Cost Effectiveness and Tobacco Control

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Outline

I. Overview

A. Scarce Resources – How to use efficiently

Three programs A, B, C: How to rank from best to worst.

Which program to support?

B. Advocacy: Justifying a program or approach

II. Methods of Evaluation

A. Cost Benefit Analysis

1. Cost and Benefits measured in monetary units

2. B > C, then program is efficient: C/B < 1

3. Smaller C/B indicates more effective program

4. **Advantage – can compare effectiveness with a wide range of programs:**

    a. **Other health programs**
    b. **Educational, infrastructure expenditures**

5. **Disadvantage: Measuring benefits in money terms is difficult and controversial**

    a. **How should a human life be valued?**

        1) **Discounted value of future earnings**

        2) **Value of Life a function of earnings**

        3) **Estimates may reflect labor market imperfections**

        4) **For retirees, non participants use shadow wage - may be hard to compute**

b. Willingness to pay to reduce probability of death

1. Reduce probability of death by Δp, pay R; value of life is $R/\Delta p$

One person pays R for Δp reduction.

$1/\Delta p$ people pay $R/\Delta p$ –

expected number of death averted is $(1/\Delta p)\Delta p = 1$

2. Willingness to pay measured by looking at market behaviors – risk permia on risky jobs. Rosen and Thaler

a) Tends to be higher than discounted future earnings

b) Using labor market data gives marginal willingness to pay but not average willingness to pay - may be biased downwards.

3. Contingent Valuation – Ask people

B. Cost Effectiveness Analysis

1. Cost measured in money terms

Net Cost = Expenditures – Savings

Computing "savings" can be problematic

Savings should be viewed as separate benefit.
Computing savings can be problematic
(Viscusi, Philip Morris)

2. Outcome is measured in some "natural" unit

Deaths averted
Life years saved
Cases averted: Decrease in number of cases of the disease

Lung cancer
Emphysema

Other measures:

Drop in mm per Hg
Length of hospital stay
Days sick/days missed from work

Tobacco Control

Cases averted
Deaths averted
Life Years Saved
Initiations averted
Number of quits
Reduction in smokers

Cost per case averted
Cost per death averted
Cost per life year saved
Cost per initiation averted
Cost per quit
Cost per discouraged potential smoker

Advantage: outcome measure usually does not need to be “justified”

Measuring the monetary value of life or life years is side-stepped

Disadvantage: comparisons are limited.

3. **Cost Effectiveness Ratio (CE Ratio) = Cost/Impact**

    a. **CE is a measure of Average Cost – Marginal Cost may be different – and CE ratio may be different if scale of the project is different**

       Implicitly – constant returns to scale often assumed.

    b. **Smaller CE ratio, more effective program**

    c. **Impact = 0, CE is infinite**

    d. **No natural cut off point for effectiveness – benchmarks derived from CE literature.**

    e. **In the U.S, mammograms - $2300 per life year saved.**

    f. **If benchmarks are not readily available, interpretation can be difficult but if cost/unit is particularly low, then expenditure justification may be self-evident.**

C. Cost Utility Analysis – Closely related to Cost Effectiveness

1. QALY's (Quality Adjusted Life Years)

Assign 1 to perfect health

Assign 0 to death

1. **Intermediate health status: between 0 and 1**

Contingent valuation – ask people (who?)

Example: Broken arm – value less than 1.
If State – Broken Arm = .9, then an intervention that saved 1 life would be equal to 10 broken arms averted

1 life = QALY
10 broken arms averted QALY goes from .9 to 1.0, gain of .1 per case, 10 cases averted generates 1 QALY.

2. Standard Gamble Utility Measurments

PU(1 for x years) + (1-p)U(0 for death) = U(Health Status less than perfect for X years).

P that equates two sides is utility of left hand side;

3. Literature provides scales to compute QALY based on lifestyle limitations:

Work/Not Work
Part-time
Occupational Restrictions
Ability to leave home – assisted/unassisted
Depressed/Not Depressed
Moderate or severe pain

4. QALY and Tobacco Control

Pulmonary Diseases: QALY > Life years lost

This is because long periods of disability associated with pulmonary conditions

Lung Cancer: QALY ~ Life Years Lost

Expected life upon diagnosis is short.

