Willingness to Pay for Quality-Adjusted Life Years: Empirical Inconsistency Between CEA and BCA

James K. Hammitt

Center for Risk Analysis
Harvard University

Why Value Health?

Evaluate government regulations and other actions

Compare multiple health effects

Compare health effects with other outcomes

- Cost of resources (could be used for other purposes)
- Environmental consequences
- Others

Programs may have Multiple Health Effects

Beneficial and adverse health effects

Within individuals

- Bicycling– improve cardiovascular health, increase risk of traffic accident

Between individuals

- Eating fish containing methyl mercury, dioxins– reduce risk of heart disease to mother, increase risk of developmental effects to children

Multiple beneficial effects complicate comparison with

Resource costs

Other consequences

Criteria for Evaluating Valuation Methods

Consistency with individuals' preferences

- Across health outcomes
- Across risks of health outcomes

Consistency with social preferences

- Aggregation across people
  - How many traffic deaths offset fitness benefit of bicycling?
- Standard for comparing value between people
  - Aggregate health, utility, or what?
- Distributional effects?
  - Compensate through other means

Some tension between these criteria

Background Concern: Do People Know Their Preferences Over Health Risks?

Limited information about health states

- People with impairment report it is better than people without report

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?

Framing

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

Standard Valuation Metrics

- Health Adjusted Life Years (HALYs)
  - Quality adjusted life years (QALYs)
  - Disability adjusted life years (DALYs)
  - Healthy years equivalent (HYEs)
  - Widely used in public health and medical applications
- Willingness to pay (WTP)
  - Willingness to accept compensation (WTA)
  - Widely used in environmental and transportation applications

Outline

- Consistency with individual preferences
  - QALYs
  - WTP
  - Integration: WTP per QALY
- Aggregation across people
  - Relative valuation of mortality risk

Consistency with Individual Preferences

QALYs

Structure imposed

Several conditions— reasonable on average but often violated

- Inconsistency with individual preferences known from the start

Depends only on “health”

WTP

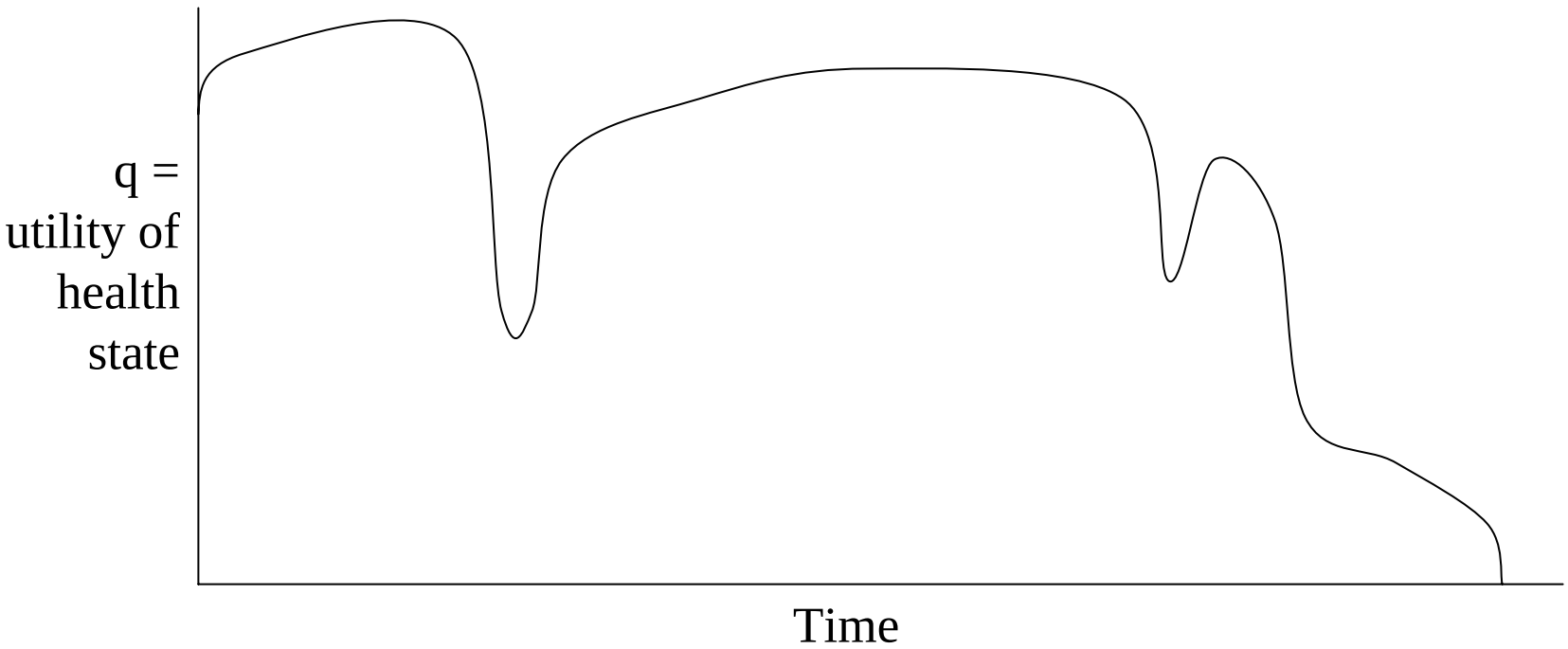
Less structured, less constrained

More susceptible to fuzzy thinking

Can incorporate other effects, including voluntary attributes

Quality Adjusted Life Years

Health Profile



Quality Adjusted Life Years

Tradeoff between health and longevity

Value of a health profile = number of QALYs

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

Tradeoffs between health and longevity implicitly assumed to be independent of wealth

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

- Need to determine “threshold cost-effectiveness ratio” in some other way

Consistency with Individual Preferences

If QALYs represent individual preferences (i.e., are a utility function), then individuals prefer

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

Quality Adjusted Life Years

Constant health state $QALYs = qT$

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

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

$0 \leq q \leq 1$

$q < 0$ for health states worse than death

T = duration

Assumptions Underlying QALYs

Constant health state (Pliskin, Shepard, & Weinstein, 1980)

1. Mutual utility independence
2. Constant proportional tradeoff of longevity for health
3. Risk neutrality over lifespan

