The Value of a Long Life: Lessons from the Theoretical Foundations of Medical Cost-Effectiveness Analysis

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Overview

- Improvements in health and resulting gains in quality of life and longevity are highly valuable
- Value is offset to some degree by costs of longevity
- Magnitude of offset in welfare terms depends on size of gains in longevity vs. gains in quality of life
- Relative size of gains in length and quality of life will be affected by choices that we make
- Best decisions about health care resource allocation will reflect the relative costs of improving the length and quality of life
  - Example from lung cancer
  - Implications for research prioritization

Economic Perspective on Value of Life

- Priceless?
- Raw materials
- Lost earnings ("Human Capital Approach")
- Revealed Preference Compensating Differential Approach
  - What people will give up/pay to reduce probability of death
  - Value of a life year: Higher lifetime wages needed get people to accept jobs with higher probability of death that decrease life expectancy by 1 year ~$50K-100K
  - Underestimates value of increase in life expectancy to extent risk averse people avoid risk
  - Overestimates value of increase in life expectancy to extent jobs with high risk of death also have high risks of injury

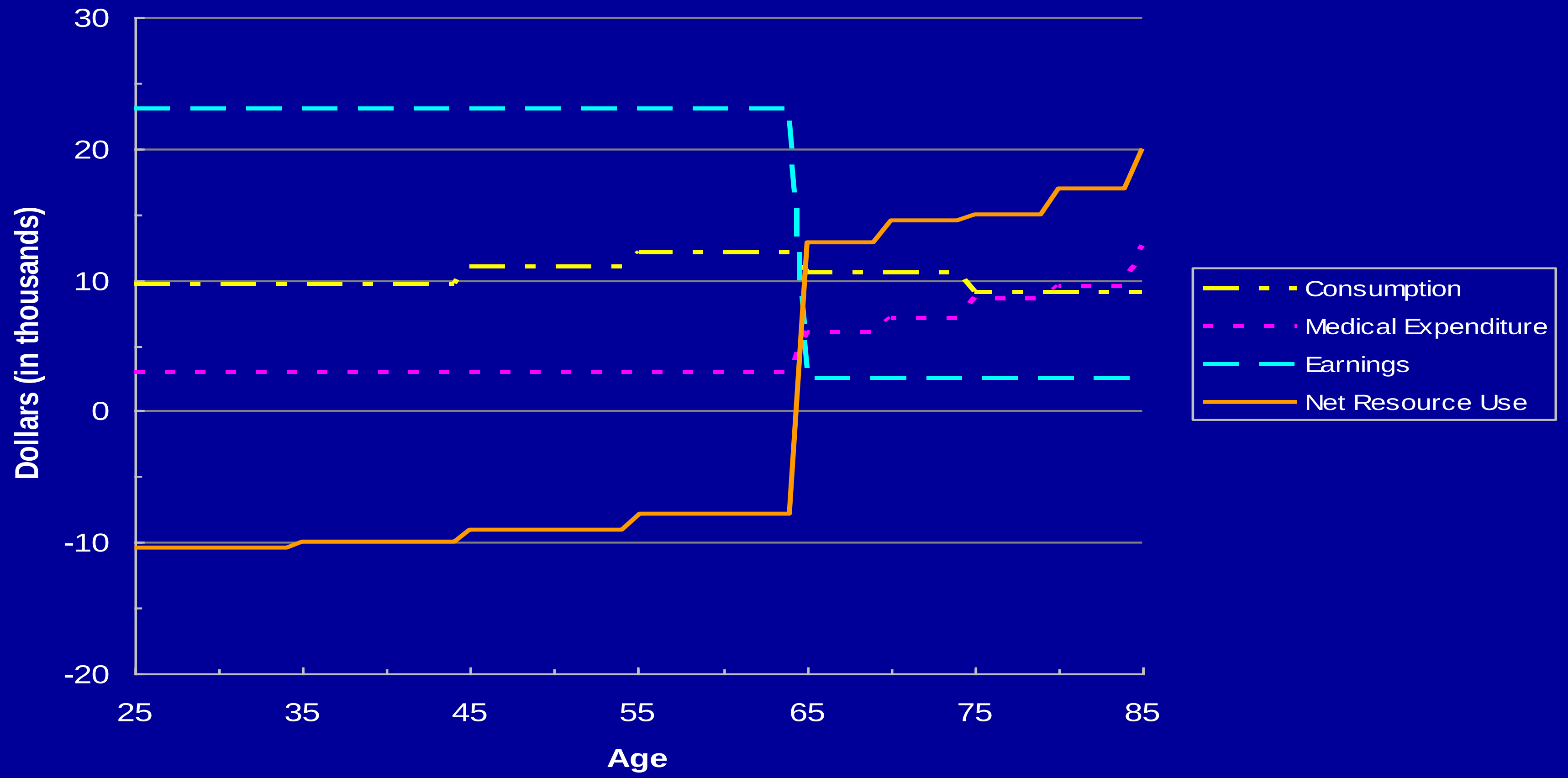
Improved Health Highly Valuable

- Cutler and Richardson (1997), Murphy and Topel (2003), Nordhaus (2003)
- Multiply value of life-year saved (LYS) from statistical value of life (SVoL) based on revealed preference studies * increase in life expectancy from 1970 to 2000
- Value Δ LY= 0.2 LYS (2-3months)/person/yr * $50,000/LYS = $10,000/person/yr
  - Comparable to increase in per capita GDP over entire period
- $3 trillion per year, or $90 trillion from 1970-2000
  - Value Δ LY = 300 million people * $50,000/LYS * 6 LYS
- Estimates may be too low
  - Some estimates of SVoL ~$200,000/yr
  - Value of improvements in quality of life adds to this

Value of Increased Longevity Offset by Costs of Longevity

- Benefits of improved health
  - Increased length and quality of life
  - Increased QALYs = $\Delta\sum\beta^{t}S_{t}Q_{t}$
    - S_t survival probability
    - Q_t quality of life adjustment
    - $\beta < 1$ time preference discount factor
  - Increased years of productivity
  - Improved productivity and reduced health care costs at all ages
- Costs of improved health
  - Increased years of consumption and medical care
- Value of improved health = benefits - costs

Consumption, Medical Expenditure, Earnings and Net Resource Use by Age



Cost Offset of Health Gain Depends on Gains in Longevity vs. Quality of Life

- Value gain LY: $V(QALY) * \Delta QALY - \Delta LY\,(C + M - E)$
  - Cost offset = $C + M - E$
- Value gain QOL = $V(QALY) * \Delta QALY$
  - Cost offset = 0
- Cost Offset of Value Gain LY vs. Value gain QOL per QALY gained ($\Delta QALY$)

$$= [V(QALY) * \Delta QALY - (V(QALY) * \Delta QALY - \Delta LY\,(C + M - E))] / \Delta QALY$$

