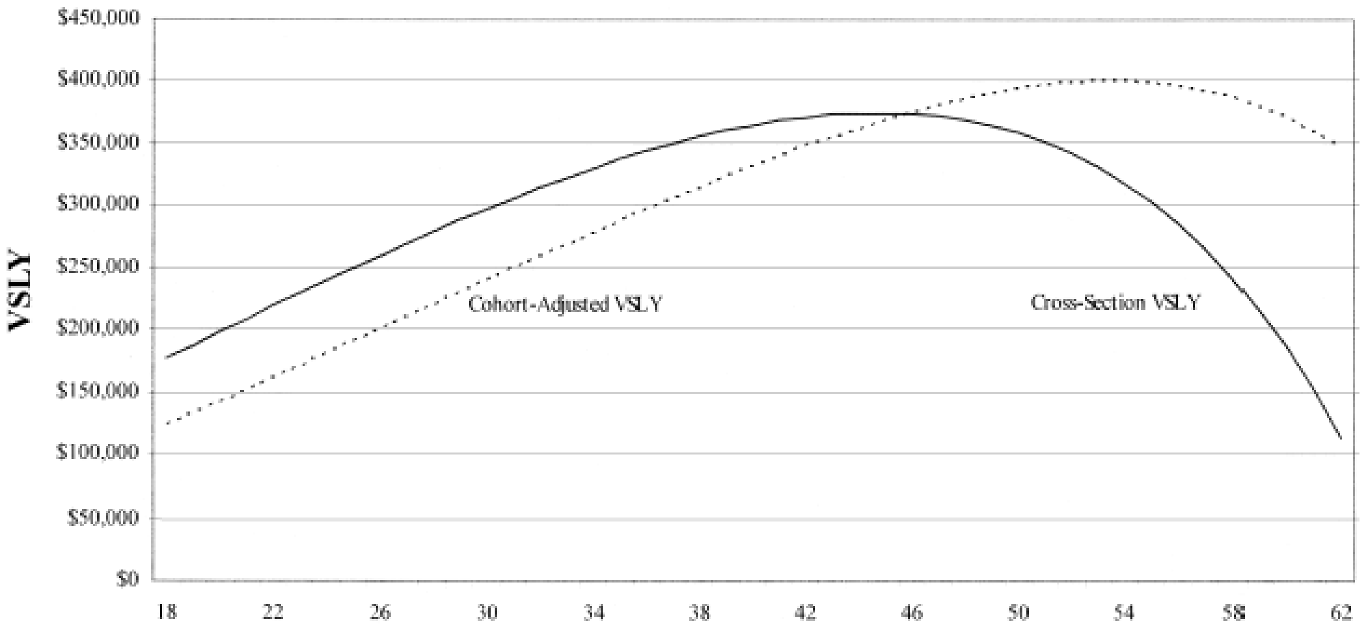


FIGURE 2.—VALUE OF A STATISTICAL LIFE-YEAR BASED ON COHORT-ADJUSTED AND CROSS-SECTION VALUE OF STATISTICAL LIFE, 1993–2000

VSLY



Stated preference (normalized to age 40)

Krupnick 2007

VSL

Elicited & implied values ($)

Δq	t	WTP	Value / case	Value / QALY	Implied WTP	Value / case
0.1	1 day	1.36	6,800	24,800,000	0.03	132
0.9	1 day	2.10	10,500	4,250,000	0.24	1,180
0.1	7 days	1.67	8,300	4,350,000	0.18	921
0.9	7 days	2.57	12,900	745,000	1.66	8,290
0.1	1 month	79	524,000	62,900,000	0.60	4,000
0.9	1 month	170	1,140,000	15,100,000	5.40	36,000
0.1	40 yrs	165	1,100,000	275,000	168	1,118,000
0.9	40 yrs	357	2,380,000	66,200	1,510	10,060,000

Implied values: VSL = 9.3m, r = 3%, LE = 40 yrs → WTP / QALY = 480k

Values per case plausible for severe, not for milder cases?

