

# **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  $D_p$ , pay  $R$ ; value of life is  $R/D_p$**

**One person pays  $R$  for  $D_p$  reduction.**

**$1/D_p$  people pay  $R/D_p$  –**

**expected number of death averted is  $(1/D_p)D_p = 1$**

**2. Willingness to pay measured by looking at market behaviors – risk premia 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 Measurements**

**$PU(1 \text{ for } x \text{ years}) + (1-p)U(0 \text{ for death}) = U(\text{Health Status less than perfect for } X \text{ years}).$**

**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 lives 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**

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

Periods in the Past	r = .01		r = .03		r = .05	
	Discrete	Continuous	Discrete	Continuous	Discrete	Continuous
0	100.00	100.00	100.00	100.00	100.00	100.00
-1	101.00	101.01	103.00	103.05	105.00	105.05
-2	102.01	102.02	106.09	106.18	110.25	110.30
-3	103.03	103.05	109.27	109.42	115.76	115.81
-4	104.06	104.08	112.55	112.75	121.55	121.60
-5	105.10	105.13	115.93	116.18	127.63	127.68
-6	106.15	106.18	119.41	119.72	134.01	134.06
-7	107.21	107.25	122.99	123.37	140.71	140.76
-8	108.29	108.33	126.68	127.12	147.75	147.80
-9	109.37	109.42	130.48	131.00	155.13	155.18
-10	110.46	110.52	134.39	134.99	162.89	162.94
-11	111.57	111.63	138.42	139.10	171.03	171.08
-12	112.68	112.75	142.58	143.33	179.59	179.64
-13	113.81	113.88	146.85	147.70	188.56	188.61
-14	114.95	115.03	151.26	152.20	197.99	198.04
-15	116.10	116.18	155.80	156.83	207.89	207.94
-16	117.26	117.35	160.47	161.61	218.29	218.34
-17	118.43	118.53	165.28	166.53	229.20	229.25
-18	119.61	119.72	170.24	171.60	240.66	240.71
-19	120.81	120.92	175.35	176.83	252.70	252.75
-20	122.02	122.14	180.61	182.21	265.33	265.38
-21	123.24	123.37	186.03	187.76	278.60	278.65
-22	124.47	124.61	191.61	193.48	292.53	292.58
-23	125.72	125.86	197.36	199.37	307.15	307.20
-24	126.97	127.12	203.28	205.44	322.51	322.56
-25	128.24	128.40	209.38	211.70	338.64	338.69
-26	129.53	129.69	215.66	218.15	355.57	355.62
-27	130.82	131.00	222.13	224.79	373.35	373.40
-28	132.13	132.31	228.79	231.64	392.01	392.06
-29	133.45	133.64	235.66	238.69	411.61	411.66
-30	134.78	134.99	242.73	245.96	432.19	432.24

**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 if  $r =$  five percent, 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:**

$$T = 100 \cdot \ln(2)/r$$

**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		r = .03		r = .05	
	Discrete	Continous	Discrete	Continous	Discrete	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  $1+r$

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

### 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:**

**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**

**Michael Drummond, O'Brien, Stoddart, Torrance, *Methods for the Economic Evaluation of Health Care Programs*, Second Edition, Oxford University Press, 1997. (Available in paperback)**

**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.**