$$= (C + M - E) * (\Delta LY / \Delta QALY)$$

$$= < \$20{,}000 * (1/QOL)$$

$$< \$50{,}000/QALY \text{ if } QOL < 0.4$$

$$< \$100{,}000/QALY \text{ if } QOL < 0.2$$

Methods for Quality of Life Adjustment

- Linear analog scale
- Standard gamble
- Time trade-off

Linear Analog Scale

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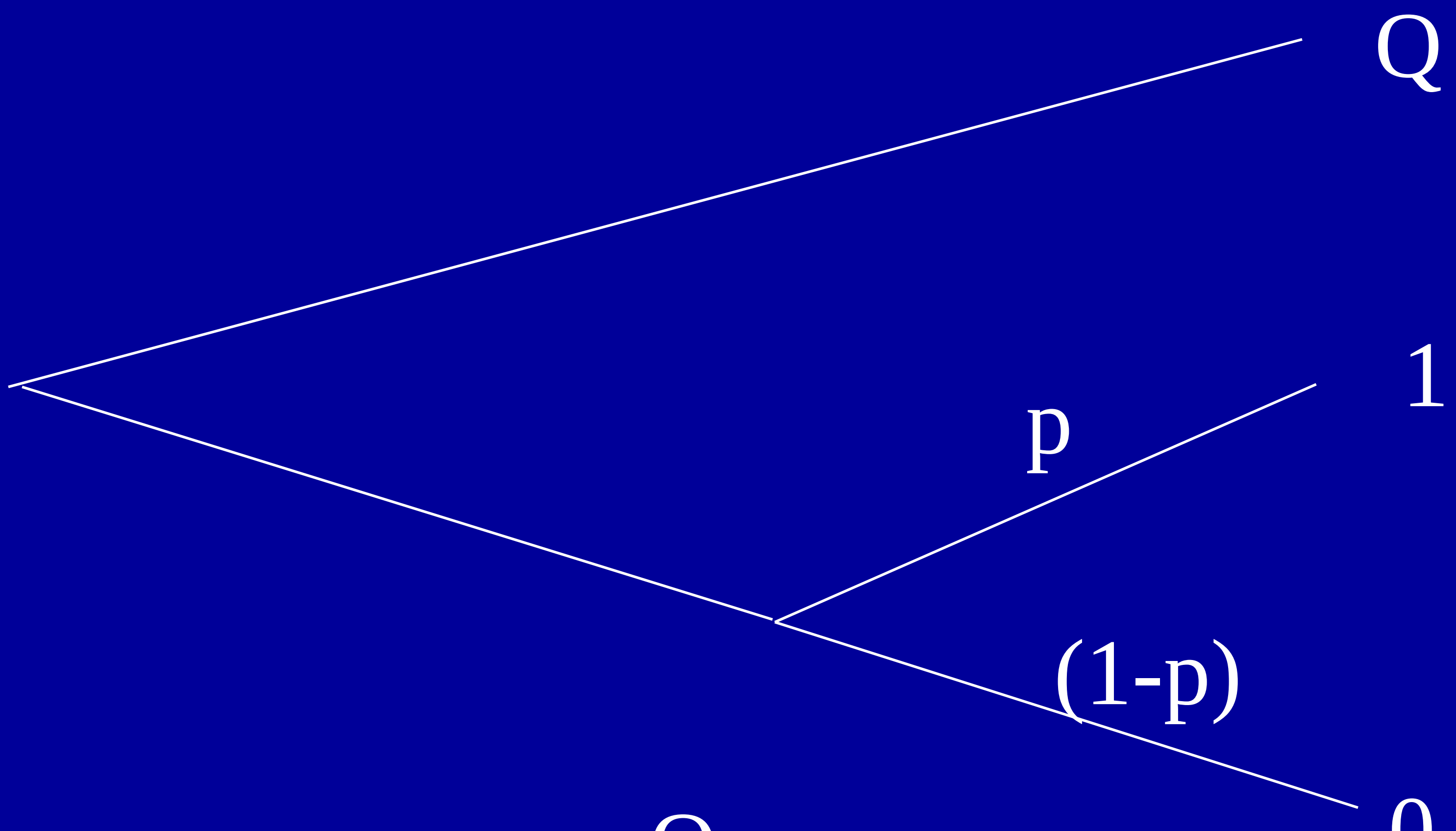
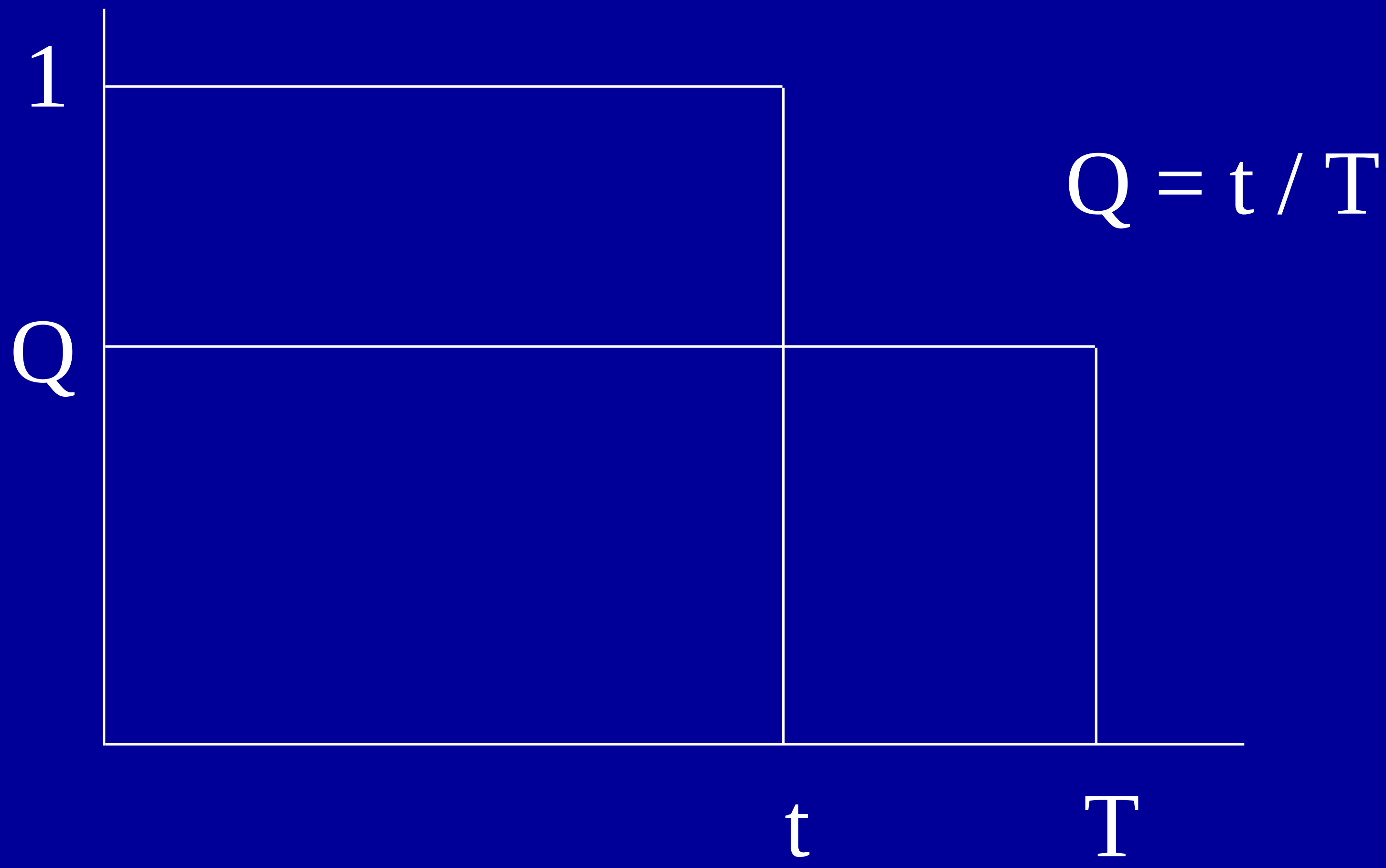
Standard Gamble



