




COLLEGE OF PUBLIC HEALTH
The University of Georgia
1785

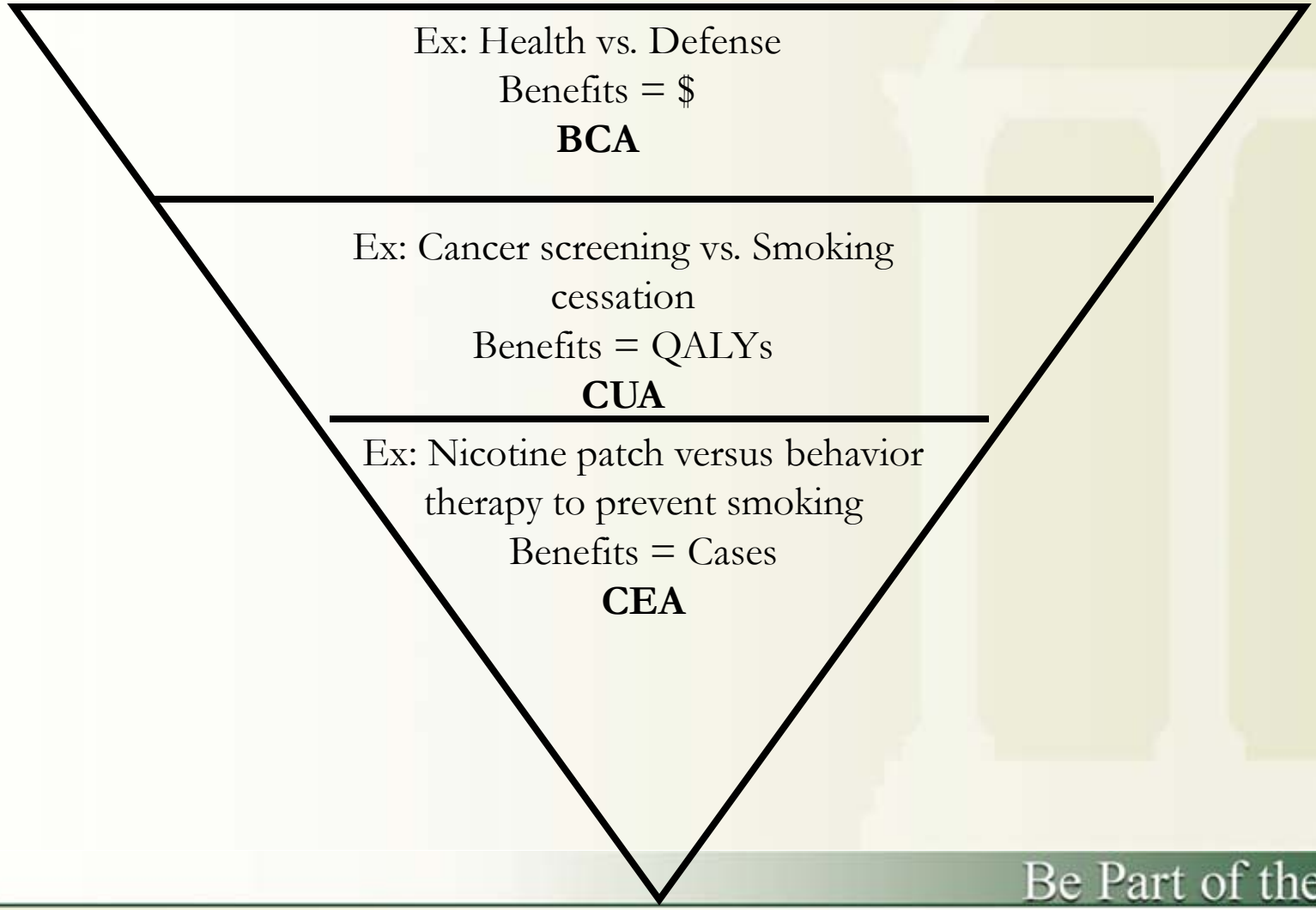
Introduction to Economic Evaluation – Part II

May 18, 2011

Outline

- Overview of BCA, CEA, and CUA
- Measuring outcomes for use in economic evaluations
  - BCA - $
  - CEA – natural units
  - CUA - QALYs
- Examples of BCA/CEAs of tobacco control programs

What EE Method to Use?