For time-varying health states

4. Additive independence of health states over time

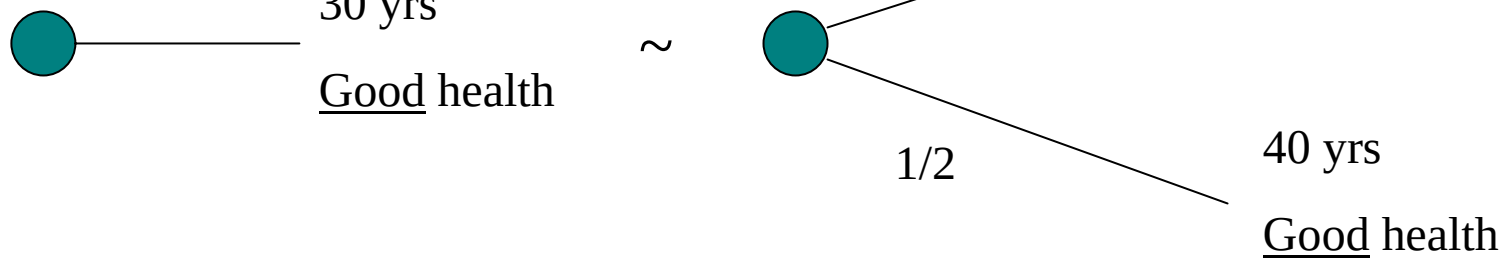
1. Mutual Utility Independence

Preferences over lotteries on **longevity** do not depend on common health states

Preferences over lotteries on **health** do not depend on common longevity

Preferences over lotteries on longevity do not depend on common health states

If



Preferences over lotteries on longevity do not depend on common health states

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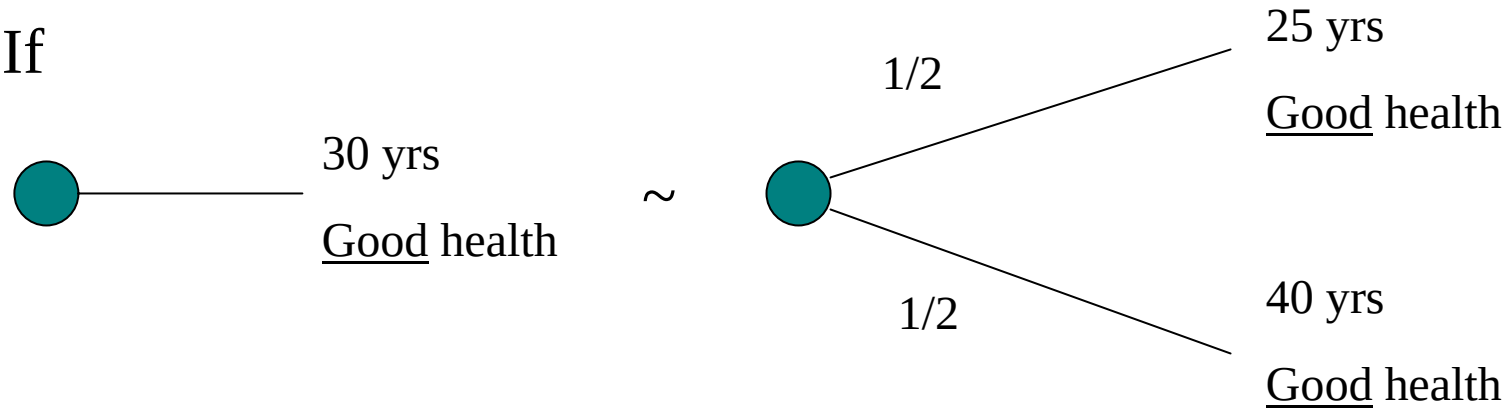
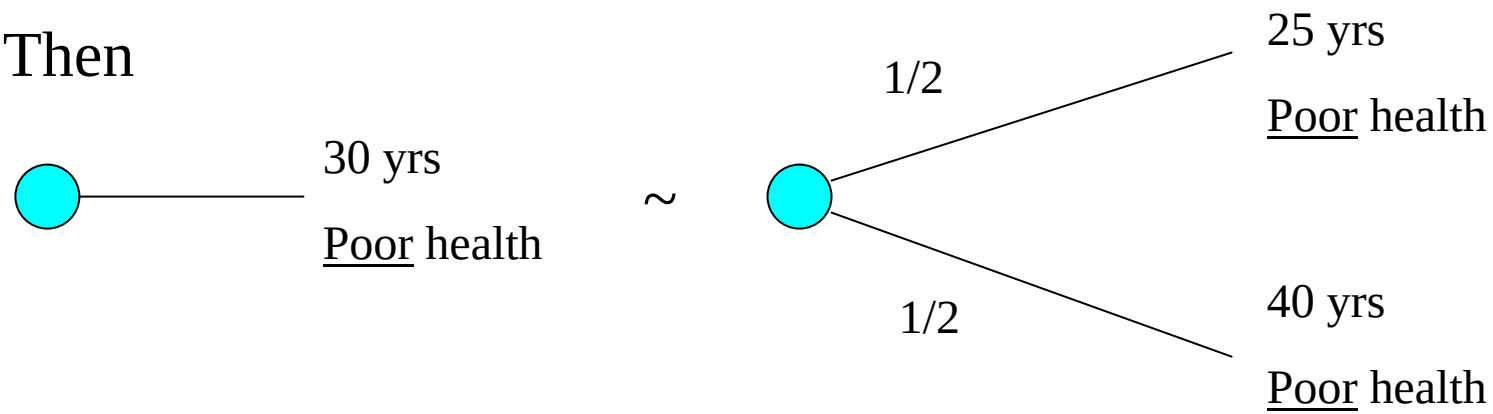
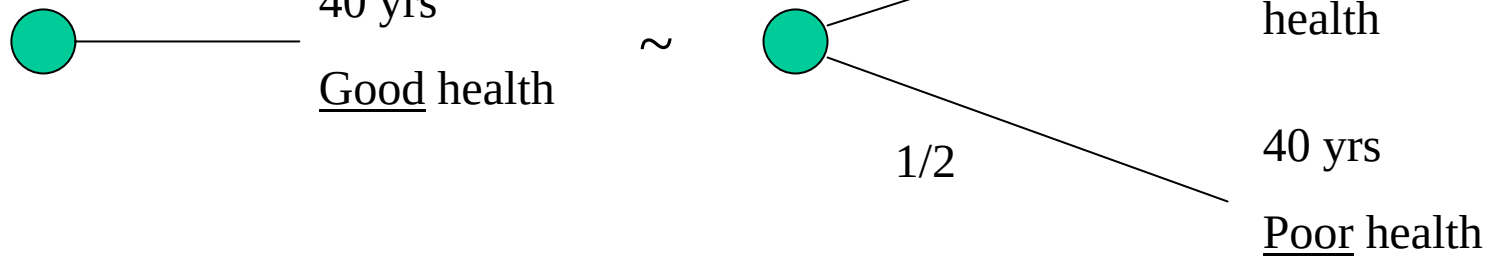