$Q = p$

Time Trade-off



Diabetes-related Complication Utilities

Complication	Mean (95% Cl)
Angina	0.65 (0.63, 0.67)
Mild Stroke	0.71 (0.68, 0.73)
Severe Stroke	0.32 (0.29, 0.34)
Peripheral Neuropathy	0.67 (0.65, 0.70)
Amputation	0.56 (0.53, 0.59)
Diabetic Retinopathy	0.54 (0.51, 0.57)
Blindness	0.40 (0.37, 0.42)
Mild Kidney Disease	0.66 (0.63, 0.69)
Kidney Failure	0.36 (0.34, 0.39)

Implications

- Cost-offsets from increased longevity are not likely to make gains in longevity undesirable
- But does this mean potential costs of longevity are irrelevant?

Cost-Effectiveness of Medical Interventions

Intervention	Cost/LY
Neonatal PKU screening	<0
Sec. prev. hyperchol. men age 55-64	2,000
Sec. prev. hyperchol. men age 75-84	25,000
Pri. prev. mild hyperchol. men age 55-64	99,000
Screening exercise test men age 40	124,000
Screening ultrasound every 5 yr. for AAA	907,000

Background: Accounting for Future Costs

- Save patient with medical care today who requires care in the future. Should we count that as a cost?
  - Related illness?
    - Angioplasty today, count bypass in future?
  - Unrelated illness?
    - Influenza vaccine today, count dialysis in future?
  - Non-medical costs and benefits?
    - Suicide prevention today, earnings in future? Consumption in future?