Cardiovascular: QALY > Life Years Lost

Strokes and heart failure generate periods of disability

5. DALY's (Disability Adjusted Life Years lost) Burden of Disease approach (Used by World Bank)

Death Assigned 1

Perfect Health Assigned 0

Intermediate Status: between 0 and 1.

Disease generates a certain number of DALY's;
Elimination saves DALY's

6. Allows aggregation of different types of outcomes:

Intervention may save lifes and reduce morbidity – CU approach takes both effects into account.

X. Costs

A. Fundamental Notion: Opportunity cost – the value of a resource or input is the monetary value of the next best alternative foregone.

B. Program Budgets may be not be appropriate or correct.

C. Other problems in determining costs:

1. **Capital expenditures are charged in the year the expenditure is made and not amortized over the life of the asset.**

2. **The agency responsible for an intervention may be part of a larger agency or department. Shared equipment, staff, facilities.**

X. Resource Cost Method (Ingredients Method)

A. List out all the resources and inputs that are used in the intervention.

a. All the factors which are required to make the intervention happen.
b. All the things that are required to replicate the intervention.
c. Need to have good understanding of the intervention

1) Talk to people involved in the intervention
2) Look at documents, budgets and expenditures related to the program.

B. Typical Factors to consider

1. Personnel

Consultants
Part-time people – part timers may not show up in budgets
volunteers – this will not show up in budgets
Full time personnel

For each type of personnel list:

qualifications and skills
time commitment

2. Facilities

This must be included even if donated or rent free.

3. Equipment and Materials

Pamphlets and educational material. Computers, soft-ware, books, office supplies, furniture and so forth.

4. Other Inputs

a. Services supplied or donated by outside vendors.
Advertising
Training sessions

a. Telephone
internet access fees
electricity, etc

5. Client Inputs

a. These are inputs provided by the target population

b. In general, this is a component that is often left out of cost calculations for interventions and programs.

X. Valuing Inputs: assigning monetary value to the inputs.

A. Market Prices:

1. **Requires competitive markets, then the market price will be a fair reflection of the value of the resource.**

2. **Wage rates, rental rates, market price of equipment and so on will usually be a good indicator of social value.**

B. Shadow Prices: Some inputs are not exchanged on competitive markets. This is because the good is inherently non-marketable, or the market is distorted by market power or other imperfections.

1. Donated input

2. inputs provided at below market prices.

C. Total Cost = Sum of costs of A + B+ C+ D+ E

1. The error introduced into the total by miscalculating any one component depends on the share of total cost that component contributes

2. Sensitivity analysis.

3. Fixed costs/Sunk Costs

a. **Allocating fixed costs and shared inputs**
b. **Economies of Scale**
c. **Sunk Costs**

- **Development of Educational Materials that can be used again.**
- **Program design**

VI. Costs over Multiple years;

A. Adjusting for Inflation:

To convert from current currency units to constant currency units, that is, valued at year T prices, Costs, C in year t, are multiplied by

$$C\ (P_T/P_t)$$

Where P_t and P_T are cost of living indices for year t and T, respectively.

B. Discounting: Benefits and Costs occur at different times.

1. Benefits in the far future are regarded by most people as less valuable as the same benefits occurring in the present, that is, right now.

Reasons for this:

a. Fundamental aspect of human nature – so called "impatience"

b. Uncertainty

c. Opportunity cost of capital/money argument:

2. A cost C incurred T years ago, has a present value of

$$PV = Cd^T = C(1+r)^T$$

a. If discounting is continuous, then

$$PV = Ce^{rT}$$

	r = .01		r = .03		r = .05	
Periods in the Past	Discrete	Continous	Discrete	Continous	Discrete	Continou
0	100.00	100.00	100.00	100.00	100.00	100.(
-1	101.00	101.01	103.00	103.05	105.00	105.1
-2	102.01	102.02	106.09	106.18	110.25	110.5
-3	103.03	103.05	109.27	109.42	115.76	116.1
-4	104.06	104.08	112.55	112.75	121.55	122.1
-5	105.10	105.13	115.93	116.18	127.63	128.4
-6	106.15	106.18	119.41	119.72	134.01	134.9
-7	107.21	107.25	122.99	123.37	140.71	141.9
-8	108.29	108.33	126.68	127.12	147.75	149.1
-9	109.37	109.42	130.48	131.00	155.13	156.8
-10	110.46	110.52	134.39	134.99	162.89	164.8
-11	111.57	111.63	138.42	139.10	171.03	173.3
-12	112.68	112.75	142.58	143.33	179.59	182.2
-13	113.81	113.88	146.85	147.70	188.56	191.5
-14	114.95	115.03	151.26	152.20	197.99	201.3
-15	116.10	116.18	155.80	156.83	207.89	211.7
-16	117.26	117.35	160.47	161.61	218.29	222.5
-17	118.43	118.53	165.28	166.53	229.20	233.9
-18	119.61	119.72	170.24	171.60	240.66	245.9
-19	120.81	120.92	175.35	176.83	252.70	258.5
-20	122.02	122.14	180.61	182.21	265.33	271.8
-21	123.24	123.37	186.03	187.76	278.60	285.7
-22	124.47	124.61	191.61	193.48	292.53	300.4
-23	125.72	125.86	197.36	199.37	307.15	315.8
-24	126.97	127.12	203.28	205.44	322.51	332.(
-25	128.24	128.40	209.38	211.70	338.64	349.(
-26	129.53	129.69	215.66	218.15	355.57	366.9
-27	130.82	131.00	222.13	224.79	373.35	385.7
-28	132.13	132.31	228.79	231.64	392.01	405.5
-29	133.45	133.64	235.66	238.69	411.61	426.3
-30	134.78	134.99	242.73	245.96	432.19	448.1

b. ASIDE: THE RULE OF 72.

If the interest rate is r percent (so that one uses r/100 in computing PV), then number years for the PV of cost to double is 72/r. Hence is r = five precent, the number of years for the present value of cost to double is 72/5 = 14.4. A more exact figure is 13.86.

The rule can be explained as follows:

$$PV = 2C = Ce^{rT}$$

We want to find T, given r and C. Note that C cancels out, so we are left with

$$2 = e^{rT/100}$$

Taking the natural log of both sides, we get:

$$Ln(2) = rT/100,$$

So T is given by:

$$T = 100*ln(2)/r$$

But ln(2) = .6931

So

$$T = 69.31/r$$

69.31 is not a very convenient number, so 72 is usually substituted on the grounds that it is pretty close to 69 and is divisible by a fair number of integers, 1, 2, 3, 4, 6, 9, 12 and 5 and 10 are pretty easy to calculate as well. – sometimes people use 70 as well. This gives a pretty good approximation.

Note: the percentage error is constant, but the absolute error increases as r declines.

$$E = 72-69.31/r = 2.69/r$$

$$\%E = E/\text{True Number} = E/(69.31/r) = .038$$

or about 4 %, If use rule of 70, error is about 1 percent.

4. **Future benefits (or future costs) also have been adjusted to determine present value.**

   The present value of a benefit occurring T years in the future is given by

   $$PV = Bd^{-T}$$

   The continuous version of this is

   $$PV = Be^{-rT}$$

5. **The rule of 72 also applies –with a twist: 72/r is the number of years for the PV to fall by half.**