Systematic Review of EE Evidence in Tobacco Control

- Kahende, Loomis, Adhikari, Marshall. A review of economic evaluations of tobacco control programs. *Int J Environmental Research in PH* 2009;6:51-68.

Benefit-cost Analysis (BCA)

- A method used to compare costs and benefits of an intervention
  - where all the costs and benefits are standardized or valued in ***monetary terms***.

- Provides a single value:
  - Net Benefits: NB (Benefits – Costs)

Quantify Benefits - BCA

- Human Capital or Cost-of-Illness (COI) approach
  - Typically includes medical costs and productivity losses averted
  - Productivity losses based on wages
    - Undervalues women, children, and the elderly

- Willingness-to-Pay (WTP) or Contingent-valuation surveys
  - e.g., how much is society ***willing to pay* to** reduce the annual mortality risk associated with secondary smoke

Example

- Mudharri, US EPA, 1994
  - BCA of a national smoke-free law for all public building with 10+ persons entering per week
  - Costs
    - Implementation of the restriction, construction and maintenance of smoking lounges, and enforcement.
  - Benefits - HUMAN CAPITAL APPROACH
    - Savings on medical expenditures by averting heart disease, the value of lives saved, costs averted by reduced smoking-related fires, and productivity improvements.
  - The net present benefit to society was between $42 and $78 billion, and this range was based on high and low estimates of costs and benefits.

Cost-effectiveness Analysis (CEA)

- Measures both the costs and outcomes, but assures that all of the outcomes are measured in the same metric across all alternatives.
  - The outcome of interest is the only relevant outcome for both strategies
    - cost per quit
    - cost per smoking days prevented
    - cost/life saved
    - Cost per life-year saved

CE Never in Isolation

- Compared to what?
  - A single option can never be "cost effective"; the term ***requires*** a comparison to another specific alternative
    - another intervention or option
    - do nothing (which has its own stream of costs and outcomes)
    - Status quo (which may be doing nothing)
- Choice of comparator
  - always use best available alternative intervention
  - always include most widely used intervention

Average, Marginal, and Incremental C/E Ratios

- Average C/E ratio (ACER)
  - ratio of costs to outcomes for a single program
- Marginal C/E ratio (MCER)
  - ratio of additional costs to outcomes obtained from one additional unit of an intervention
- Incremental C/E ratio (ICER)
  - ratio of additional costs to outcomes obtained when one program is compared with the next least effective program

Average C/E Ratio - Strategy A

$$\frac{\text{Cost Strategy A}}{\text{Outcome Strategy A}}$$

Marginal C/E Ratio - Strategy A

$$\frac{\text{Cost Strategy A' - Cost Strategy A}}{\text{Outcome Strategy A' - Outcome Strategy A}}$$

Incremental C/E Ratio - Strategy B

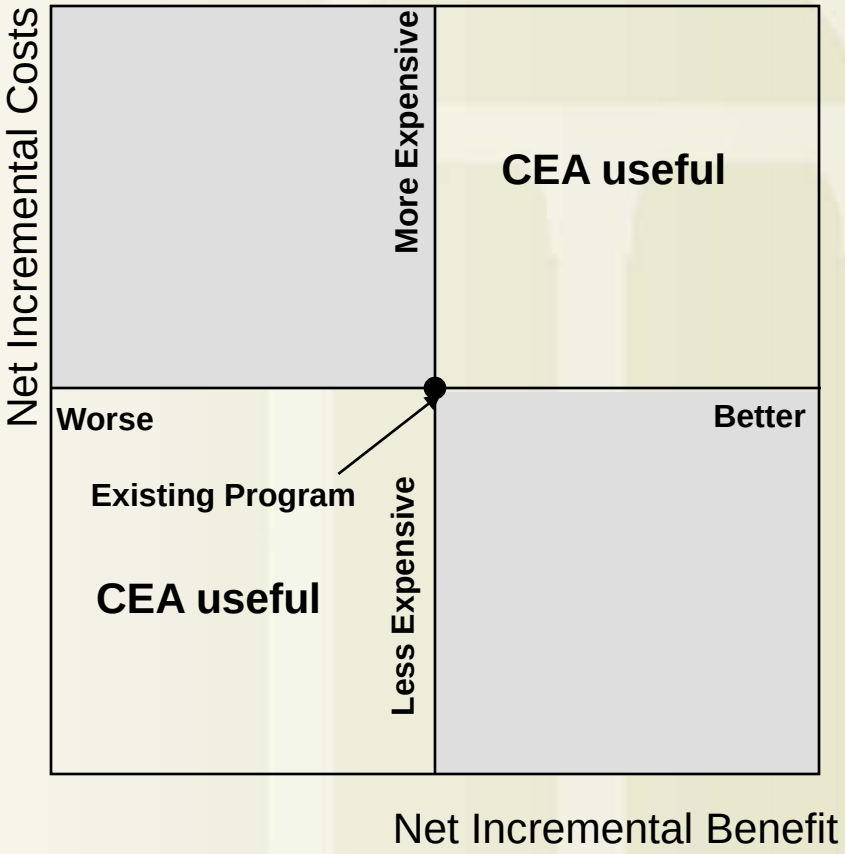
$$\frac{\text{Cost Strategy B - Cost Strategy A}}{\text{Outcome Strategy B - Outcome Strategy A}}$$