Traditional Treatment of Future Costs and Benefits in CEA

- Analyses generally <u>include</u>:
  - Future benefits
    - Length of life/Quality of life = QALYs
  - Future medical costs for related illnesses
- Analyses generally <u>exclude</u>:
  - Future medical costs for unrelated illnesses
    - Few exceptions: Weinstein, OTA
  - Future non-medical costs
- Controversies reflect weak theoretical foundation of CEA

Theoretical Background: Phelps & Garber (1997)

- Use lifetime utility maximization model
- Conclude: Obtain same relative rankings of interventions if you include or exclude future medical costs for unrelated illness as long as they are:
  - treated consistently
  - truly unrelated = "conditional independence"

Theoretical Background: Meltzer (1997)

- Use lifetime utility maximization model
- Conclude:
  - Must include all future net resource use
    - Medical costs - both related and unrelated - and future non-medical costs net of earnings
    - “Net resource use”= consumption + medical expenditures - earnings
    - From -$10,000/ year @ age 25 to +$20,000/year @ age 85
  - Relative rankings of interventions not independent of future costs
    - Analyses that omit future costs favor interventions that extend life over those that improve quality of life
  - Phelps/Garber inadvertently assume net annual resource use is zero

Intuition

- Consider two interventions with equal current cost that both produce one QALY
    - ***A*** increases life expectancy by one year at QOL=1
    - ***B*** increases life expectancy by two years at QOL=0.5
- Which is preferred?
    - From utility side: Indifferent
    - From cost side: ***A*** preferred since it saves the costs of supporting an extra year of life
    - Hence, ***A*** preferred overall
- Omitting future costs favors interventions that extend life (***B***) versus those that increase QOL (***A***)