Then



Preferences over lotteries on health do not depend on common longevity

If



Preferences over lotteries on health do not depend on common longevity

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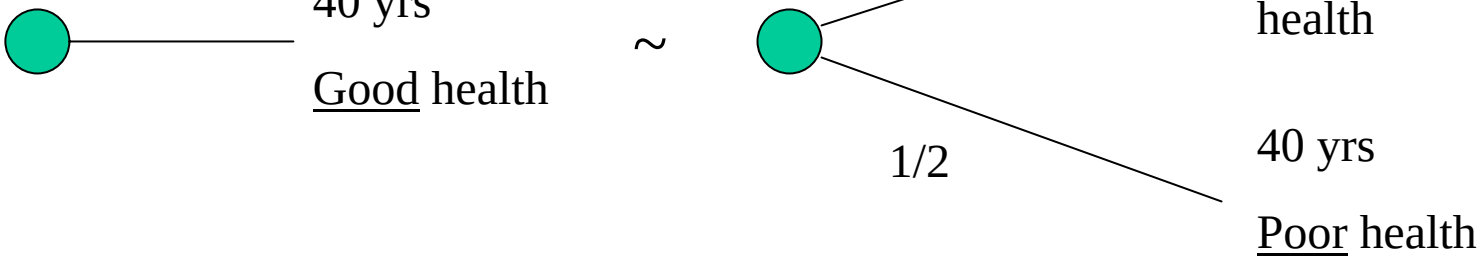

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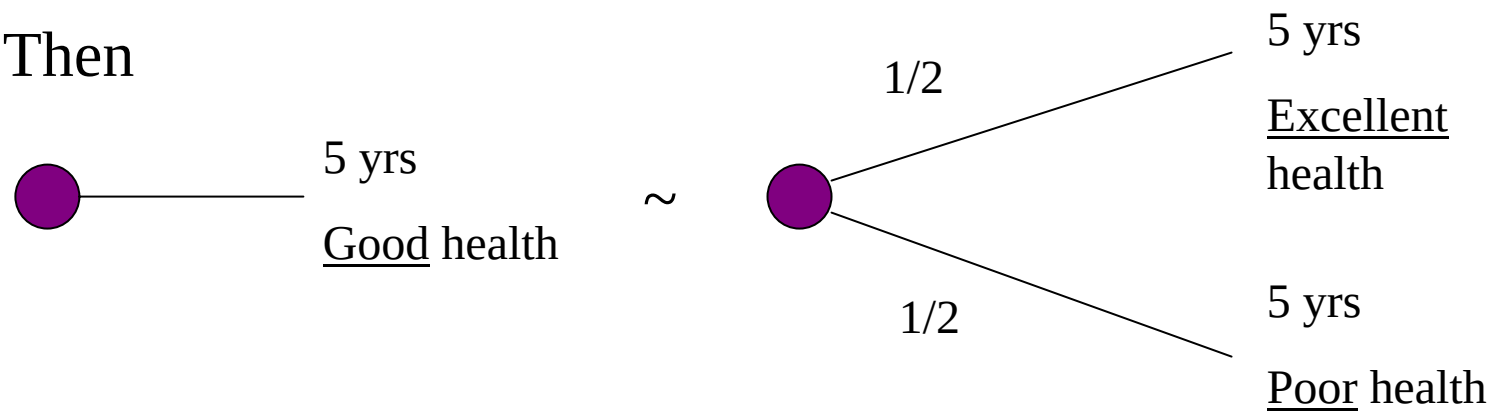
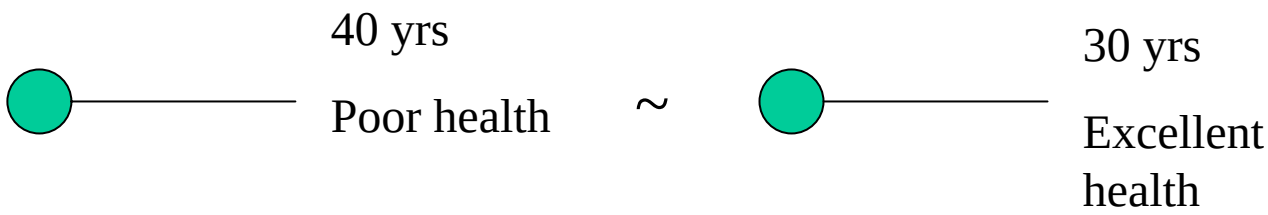


2. Constant Proportional Tradeoff of Longevity for Health

If



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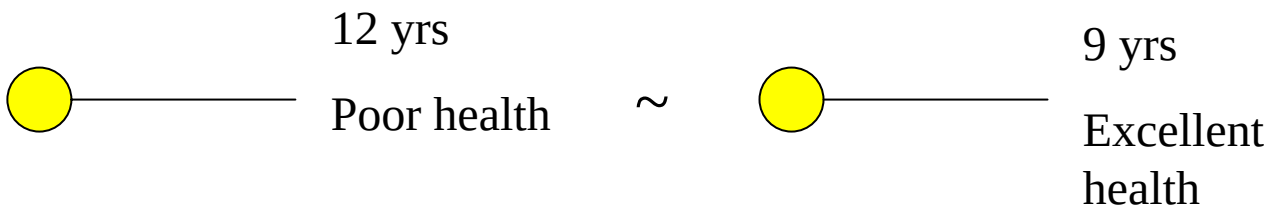
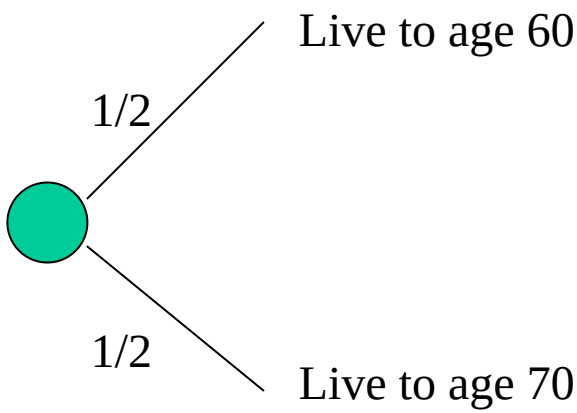