Costs include:

program costs – (medical costs + productivity losses averted*)

Cost-Consequence Space

- Different actions are indicated in the different quadrants
- CEA analysis is only useful when there is a ***TRADEOFF*** between cost and outcomes



Quantify Outcomes — CEA

- Intermediate outcomes:
  - Reduced cigarette smoking
  - Decreased hypertension
- Final outcomes:
  - Increased disability-free days
  - Increased # of life years (LYs) or life expectancy
  - Increased health-related quality of life (HRQoL)

CEA Caveat

- Outcomes cannot be combined; they must be considered separately. Consider one or two of the most important measures.
- Number of summary measures depends on number of outcomes chosen.
  - If A and B are the most important, then:
    - Cost/outcome A (cost per 1% increase in smoking days).
    - Cost/outcome B (cost per 1% reduction in hypertension).
    - **Translation for policy-makers can be difficult.**

Hollis, McAfee, Fellos, et al
Tobacco Control
2007; 16(S1): i53-i59

THE EFFECTIVENESS AND COST-EFFECTIVENESS OF TELEPHONE COUNSELING AND THE NICOTINE PATCH IN A STATE TOBACCO QUITLINE

Tobacco Quitlines Overview

- Quitlines are telephone-based tobacco cessation services that help tobacco users quit
- In this particular intervention, counselors, with motivational interviewing training, follow computer driven scripts providing
  - Caring
  - Motivation
  - Quitting strategies
- Participants offered referrals, mailed “quit kits”, and given information on pharmacotherapy options

Study Overview

- Comparison of the cost-effectiveness of three protocols
  - Intensive: multiple and longer calls
  - Moderate: multiple calls
  - Single brief call
- Three protocols further divided into 2 groups each
  - Offered free nicotine patches (NRT)
- Part of an RCT
- Outcome:
  - 30 days of abstinence at 12-month follow-up

Study Overview

- Perspective: State program
- 5 methods compared to the brief, no NRT option provided
- Costs:
  - Training
  - Counselors time
  - Administrative and technical support
  - Facility space
  - Supplies

Results

Table 3 Smoking cessation and cost effectiveness

Characteristics	No NRT offer			NRT offer			
	Brief (n=872)	Moderate (n=718)	Intensive (n=720)	Brief (n=868)	Moderate (n=715)	Intensive (n=721)	p Value
Abstinence* 6 months (%)	10.2	10.7	13.1	16.8	21.3	24.3	<0.0001
Abstinence* 12 months (%)	11.7	13.8	14.3	17.1	20.1	21.2	<0.0001
Cost/participant (SD), 2004$	$67 ($20)	$107 ($33)	$132 ($57)	$193 ($79)	$242 ($92)	$268 ($99)	<0.0001
Incremental cost/quit† (range), 2004$	NA	$1912 ($2551–$1273)	$2640 ($4120–$1161)	$2467 ($3622–$1311)	$2109 ($2980–$1239)	$2112 ($2946–$1278)	NA

*Abstinent from all forms of tobacco for 30 days or more at follow-up.
†Incremental cost per additional quit relative to brief/no NRT arm. Ranges calculated using standard deviations and 12-month abstinence.