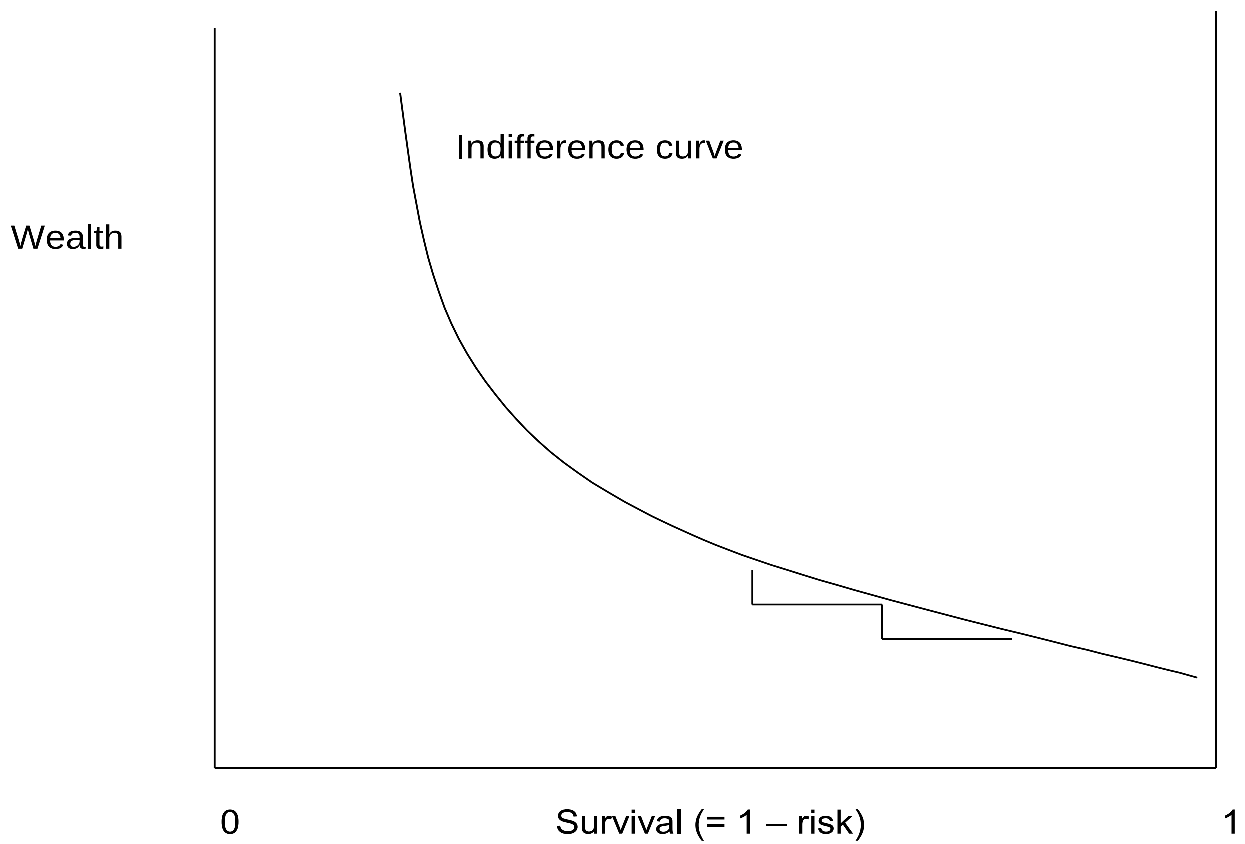
- Last value ($10 million) ≈ VSL ($9.3 million)