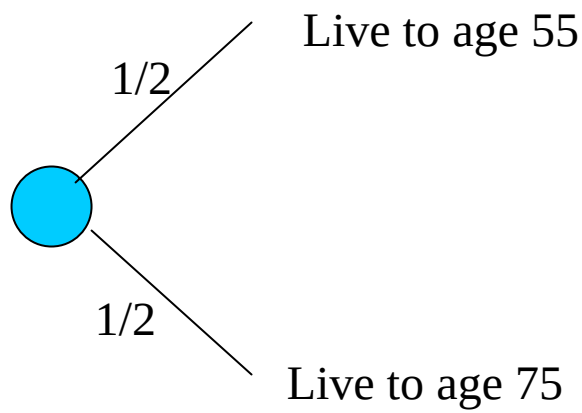
2. Constant Proportional Tradeoff of Longevity for Health

q does not depend on T

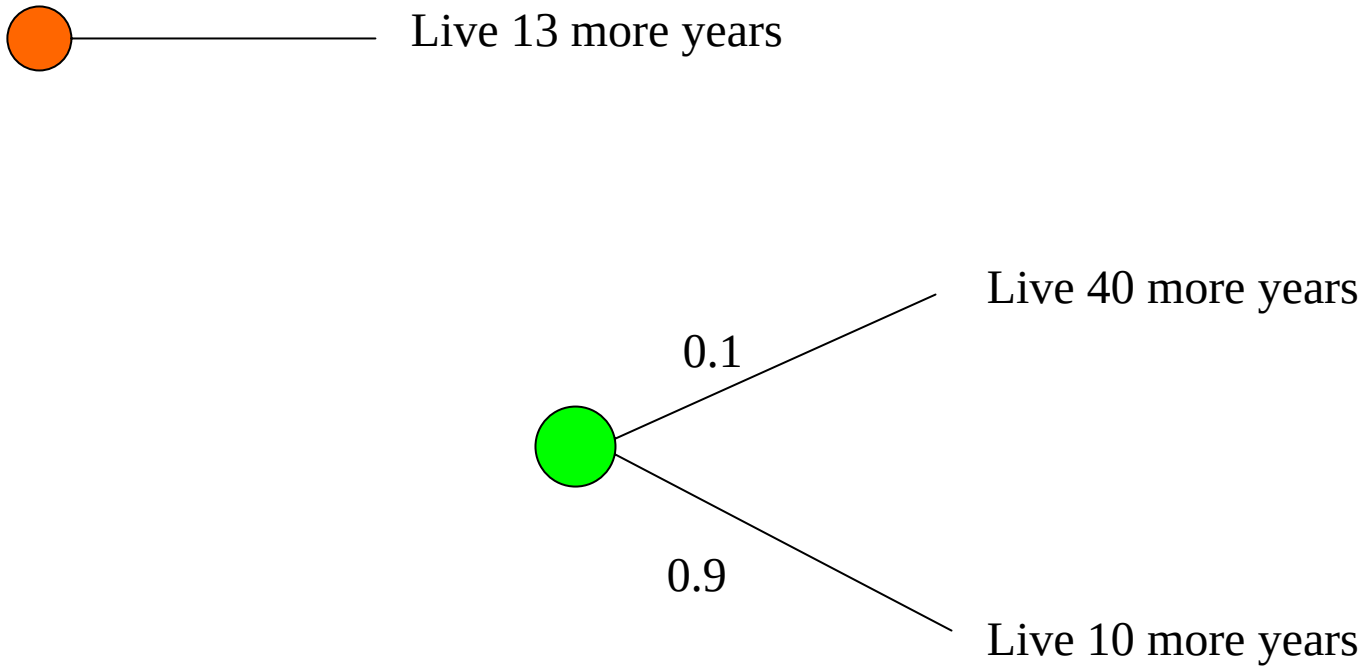
Empirically, people are often willing to trade a larger fraction of a large lifespan

Which Would You Choose?





Which Would You Choose?



3. Risk Neutrality over Lifespan

Lotteries on longevity evaluated solely by life expectancy

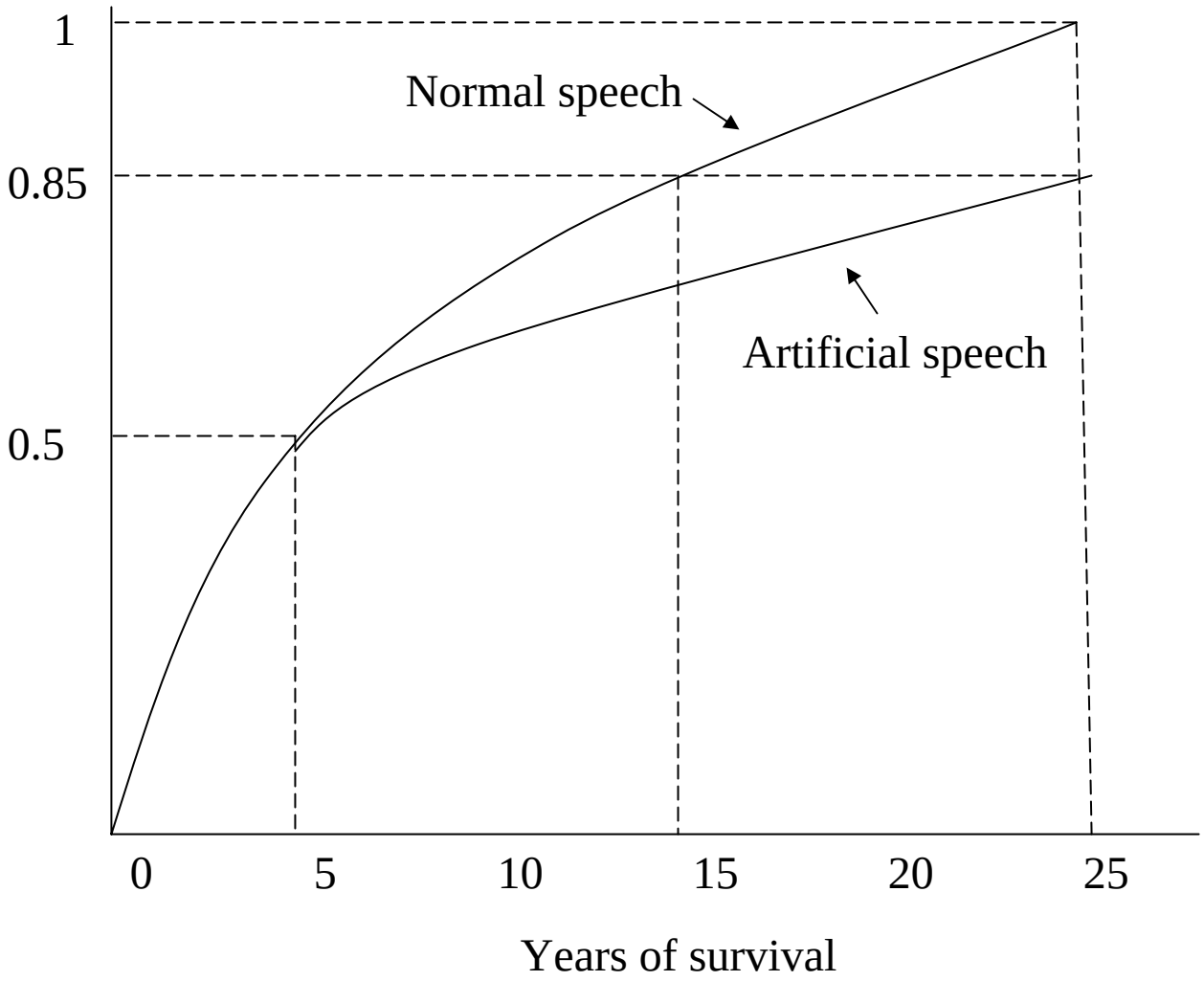
(for common health state)