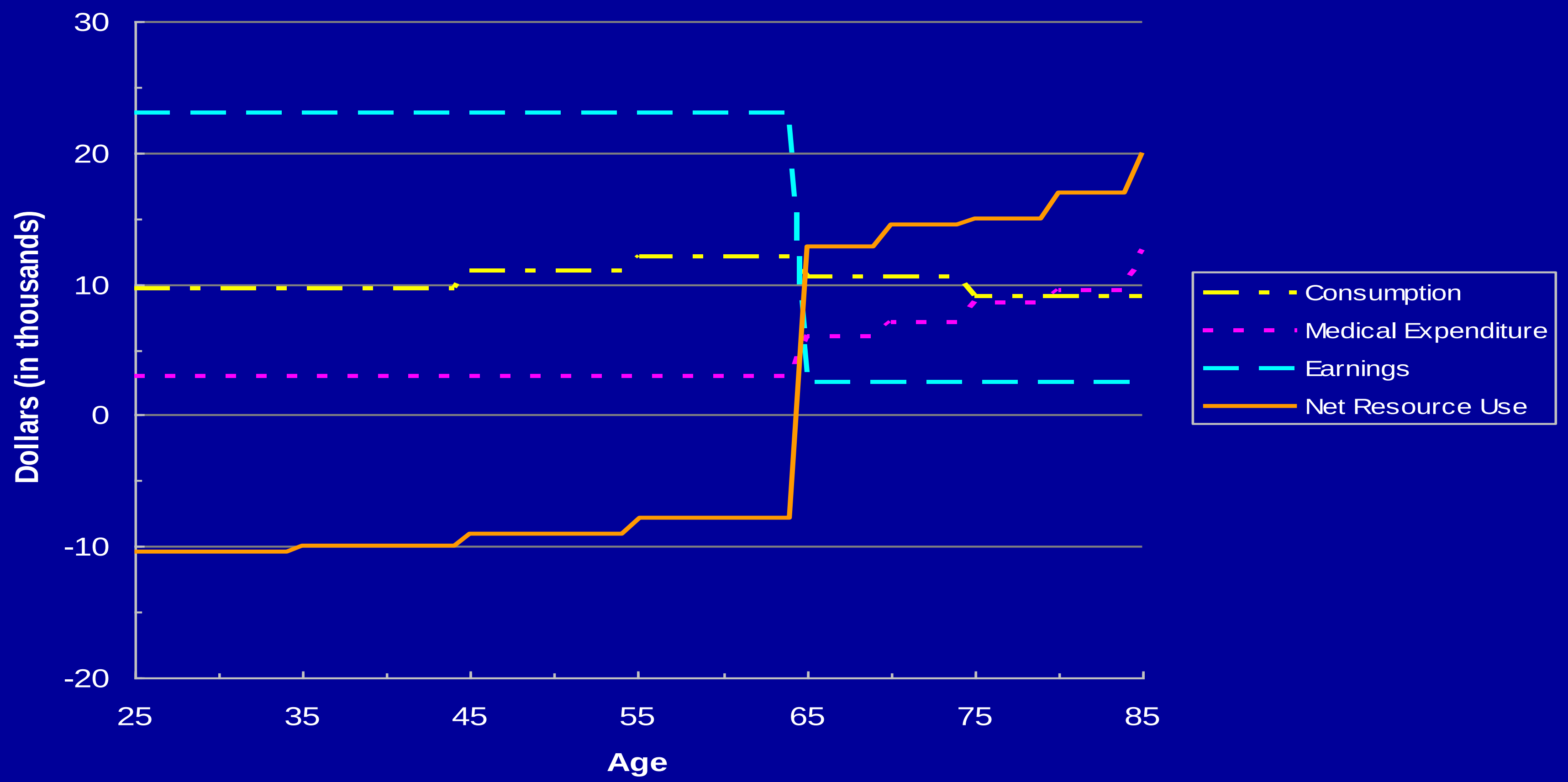
Accounting for Future Costs

$$\frac{\Delta\text{cost}}{\Delta\text{QALY}} = \frac{\Delta\text{present cost}}{\Delta\text{QALY}} + \frac{\Delta\text{future