WTP not very sensitive to severity or duration of illness

Conclusion

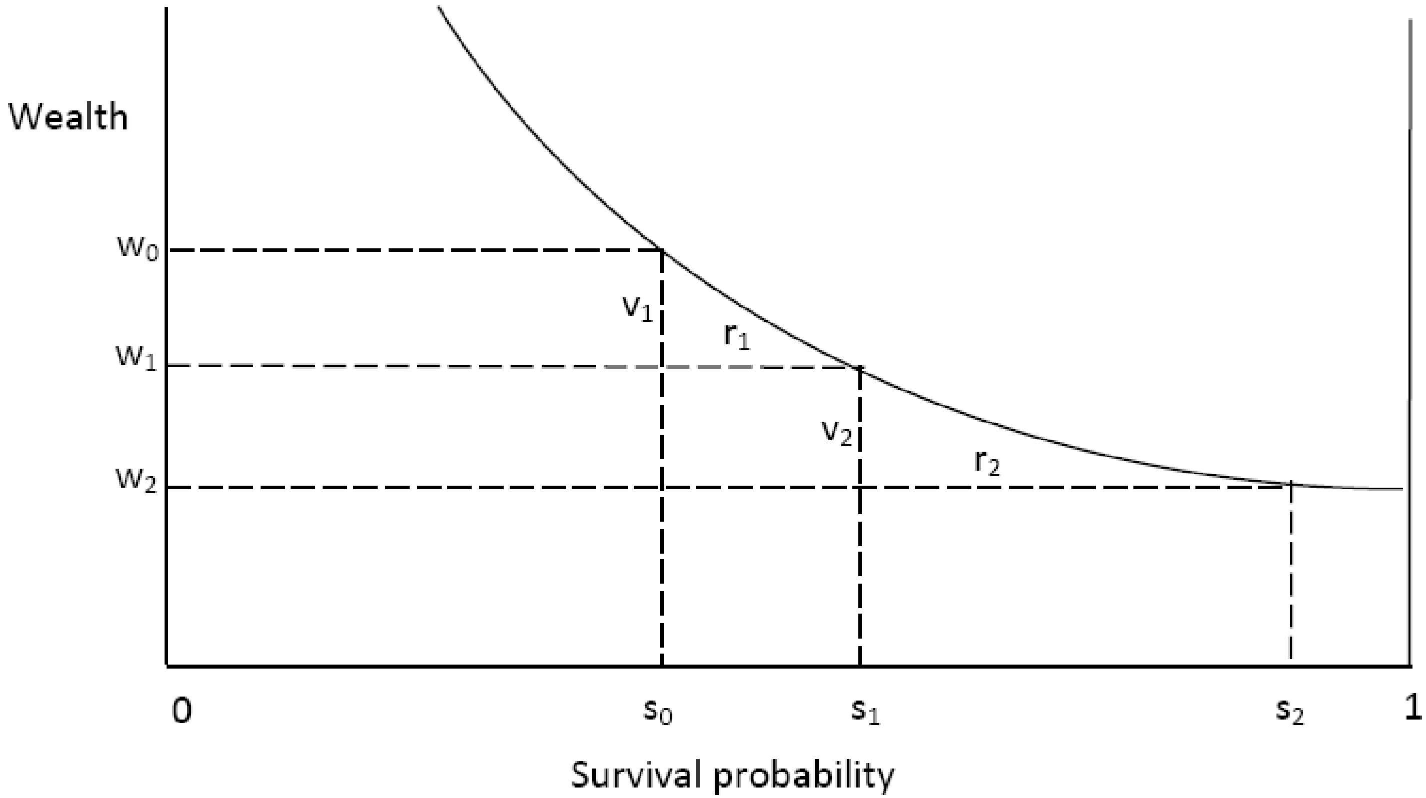
- WTP per QALY is not constant across health gains
- Increasing, strongly concave function of expected gain in QALYs
  - Elasticity with respect to ΔHRQL $\approx$ 0.4 (0.2 for acute illness)
  - Elasticity with respect to duration $\approx$ 0.1 (0.1 for acute illness)
  - More sensitive to risk reduction than to QALYs; elasticity with respect to $\Delta r \approx 1.0$ (0.5 for acute illness)
- Depends on other information
  - Name of illness (chronic)
  - Type of food (WTP ~60% greater for chicken than for hamburger or packaged deli meat)
- WTP $\neq$ ΔQALY x constant
  - Can it be reliably predicted using a more elaborate function?
- Utility: ex ante (decision), ex interim (experience), ex post (memory)
  - Ex post dominated by peak & final sensation, insensitive to duration
  - Kahneman

Continuity of marginal rate of substitution implies near proportionality for small risk changes



$$VSL = \frac{dw}{dp} = \frac{u_a(w) - u_d(w)}{(1-p)u_a'(w) + pu_d'(w)} = \frac{\Delta u(w)}{Eu'(w)}$$

Scope sensitivity of WTP for risk reduction



$$V = \frac{v_3}{v_1} = \frac{v_1 + v_2}{v_1} = 1 + \frac{v_2}{v_1} = 1 + \frac{r_2 VSL_b}{r_1 VSL_a}$$

- v_1 ($s_0 \rightarrow s_1$) = r_1 x VSL_a (VSL somewhere between s_0 & s_1)
- v_2 ($s_1 \longrightarrow s_2$) = r_2 x VSL_b (VSL somewhere between s_1 & s_2)
- v_3 ($s_0 \longrightarrow s_2$) = $v_1 + v_2$