Indifferent between lotteries in previous choices

3. Risk Neutrality over 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



Empirical Evidence on Risk Posture

	RN	RA	RS
Pliskin, Shepard, Weinstein (1980), 10 members of Harvard faculty seminar on Analysis of Health and Medical Practices	4	2	4
Corso and Hammitt (2001), N = 865, 25% consistent over four choices	0%	55%	45%
N = 610, 22% consistent over five choices	0%	60%	40%

Alternative Assumptions

(Bleichrodt, Johannesson and Wakker, 1997)

Risk neutrality for each health state

- Utility is proportional to duration
- Implies longevity is utility independent of health state

"Zero Condition"

- Individual is indifferent among all health states when duration is zero

(Miyamoto et al. 1998 extend to non-risk-neutral case)

Time-Varying Health States

4. Additive independence across periods

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

4. Additive Independence Across Periods

Utility of health profile independent of the sequencing of health states

Utility of each health state independent of health in other periods

- Preferences over lotteries on health in one period do not depend on level of health in other periods

People prefer stability, improving health sequences?

- Also conflicts with discounting

Willingness to Pay

Willingness to Pay

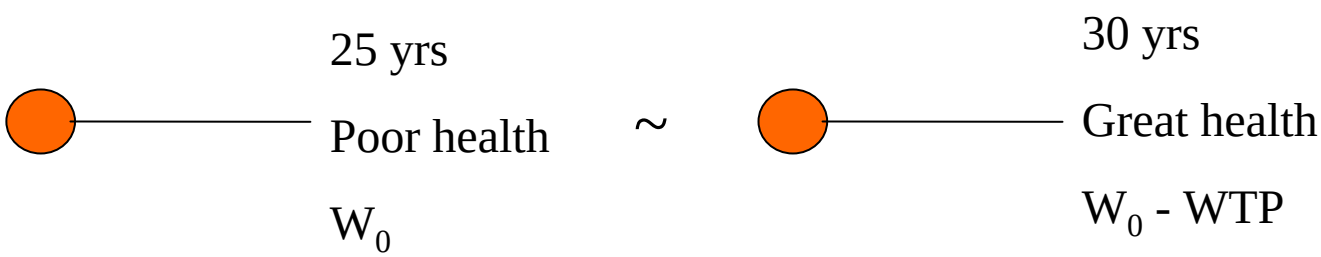
Rate of substitution between (health and longevity) and wealth / income

Value changes in

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

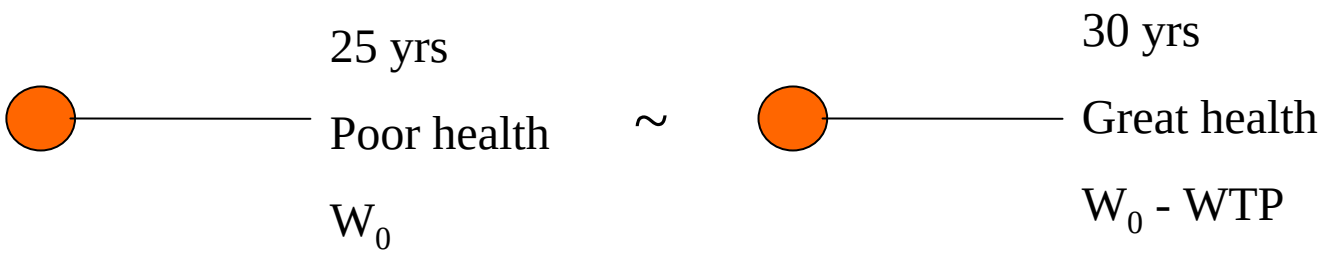
Willingness to Pay

Compensating variation

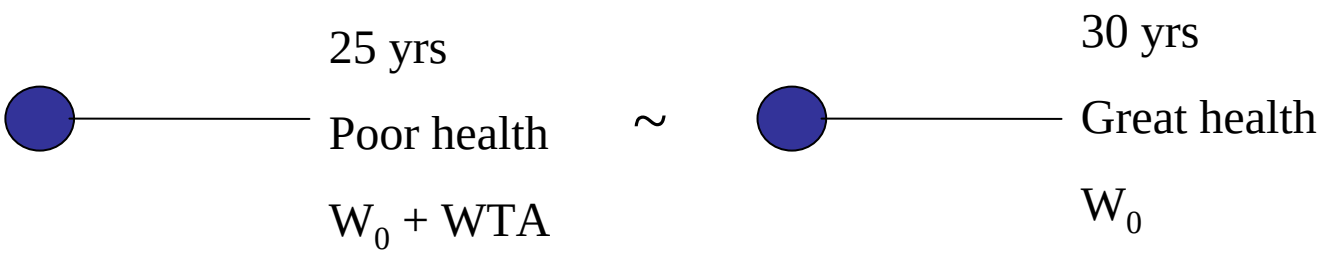


Willingness to Pay / Willingness to Accept

Compensating variation



Equivalent variation



Willingness to Pay

For minor illness, WTA ≈ WTP

For serious illness or fatality, WTA may be much greater than WTP

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

Value per Statistical Life (VSL)