- Example of how CE Ratios calculated:
  - Comparing No NRT/Moderate to No NRT/Brief
    - ($107 - $67) / (.138 - .117) = **$1905 (table shows $1912)**
  - Comparing NRT/Intensive to No NRT/Brief
    - ($2112 - $67) / (.212 - .117) = **$2138 (table shows $2112)**

Limitations

- Outcomes relied on self-reports
- Outcomes not collected beyond one year
- No placebo NRT included (increased outcomes could be due to increased expectancy of quitting)
- **Average CE ratios (compared to No NRT/brief) included in analysis, rather than incremental CE ratios**

Incremental CE Ratios

	Effects at 12 months	Costs	Inc CE Ratio
No NRT/Brief	11.7	67	--
No NRT/Moderate	13.8	107	1905
No NRT/Intensive	14.3	132	5000
NRT/Brief	17.1	193	2179
NRT/Moderate	20.1	242	1633
NRT/Intensive	21.1	268	2600

1. Order interventions by increasing effectiveness.
2. Eliminate programs where effectiveness increases, but costs decrease ("dominance")
3. Calculate incremental CE ratios – comparing each program to next least effective program
4. Eliminate programs where "extended dominance" occurs – that is, there is the CE ratio does not increase with increasing effectiveness

Incremental CE Ratios

	Effects at 12 months	Costs	Inc CE Ratio
No NRT/Brief	11.7	67	--
No NRT/Moderate	13.8	107	1905
~~No NRT/Intensive~~	~~14.3~~	~~132~~	~~5000~~
NRT/Brief	17.1	193	~~2179~~ 2606
NRT/Moderate	20.1	242	1633
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Incremental CE Ratios

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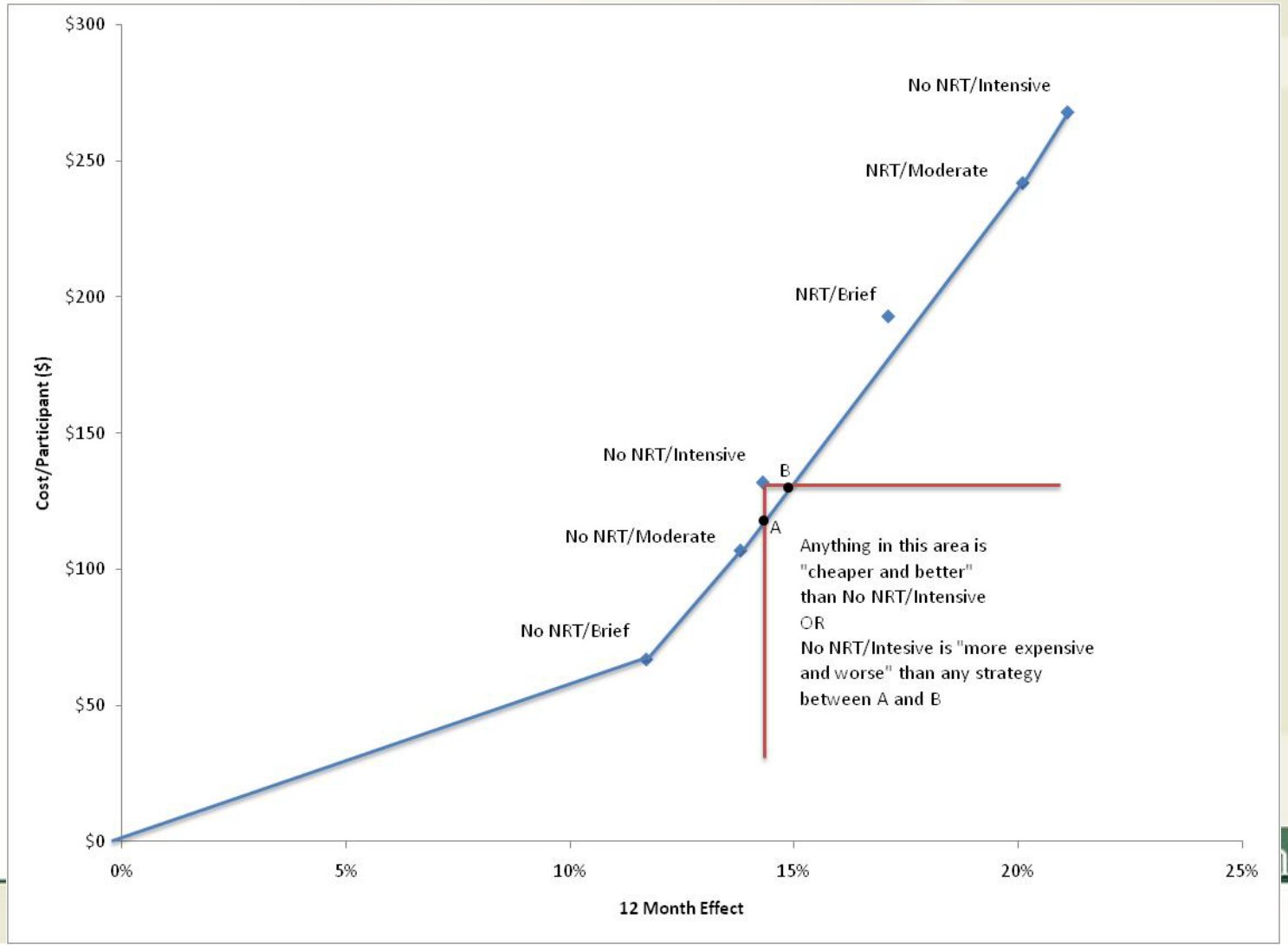
~~NRT/Brief~~	~~17.1~~	~~193~~	~~2179~~ ~~2606~~
NRT/Moderate	20.1	242	~~1633~~ 2143
NRT/Intensive	21.1	268	2600