Periods in the Future	R = .01 Discrete	R = .01 Continous	r = .03 Discrete	r = .03 Continous	r = .05 Discrete	r = .05 Continous
0	100.00	100.00	100.00	100.00	100.00	100.00
1	99.01	99.00	97.09	97.04	95.24	95.12
2	98.03	98.02	94.26	94.18	90.70	90.48
3	97.06	97.04	91.51	91.39	86.38	86.07
4	96.10	96.08	88.85	88.69	82.27	81.87
5	95.15	95.12	86.26	86.07	78.35	77.88
6	94.20	94.18	83.75	83.53	74.62	74.08
7	93.27	93.24	81.31	81.06	71.07	70.47
8	92.35	92.31	78.94	78.66	67.68	67.03
9	91.43	91.39	76.64	76.34	64.46	63.76
10	90.53	90.48	74.41	74.08	61.39	60.65
11	89.63	89.58	72.24	71.89	58.47	57.69
12	88.74	88.69	70.14	69.77	55.68	54.88
13	87.87	87.81	68.10	67.71	53.03	52.20
14	87.00	86.94	66.11	65.70	50.51	49.66
15	86.13	86.07	64.19	63.76	48.10	47.24
16	85.28	85.21	62.32	61.88	45.81	44.93
17	84.44	84.37	60.50	60.05	43.63	42.74
18	83.60	83.53	58.74	58.27	41.55	40.66
19	82.77	82.70	57.03	56.55	39.57	38.67
20	81.95	81.87	55.37	54.88	37.69	36.79
21	81.14	81.06	53.75	53.26	35.89	34.99
22	80.34	80.25	52.19	51.69	34.18	33.29
23	79.54	79.45	50.67	50.16	32.56	31.66
24	78.76	78.66	49.19	48.68	31.01	30.12
25	77.98	77.88	47.76	47.24	29.53	28.65
26	77.20	77.11	46.37	45.84	28.12	27.25
27	76.44	76.34	45.02	44.49	26.78	25.92
28	75.68	75.58	43.71	43.17	25.51	24.66

29	74.93	74.83	42.43	41.90	24.29	23.46
30	74.19	74.08	41.20	40.66	23.14	22.31

VII. Present discounted value of life years saved:

Discrete case:

T expected lifetime if no intervention
X is age of intervention
T is added years of life
d **is 1+r**

PV = 1x$d^{-(T-x)}(d^{-1} + d^{-2} + d^{-3} + \ldots + d^{-t})$**.**

Continuous Case

PV = $(1/r)e^{-r(T-x)}[1 - e^{-rt}]$

Stream of benefits, B, occurring each year, but extending out into the indefinite future is

B/r.

X. What is the appropriate discount rate to use?

A. Past Practice: 5 percent

B. **Current Practice: 3 percent**

C. Sensitivity Analysis: 1 percent to 10 percent

X. Extended Example – ASSIST

A. Nature of the Program

1. 120 Million Dollars, 17 States

2. Used to Support Local and State Tobacco Control Programs and Advocacy

3. Expenditures Over 7 year period – 1991 to 1998

4. Impact Measured in 1999 in terms of prevalence reduction.

B. Outcomes:

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1. Reduction in Prevalence of .0062

a. No significant age differences

b. Gender differences

2. Issues in Measuring Impact

a. Prevalence Rates are falling in ASSIST and Non-ASSIST states - downward time trend

b. Education Levels rising

c. Income Levels Rising

d. Average year of birth rising: Median age about the same in 1990 and 1999, but median person in 1990 was 7 in 1964 (year of Surgeon General's Report), Median person in 1999 was seven in 1971, year TV Adds banned in US, seven years after Surgeon General's Report.

World War II generation dying off - heavy smokers.

e. Other Tobacco Initiative undertaken at the same time

f. Changes in tobacco control policies not attributable to ASSIST.

3. Reduction in Smokers

a. Quits - older cohorts

b. Non-initiation - younger cohorts

c. Non re-initiation

4. Discounted Life Years Saved

- **More Speculative, but much better benchmarked.**

  For example, assuming health technology is constant.

  Gender differences are important

- **Need to make assumptions about quits, initiation and relapses**

Basic References

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> **Invaluable, best single source, excellent references.**

Henry Levin, McEwan, *Cost Effectiveness Analysis,* Sage Publications, 2001. (Available in paperback)

> **Less essential than Drummond, but more accessible (less technical), more applied and practical. Examples tend to be from education and not medicine, and public health.**

Frank Sloan, (editor), *Valuing Health Care*, Cambridge University Press, 1995. (Available in paperback)

> **A collection of article by leading experts on basic issues of cost-benefit and cost-effectiveness analysis. A very useful book.**

Richard Zerbe, *Benefit Cost Analysis: In Theory and Practice*, Harper-Collins, 1994 (Hardback only)

> **A very complete look at cost-benefit analysis, not a lot of material on cost-effectiveness.**