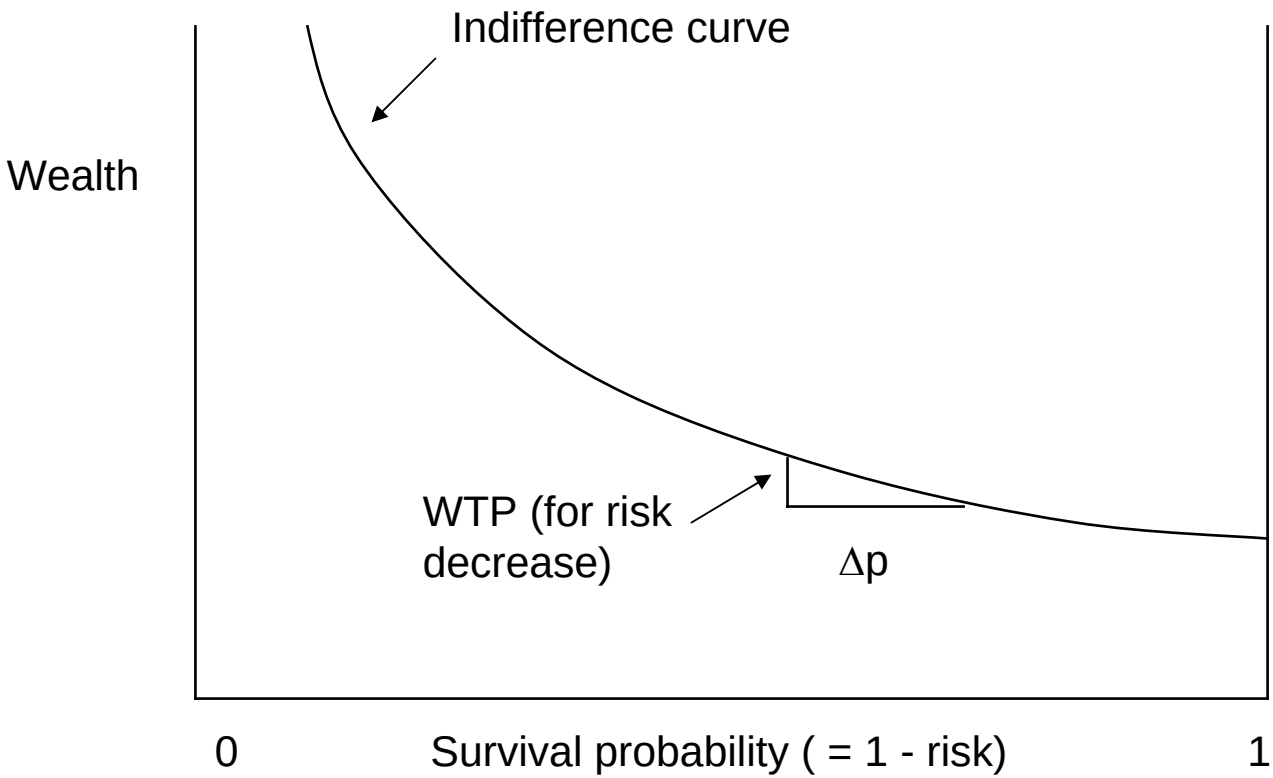
Schelling (1968)

"The Life You Save May Be Your Own"

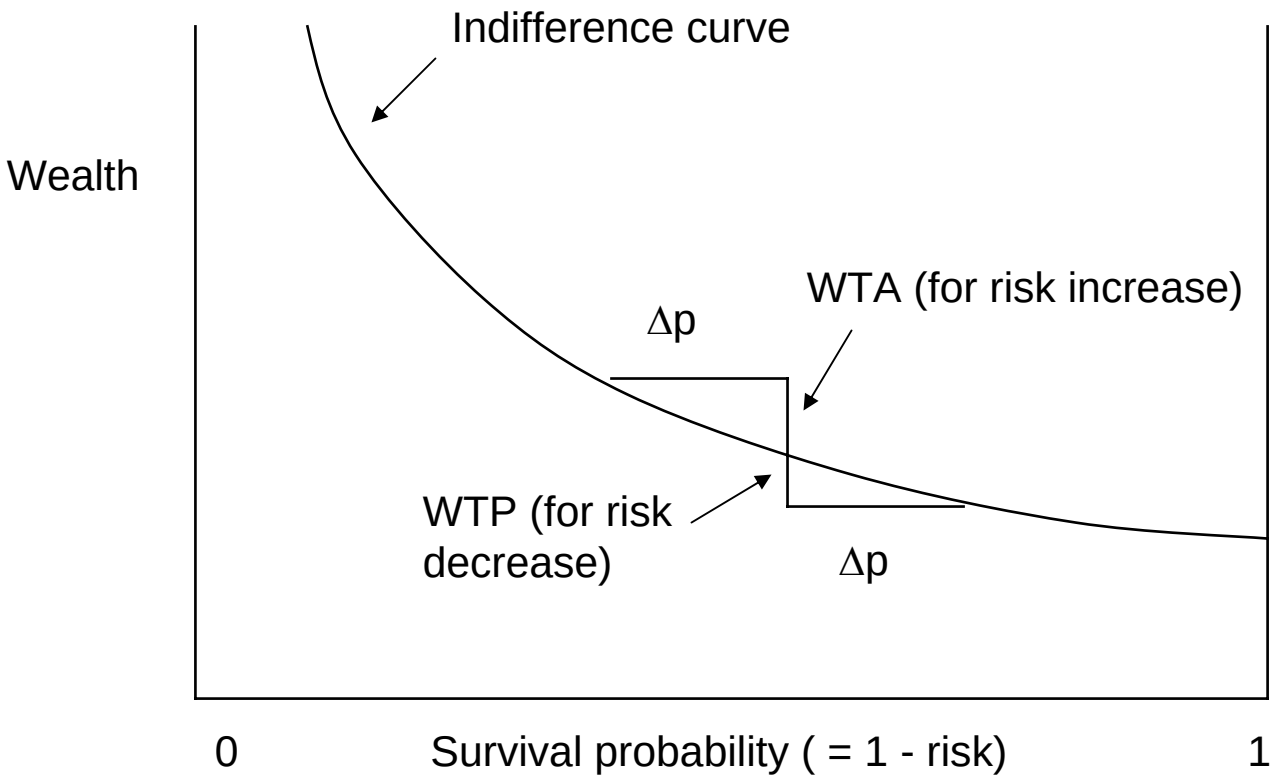
Ex ante problem is

- Own WTP
- For small change in own mortality risk
- Within specified time period

$$VSL \approx \frac{WTP}{\Delta p}$$



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



Value per Statistical Life

If N (= 100,000) people are each willing to pay $50 to prevent a risk of death of 1 in N, then value per statistical life is $5 million

$$VSL = \frac{WTP}{\Delta p} = \frac{N \cdot WTP}{N \cdot \Delta p} = \frac{Total\_WTP}{E(lives\_saved)}$$