Example of how incremental CE ratio calculated:
-comparing NRT/Moderate to No NRT/Moderate
($242 - $107) – (.201 - .138) = $2143

Example of Extended Dominance



Sub-variant of CEA

- Cost-Utility Analysis - CUA
  - measures outcomes in terms of the ***value*** (***utility***) placed on the outcome, not the outcome itself
  - requires an ability to place numeric comparisons of various outcome states
  - We all know that life in different health states is not valued equally:
    - a year of life in full health
    - a year of life after a stroke
    - a year of life in severe pain
    - a year of life with lung cancer

Cost-Utility Analysis — CUA

- Compares costs and benefits, where benefits = # of life years saved *adjusted* for loss of quality.
- Combines length and quality of life.
- Compares disparate outcomes in terms of utility.
  - Quality-adjusted life years (QALYs).
  - Disability-adjusted life years (DALYs).
- Derives a ratio of cost per health outcome.
  - $/QALY or $/DALY.

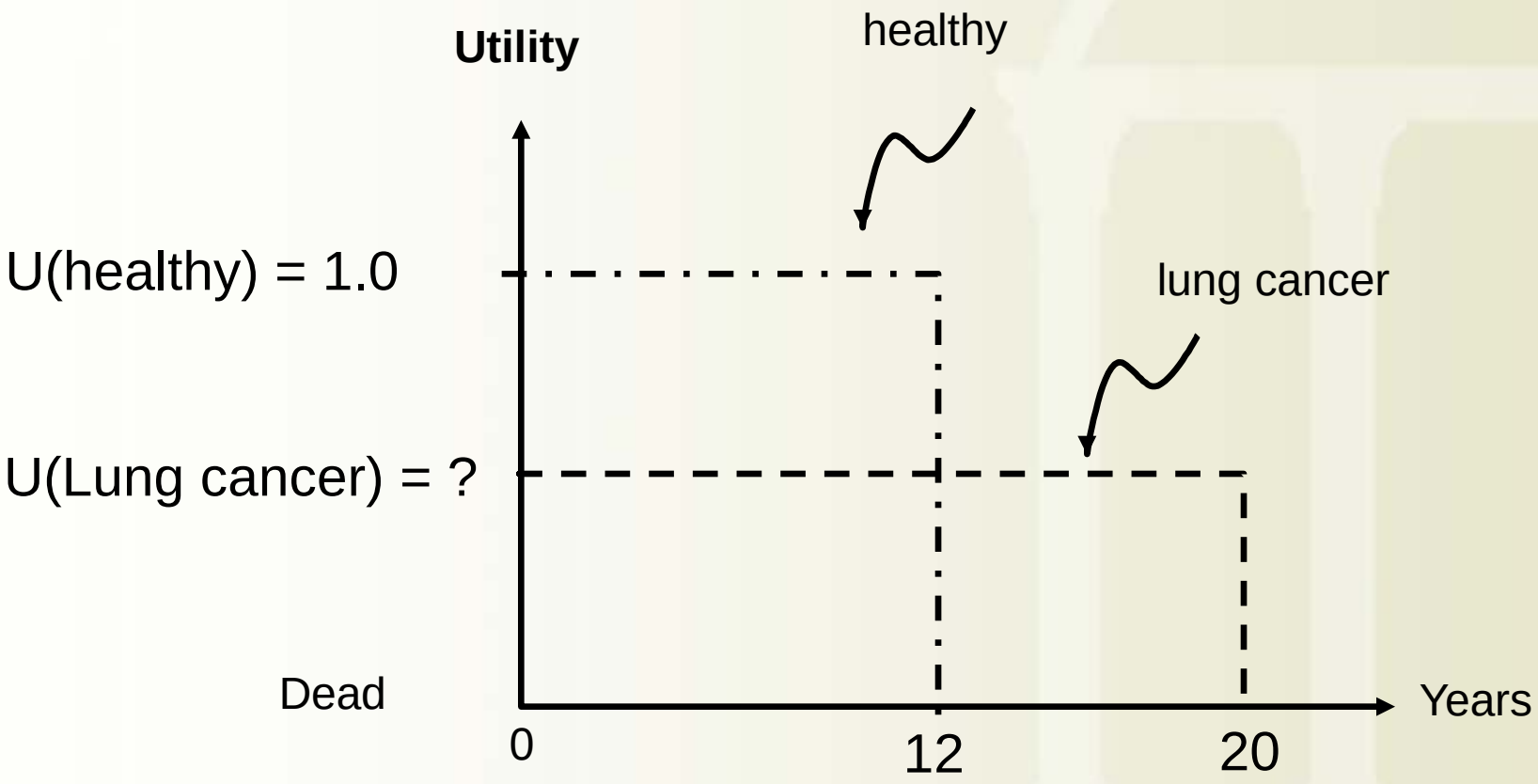
When Is CUA Used?