cost}}{\Delta\text{QALY}}$$

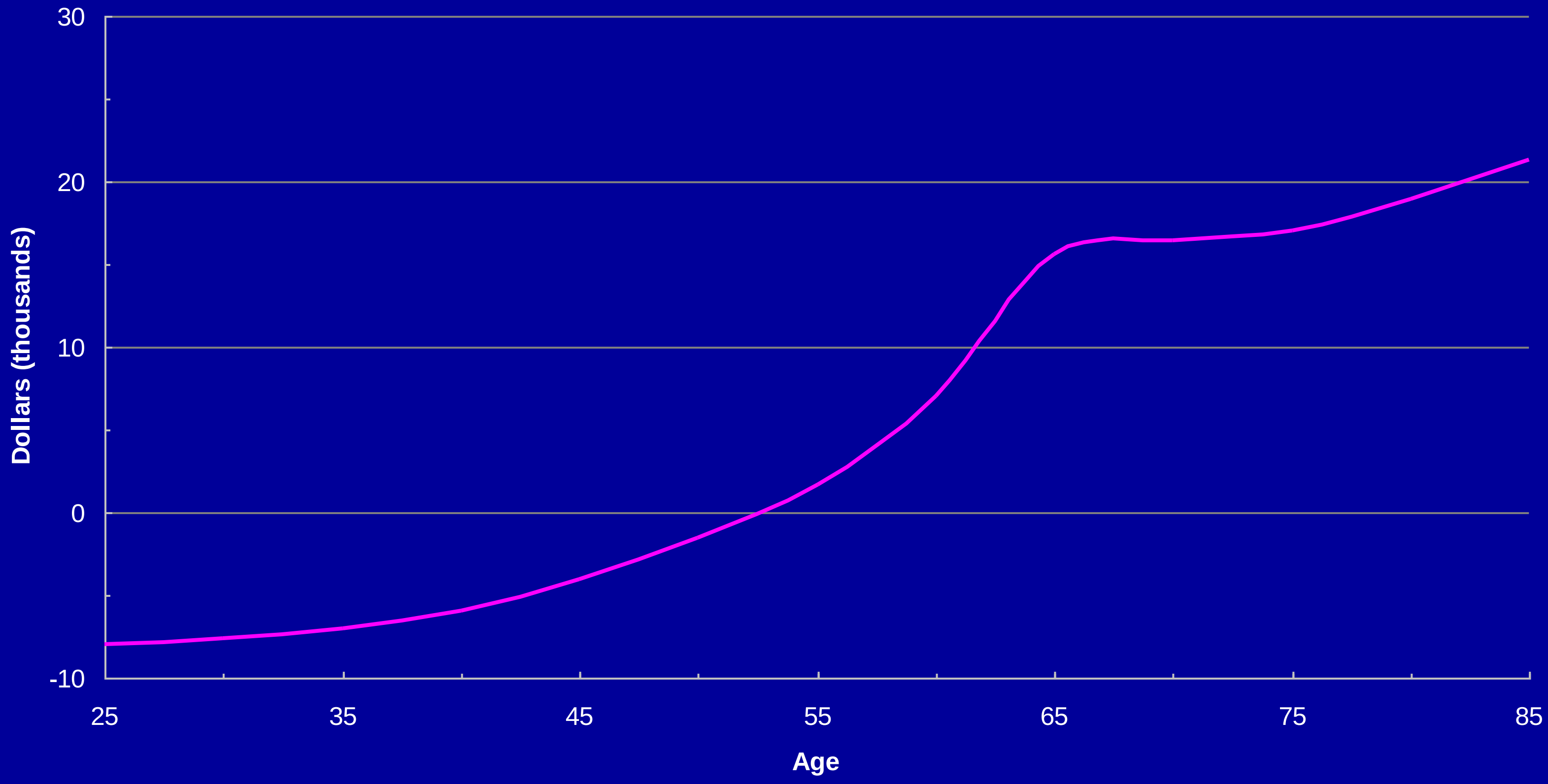
$$= \frac{\Delta\text{present cost}}{\Delta\text{QALY}} + \frac{C * \Delta\text{LY}}{\Delta\text{QALY}}$$