Since WTP is not exactly proportional to Δp, VSL depends on Δp

Value per Statistical Life

Is NOT a measure of the intrinsic worth of an individual

Does NOT measure what an individual would pay to avoid certain death (or accept as compensation for certain death)

Depends on

- (total) baseline risk
- income and wealth

May depend on the type of risk

- e.g., acute or chronic, “voluntary” or “involuntary”
- WTP to reduce risk of fatal degenerative disease 30% larger for cancer than for other disease (Hammitt & Liu, 2004)

Standard Model
(single period)

$EU = (1 - p)\, u_a(w) + p\, u_d(w)$

p = mortality risk (probability)

$u_a(w)$ = utility if survive period with wealth w

$u_d(w)$ = utility if die in period with wealth w

$$VSL = \left.\frac{dw}{dp}\right|_{EU=c}$$

Value per Statistical Life

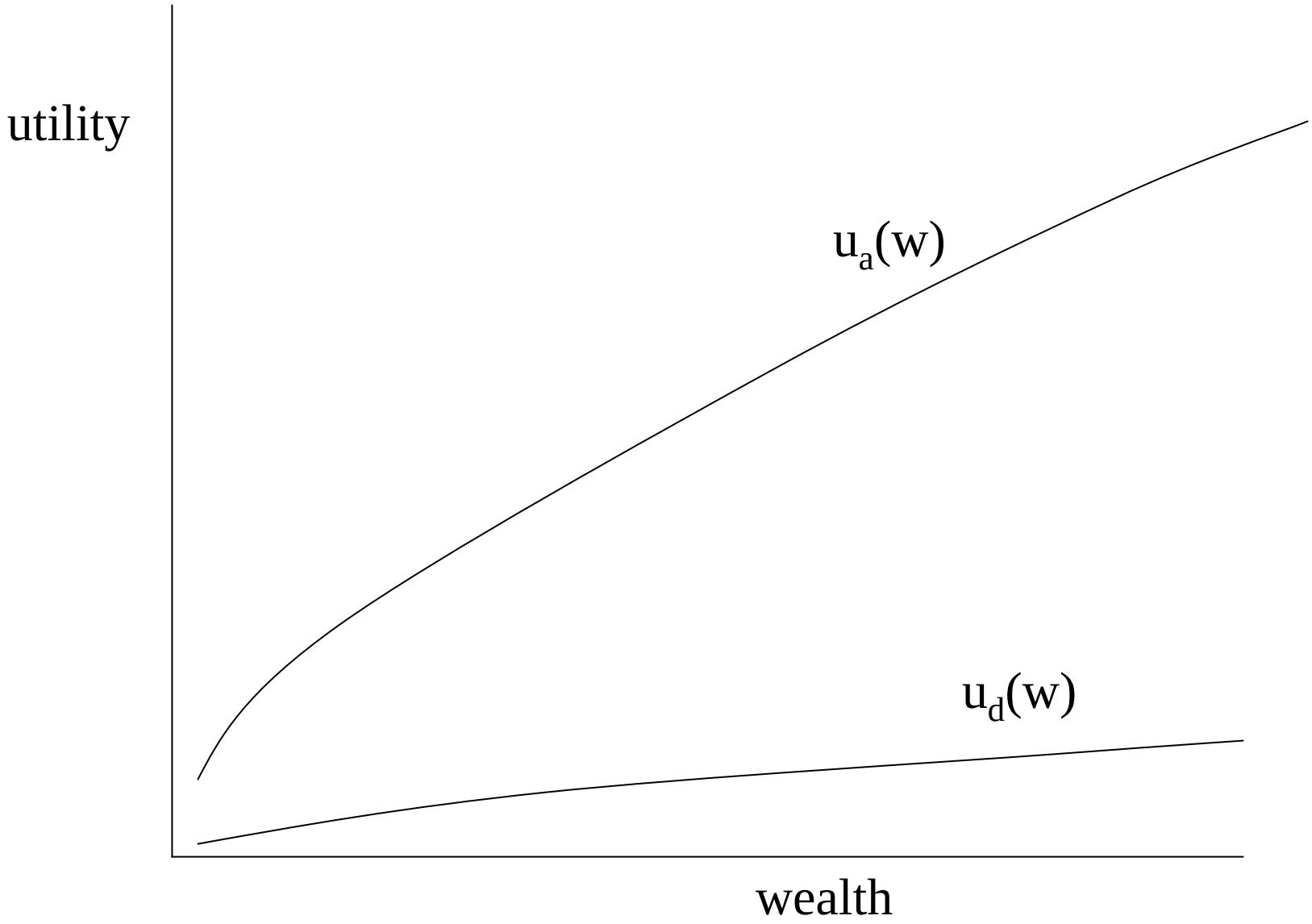
$$VSL = \left.\frac{dw}{dp}\right|_{EU=c} = \frac{u_a(w) - u_d(w)}{(1-p)u_a'(w) + pu_d'(w)} = \frac{\Delta u(w)}{Eu'(w)}$$

Assume

$u_a(w) > u_d(w)$

$u_a'(w) > u_d'(w) \geq 0$

$u_a''(w) \leq 0,\ u_d''(w) \leq 0$


utility
$u_a(w)$
$u_d(w)$
wealth

Effect of Wealth on VSL

$$\frac{\partial}{\partial w} VSL = \frac{\overset{+}{(Eu')}\overset{+}{(u'_a - u'_d)} - \overset{+}{(u_a - u_d)}\overset{-}{(Eu'')}}{\underset{+}{(Eu')^2}} > 0$$

VSL increases with wealth

Estimated income elasticity

Cross-sectional: 0.4 - 0.6

Developing country to US: 2 - 3?