- When quality of life is ***the*** important outcome.
- When the program affects both morbidity and mortality.
- When programs being compared have a wide range of outcomes.
- When one of the programs being compared has already been evaluated using CUA.

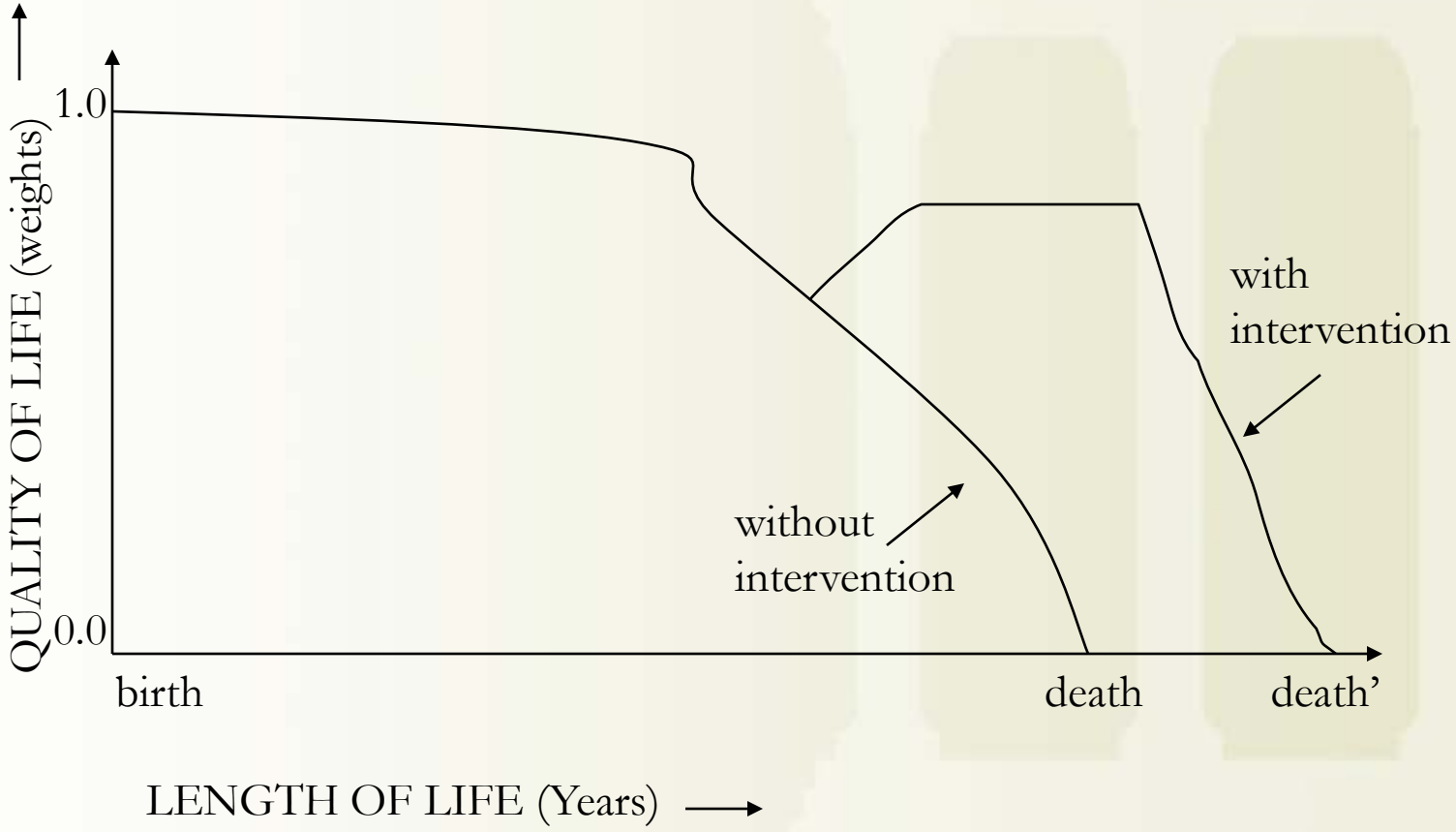
Quantify Benefits — CUA

- Utilities, or preference weights, are:
  - A quantitative approach for describing *preferences* for quality of life.
  - Typically based on a 0 to 1 scale, where:
    - 0 = death.
    - 1 = perfect health.

Time Trade-Off



Valuation of Benefits in a CEA:
Combining Length of Life with Quality of Life



NOTE: Incremental C/E Ratio for CUA

$$\frac{\text{Cost Strategy B - Cost Strategy A}}{\text{Outcome Strategy B - Outcome Strategy A}}$$

Costs include:

program costs – (medical costs ~~+ productivity losses~~ averted*)

Wang, Crossett, Lowry, Sussman, & Dent
Achives of Pediatric Adolescent Medicine
2001; 155: 1043-1050

COST-EFFECTIVENESS OF A SCHOOL-BASED TOBACCO-USE PREVENTION PROGRAM

Project Toward No Tobacco Use (TNT)

- School-based education program for juniors and seniors
- Teaches refusal skills, awareness of social misperceptions about tobacco use, and misconceptions about physical consequences