$$= \frac{\Delta\text{present cost}}{\Delta\text{QALY}} + C * \frac{\Delta\text{LY}}{\Delta\text{QALY}}$$

Consumption, Medical Expenditure, Earnings and Net Resource Use by Age



Present Value of Future Net Resource Use Per Year of Life Saved by Averting Death (by Age)



Approximate Effects of Future Costs

Intervention	Cost/QALY without future costs	C	ΔLE/ΔQALY	C∗(ΔLE/ΔQALY)	Cost/QALY with future costs
Treatment Severe Hypertension Men Age 40	$18,000	-$5,000	1.03	-$5,200	$12,800
Treatment Severe Hypertension Men Age 60	$60,000	$8,000	1.07	$8,500	$68,500
Adjuvant Chemo Duke's C Colon CA Men Age 60	$67,000	$8,000	18	$144,000	$211,000
Hemodialysis for ESRD Men Age 60	$117,000	$8,000	1.5	$12,000	$129,000

Effects of Future Costs for Interventions among the Elderly

INTERVENTION	ΔLY	ΔQALY	ΔLY/ΔQALY	Δcost/ΔQALY w/o future costs	Δcost/ΔQALY w/ future costs
Hip Replacement Women age 60	-0.03	6.9	-0.005	Cost-saving	Cost-saving
Hip Replacement Men age 85	-0.02	2.0	-0.01	$9,177	$9,042
Treatment Mild HTN Men age >70	0.06	0.05	1.25	$5,000	$32,000
Radiation Tx. MDPC Age 65	0.8	0.4	2	CECRC	CECRC+$32,000
Prostatectomy MDPC Age 65	0.7	0.2	3.5	CECRC	CECRC+$56,000

HTN = Hypertension, MDPC = Moderately Differentiated Prostate Cancer
CECRC = Cost-effectiveness based on Current and Related Costs

Cost-Effectiveness of Taxol/Cisplatin for NSLC (Berthelot et al, JNCI 2000)

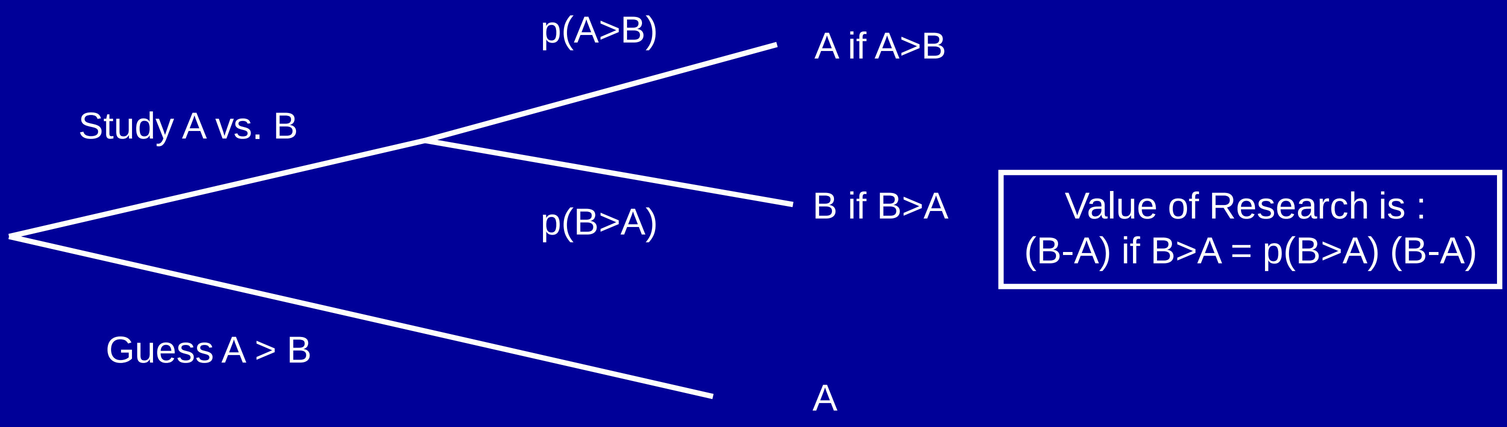
Dose	$\Delta\$/\Delta LY$	$\Delta\$/\Delta QALY$	$\Delta LY/\Delta QALY$
Low	15,400	21,500	1.4
Medium	21,500	30,100	1.4
High	27,000	37,800	1.4