Effect of Baseline Risk

$$VSL = \frac{u_a(w) - u_d(w)}{(1-p)u_a'(w) + pu_d'(w)}$$

$$\frac{\partial}{\partial p} VSL = \frac{(u_a - u_d)(u_a' - u_d')}{(Eu')^2} > 0$$

(+ over $u_a - u_d$; + over $u_a' - u_d'$; + over $(Eu')^2$)

"Dead-anyway effect"

Effect of Health is Ambiguous

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

If survival is in good health rather than poor

- Δu is higher
- Eu' may be higher

VSL higher for people with cancer, heart, lung disease

- (Krupnick et al. 2002 CV, Smith et al. 2002 wage differential)

Effect of Life Expectancy is Ambiguous

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

If survival is with long life expectancy

Δu is higher

Eu' may be higher

- Investment opportunities, future earnings

Effect of Life Expectancy

Lifecycle models suggest VSL rises then falls with age

$$\text{Max} \quad V = \sum_{t=0}^{\infty} s(t)\left(\frac{1}{1+r}\right)^{t} u(c_t)$$

subject to budget constraint based on earnings (can save, may be able to borrow)

Peak VSL somewhere between 25 and 65?

Sensitive to assumptions about discounting (Shepard & Zeckhauser, 1984, Ng, 1992)

Contingent Valuation

Krupnick et al. (2002), Alberini et al. (2002)

VSL constant for ages 40-70

Older than 70

- 30% smaller in Canada ($p < 10\%$)
- 20% smaller in US (not significantly different from zero)

Compensating Wage Differential

Smith et al. (2002)

- VSL constant ages 51-65
- Comparable to estimates for younger cohorts

Aldy and Viscusi (2003)

- VSL follows inverted U
- Peaks around age 35
- < ½ as large by age 60

Relative Value of Reducing Mortality Risk

	QALY	WTP
Life expectancy	Increase	Ambiguous
Health	Increase	Ambiguous
Wealth	No effect	Increase
Baseline risk	No effect	Increase
Competing risk	Decrease	Decrease
Qualitative attributes	No effect	May affect

Integration: WTP per QALY

Is WTP Proportional to Expected QALY Loss?

If WTP per QALY is constant (for individual)

- BCA and CEA would yield equivalent results
- Could estimate WTP from information on QALYs

Empirical Test

- Contingent valuation
- WTP to reduce risk of short-term morbidity
  - Food borne illness
- Assessed current health, health if sick, using HUI and VAS

Survey Sample

Internet panel (Knowledge Networks)

Representative of general US adult population

- Recruited to panel by random-digit dialing

2795 respondents / 4481 recruited = 62%

2049 usable responses

- 418 were asked first about risk to child
- 255 did not answer health questions
- 58 do not eat any of the three foods
- 18 did not answer WTP

Survey Sample

Variable	Mean (SD)
Age	46 yrs (17)
Male	47%
Household income	$48 000 (36 000)
Married	52%
Household size	2.4 (1.3)

Survey Instrument

Risk reduction	Symptoms	Duration	Conditional mortality	Food
1 in 10,000	Mild	1 day	None	Chicken
3 in 10,000	Moderate	3 days	1 in 10,000	Hamburger
	Severe	7 days	1 in 1,000	Deli meat

Mild	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.
Moderate	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.
Severe	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.

Health state	VAS	HUI
Current health	0.75 (0.17)	0.80 (0.20)
Mild	0.58 (0.21)	0.51 (0.27)
Moderate	0.46 (0.23)	0.26 (0.30)
Severe	0.42 (0.25)	0.11 (0.30)

Model

WTP = Δrisk x ΔQALYs x WTP/QALY

= Δrisk x [ΔHUI x duration] x WTP/QALY

log(WTP) = δ log (Δrisk)

+ α log (ΔHUI)

+ β log (duration)

+ γ log (WTP per QALY)

+ other covariates + error

Null hypothesis: $\delta = \alpha = \beta$ = 1

Regression Estimates

Variable	Double bounded	Single bounded
log (Δrisk)	0.48 (0.08)	0.74 (0.13)
log (ΔHUI)	0.17 (0.05)	0.21 (0.09)
log (duration)	0.11 (0.05)	0.14 (0.09)

Reject proportionality to Δrisk, ΔHUI, duration

Severity	DHUI	Duration	WTP ($000)	WTP/QALY ($000)
Mild	0.293	1 day	9.1	790 – 950
Mild	0.293	3 days	10.2	760 – 960
Mild	0.293	7 days	11.2	650 – 870
Moderate	0.540	1 day	10.1	820 – 1,020
Moderate	0.540	3 days	11.4	720 – 950
Moderate	0.540	7 days	12.5	550 – 760
Severe	0.695	1 day	10.5	820 – 1,040
Severe	0.695	3 days	11.9	690 – 920
Severe	0.695	7 days	13.0	500- 700

Empirical Test

WTP is a ‘flatter’ function of health risk than QALYs

WTP/QALY values very high in this study

Interpersonal Aggregation

Interpersonal Aggregation

- Evaluate policy by summing individual changes in QALYs or WTP
  - Usually do not evaluate differences (disparities) between people in
    - Effect of policy
    - Baseline health or well being
  - Could incorporate differential effects or beneficiaries using weighted sum of changes

Interpersonal Comparison

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

- Who benefits more from an extra year of life?

Neoclassical economics assumes utility cannot be measured, compared between people

Any standard we choose is arbitrary

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

Role of Allocative Efficiency

Use of WTP based on potential Pareto improvement or Kaldor-Hicks compensation test

Those who benefit from a policy could compensate those who are harmed so that everyone would benefit

Separate size of the pie from its division

- Maximize so everyone could have a larger piece

Role of Allocative Efficiency

- Society allows market principles to govern allocation of many goods, but not all
  - E.g., proscribe potential gains from trade of child labor, body parts, votes
  - In these cases, need other methods to determine “how much?”
- A social question that's wrapped up in a moral question:
  - Maximize “health” or use market principles to maximize potential welfare (allocative efficiency)?

Tension between Individual and Social Perspectives

WTP

- Use population-average values
- Conflicts with effects of wealth

QALYs

- Discount future QALYs for intertemporal equity
- Conflicts with assumed individual risk neutrality

Conceptual Summary

	QALY	WTP
Conceptual basis	Tradeoff between health and longevity	Tradeoff between (health, longevity) and wealth
Social objective	Maximize health and longevity	Maximize self-perceived welfare
Standard for interpersonal comparison	Healthy year	Purchasing power

Conclusion

QALYs and WTP have different conceptual bases

- QALYs impose more structure on preferences

Anticipate systematically differences in relative valuation of risks

Empirically, WTP is a ‘flatter’ function of health risk than QALYs