- Designated by the CDC as a Program That Works
- Three types of curricula: physical consequences, informational social influence, and normative social influence

Efficacy Trial

- Students randomly assigned to 1 of 4 curricula: the three mentioned on previous slide and a "usual care" curriculum

- 2-year follow-up found that each of the three curricula were effective, all 3 used in a combined fashion for the CEA

Programmatic Costs

- Collected retrospectively
- Only direct costs included at a program perspective

Table 1. Intervention Costs*

Intervention	Cost, $
Training of health educators	
2 Health educators received $10/h for 15 d (120 h) of training	2 × $10/h × 120 h = 2400
2 Health educators received the training at a fee of $56/d for 15 d (120 h) of training	2 × $56/d × 15 d = 1680
Subtotal	4080
Teaching	
2 Health educators taught at 4 schools each for 10 d (80 h) for $10/h	2 × 4 × 80 h × $10/h = 6400
2 Health educators taught 2-d (16-h) booster sessions at 4 schools each for $10/h	2 × 4 × 16 h × $10/h = 1280
Subtotal	7680
Materials	
2 Teacher manuals at $45 per manual	90
1234 Student manuals at $3.69 per manual	4553
Subtotal	4643
Total	**16 403**

*Values provided by the Project Toward No Tobacco Use evaluation study group.