Implications for Value of a Long Life

- Extending life is highly valued
  - Value depends on QOL
- Longevity produces cost offset: C + M - E
- Less important than health gains unless QOL very low
- But cost-offset can change cost-effectiveness of medical interventions
  - Recognition of this causes us to favor interventions that improve quality versus length of life
  - Increase value of life extension by improving QOL
- Value of life extension influenced by choices we make
  - Technology development is an example, favor length or quality of life

Value of Information Approach to Prioritizing Research

- Systematic approach to valuing benefits of research
  - Change in expected value of outcome given decision with research compared to without research
  - Developed by Raiffa & Schleifer 1950s, Claxton 2000, Meltzer 2002
  - Used in UK by National Institute of Health and Clinical Excellence
  - Often valued in QALYs net of costs, possibly including longevity costs, so QOL benefits make research more valuable
  - Growing use in US



Quantitative VOI Estimates

Topic Area	VOI Estimate ($ Million)
MR in Knee Trauma	8
LVAD as Destination Therapy	8
Azithromycin vs. Augmentin in Sinusitis (ignoring costs)	40
Pegylated Liposomal Doxyrubicin in Ovarian CA	206
Azithromycin vs. Augmentin in Sinusitis (including costs)	250
Treatment of Intermittent Claudication	573
Cognitive Behavioral Therapy for Post-partum Depression	603
Typical/Atypical Antipsychotics in Schizophrenia	124,658

Practical Applications of Value of Information

- VOI requires modeling population value of information

$$VOI = \sum_t \beta^t \times D(t) \times I(t) \times N_t \times IVOI$$

where

β^t *is time preference discount factor*

$D(t)$ *is depeciation of knowledge over time*

$I(t)$ *is extent of implementation*

N_t *is number of eligible individuals* in *each cohort*

IVOI is individual VOI

- VOI based on decision models
  - IVOI modeled with decision model
  - UK (NICE): Alzheimer's Disease Tx, wisdom teeth removal
- Minimal modeling approaches to VOI
  - IVOI comes (nearly) directly from clinical trial
  - US (NIH): CATIE Trial of atypical antipsychotics
- Bound with more limited data (conceptual VOI, burden of illness)
  - PCORI

DRAFT

Methods for Establishing Research Priorities

Draft Chapter Framework

pcori

PATIENT-CENTERED OUTCOMES RESEARCH INSTITUTE

Value of Information

Topic Generation

Topic Area

Topic Area

Topic Area

Topic Area

Gap Analysis in Systematic Review

Value of Information Analysis

Peer / Stakeholder Review

Topic Generation

- Need to consider topic if are going to prioritize it
- PCOR perspective creates large number of new questions
- How do you involve patients and other stakeholders?

Gap Analysis in Systematic Review

- How should systematic reviews be performed?
- How used to generate research topics?
- How to incorporate patient perspective?

Value of Information Analysis

- Provide Board and/or grant applicants with tools to quantify expected benefits of research
- When is VOI worth it? Is it a $$ amount? Can costs of VOI be reduced?
- How to incorporate patient perspective?

Peer / Stakeholder Review

- Design of review process?
- Balance between directive and investigator-initiated research?
- Feedback for grant recipients and format for feedback?