Outcome Steps

1) Estimation of the number of established smokers prevented
2) Estimation of the number of life years (LYs) saved and QALYs saved
3) Estimation of the lifetime medical costs saved

Established Smokers Prevented

- Smoking progression model
- Divided the students at 2-year follow-up into nonsmokers, experimenters, and established smokers
- Used probabilities from a natural history on smoking (from a national sample) to model the movement of individuals among the three states
- Students modeled from age 14 to age 26, assumed that smoking would likely not be initiated after this age

LYs Saved

- Used estimates of life expectancy from the National Health Interview Survey and National Mortality Followback Survey
- Example:
  - Life expectancy of a never smoker is…
    - 2 years longer than a former smoker
    - 3.5 years longer than a light smoker
    - 14.2 years longer than a heavy smoker
  - Discounted (from 26 to end of LE) at an annual rate of 3% to
    - 0.26 discounted LYs
    - 0.47 discounted LYs
    - 2.13 discounted LYs, respectively
  - Weighted average (based published distributions of smokers) of discounted LYs: 31.7%*0.26 + 52.3%*0.47 + 16%*2.13 = 0.67 LYs
    - 0.67 LYs represents the discounted LYs saved per established smoker prevented (comparing never smoker to weighted average of “other” smoker types)

QALYs Saved

- Used published estimates for conversion of LYs to QALYs for smokers
- Example:
  - 1.31 LYs saved per quitter estimated as 2.34 QALYs saved for men aged 25 to 29 years
- From JAMA 1997 (Cromwell et al) - 1.57 QALYs saved is equivalent to 1 LY saved
  - What does this mean?
    - If you don't smoke – for every addl year of life gained, you also gain ½ a year adjusted for quality of life gains.

Medical Costs Saved

- Used published estimates for medical expenditures associated with becoming a smoker versus not becoming a smoker
- Example:
  - A male smoker spends $8,638 more than a never smoker for medical care
  - A female smoker spends $10,119 more than a never smoker for medical care

Results

- Incremental CE Ratios compared to “no smoking” curriculum
- CEA including medical care costs saved (base, worst, and best case at right) is negative due to overall cost savings
- **NOT RECOMMENDED** to report negative CE ratios

Table 4. Results From Base-Case and Multivariate Sensitivity Analyses*

Parameters	Base Case	Worst Case	Best Case
Intervention cost, $	16 403.00	36 563.00	16 403.00
Established smokers prevented, No.	34.9	19.7	51.0
Medical care cost saved, $	327 139.50	160 991.50	478 329.00
Discounted LYs saved	23.3	13.2	34.1
Discounted QALYs saved	36.6	20.7	53.6
Cost per LY saved, $	−13 316.50	−9426.80	−13 538.70
Cost per QALY saved, $	−8481.80	−6004.40	−8623.40
Cost per LY saved (excluding medical care costs saved), $	702.90	2770.10	480.80
Cost per QALY saved (excluding medical care costs saved), $	447.70	1764.40	306.20

*LY indicates life year; and QALY, quality-adjusted life year.

Limitations

- Retrospective estimation of costs
- Number of established smokers prevented modeled rather than directly measured
- One source of data available for probabilities of smoking progression
- No consideration of continued effectiveness of TNT beyond 2-year follow-up
- Did not account for all of the costs of smoking to society

Where to Get QALY Weights?

Source	Examples	Disadvantages
Literature	▪ Individual studies ▪ CUA databases – Tufts***	▪ Lack of comparability
Indirect measures	▪ Beaver Dam study, QWB ▪ Joint US-Canadian health survey included HUI ▪ MEPS included EQ-5D US	▪ Only common diseases ▪ No severity levels
Direct measures	▪ Expert panel ▪ Special sample survey	▪ Expense ▪ Time ▪ Representation

***https://research.tufts-nemc.org/cear4/default.aspx

Smoking Related Utilities

Smoking Classification	Age	Male Utility	Female Utility	Source
Never Smoker	40-44	0.90	0.88	Amhad. (2005). The cost-effectiveness of raising the legal smoking age in California. *Med Decis Making*, 25(3): 330-340
Former Smoker	40-44	0.88	0.87	
Current Smoker	40-44	0.82	0.83	
Never Smoker	75-79	0.76	0.66	Kaper, Severens, et al. (2006). Encouraging smokers to quit: the cost effectiveness of reimbursing the costs of smoking cessation treatment. *Pharmacoeconomics*, 24(5): 453-464
Smoker	75-79	0.67	0.61	
Never Smoker	18-19	0.93	0.92	
Smoker	18-19	0.91	0.89	

Final Comments

- Economic evaluation (EE) methods are valuable to decision making and for setting policy.

- For practitioners and evaluators, these skills are necessary because the DEMAND for these analyses is growing.



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Thank You!

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