COST-BENEFIT AND COST EFFECTIVENESS ANALYSES

I. Definitions

A. Cost-benefit analyses

1. Relates all costs and benefits that might arise as a result of an intervention or prevention program up to a pre-specified time
   a. Both costs and benefits are defined as to their economic value (i.e., as money)
2. Appropriate analyses if country is concerned mainly with the productivity consequences of improved health
3. Advantages
   a. Establishes criteria for acceptance of a program
      (1) Benefits must be at least equal to costs
   b. Provides guidance for comparing programs in one sector with those in another
      (1) Rank the degree to which benefits exceed the costs
4. Disadvantage
   a. Both benefits and costs must be given a monetary value
      (1) Difficult to value in money terms a human life, the inability to have a child, or the pain and discomfort caused by illness

B. Cost-effectiveness analyses

1. Relates all costs to the changes in predefined units of health outcomes
   a. Costs are defined in economic terms and effectiveness is defined as changes in morbidity, mortality, disability, or DALYs
2. Appropriate analyses if country states that health is a basic right of the society
3. Advantage
   a. Can easily combine cost data with the results from disease or health condition impact studies
4. Disadvantages
   a. Can only compare cost-effectiveness ratios among alternative programs with a single goal
   b. Cannot determine if the value of a program exceeds the cost

II. Evaluation of Intervention/Prevention Programs

A. Three “E” words
1. Efficacy
   a. Does a program work as intended in an ideal setting
2. Effectiveness
   a. Does a program work as intended in an ordinary setting
3. Efficiency
a. What is the cost of the program in relation to the effectiveness.

B. Components in evaluation of health programs

![Diagram showing input, intervention program, output, effect, impact]

**Figure 1.** Scheme for epidemiological evaluation of health programs.

1. **Input**
   
a. **Definition**
   (1) The salaries, facilities, equipment and supplies necessary for the production of the program activity
   
b. **Examples**
   (1) Salaries of the program personnel
   (2) Facilities
   (3) Equipment
   (4) Supplies

2. **Output**
   
a. **Definition**
   (1) The goods and services that are products of the program activity
   
b. **Examples**
   (1) Brochures
   (2) Vaccinations
   (3) Vasectomies
   (4) Condoms
   (5) Health education sessions
   (6) HIV tests
   (7) STD treatments

3. **Effect**
   
a. **Definition**
   (1) Among program participants or community of program participants, change in immune status, knowledge, or practices created by participation in the program activity
   
b. **Examples**
   (1) Increased resistance to the target disease
   (a) Rise in antibody titer among vaccinated individuals
   (b) Decreased demand for curative services
(2) Improved knowledge or practices regarding risk factors of disease
   (a) Understands need for condoms
   (b) Change in number of sexual partners
   (c) Reduction in smoking
   (d) Returns for second or third dose in a series of vaccinations
   (e) Increased willingness to utilize future preventive services

4. Impact
   a. Definition
      (1) The effect in the community of the participants on the burden of illness at
          the community level
   b. Examples
      (1) Reduced incidence of the specified target disease
          (a) Reduced use of medical facilities for treatment of the disease
      (2) Reduced functional disability caused by the disease or injury
      (3) Reduced mortality caused by the disease the disease or injury
      (4) Gains in DALYs

C. Types of evaluation
   1. Comparison of input with output
      a. Easiest form of evaluation
         (1) Cost (input) per administered product or activity (output)
            (a) Requires cost of service and count of products or activities
      b. Cannot determine the effect on the participants or impact on the community of
         the product or activity
   2. Comparison of input with effects
      a. More difficult and costly to perform
         (1) Cost (input) per change in the program participants
      b. Cannot assess the comparative effect one program has over another in reducing
         the burden of illness facing the community
   3. Comparison of input with impact
      a. Relatively difficult to assess
         (1) Cost (input) per unit change in morbidity, mortality or disability (impact)
         (2) Useful methods for assessing impact
            (a) Interview with parent or other able respondent
               i) Lay interpretation of signs and symptoms
               ii) May have physician do a "verbal autopsy"
            (b) Examination by health personnel
               i) Medical interpretation of signs and symptoms
               ii) Laboratory support for selected variables
            (c) Review of available medical records
i) Ambulatory clinics
ii) Hospitals

b. Method of choice for evaluating the effect various programs have on the burden of illness at the community level
   (1) Reducing the burden of illness is the main goal of most health programs

III. Terms and Concepts

A. Treatment of time in the valuation of costs and benefits in multi-year projects

1. Discounting

   a. A procedure for estimating what something is worth today, given that it cannot be obtained or used until sometime in the future
      (1) The value today of a future benefit or cost is termed the "present value"
      (2) Present value is affected by...
         (a) Inflation
            i) Prices for products and labor increase with time
         (b) Rate of return on alternative investments
            i) Money that is not spent until later can be invested in other more immediate programs
         (c) Value of present versus future benefits or consequences
            i) A benefit today is more valuable than the same benefit one month from now
            ii) An adverse consequence one month from now is more valuable than the same consequence today

2. Discount rate

   a. The annual rate at which the value of some future cost or consequence is reduced to find its current or present value

3. Present value

   a. The value now of future costs or benefits discounted at a given rate
   b. At a given discount rate \( r \) as a proportion, an event occurring in year \( n \) has a present value of...
      \[
      PV = \frac{\text{cost of the event in year } n}{(1 + r)^n}
      \]
      (1) Year can be measured two ways

      
      |   | 1   | 2   | 3   | 4   | 5   |
      |---|-----|-----|-----|-----|-----|
      | 0 | 1   | 2   | 3   | 4   | 5   |
(a) By starting point of interval (start with year = 0)
   i) Identical to age of person (age at last birthday)
(b) By interval (start with year = 1)
   i) Identical to year of life of person
(2) In Excel, year for Net Present Value (NPV) is measured by interval
   (a) payment is made at end of interval

4. Examples

a. Individual level
   (1) You can be paid either $1,000 today (year 0, baseline) or $1,100 in one year (year 1)
      (a) If you are a skilled investor, the $1,000 you are given today might grow by 15% to $1,150 one year from now
         i) Conversely, the $1,100 one year from now (i.e., year 1) would be worth ...

         \[
         \frac{\$1,100}{(1 + 0.15)^1} = \frac{\$1,100}{1.15^1} = \$957
         \]

      (b) Thus assuming a discount rate of 0.15, it would be better to accept the $1,000 today rather than the $1,100 one year from now

b. Program level - one
   (1) What is the present value of three five-year projects funded for a total of $100,000 but at different amounts during each year? (Note: first year = year 0)
      (a) Discount rate is 0.10 (or 10%)

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(b) Formula for net present value (NPV) at baseline (i.e., time 0)

\[
Cost_0 + \frac{Cost_1}{(1 + r)^1} + \ldots + \frac{Cost_n}{(1 + r)^n}
\]

Where \( n \) is the time period under consideration (in days, months or year) and \( r \) is the discount rate for the time period, stated as a proportion
(c) Formula for NPV of Project B at start of project

\[ NPV = \frac{$20,000}{1.10^1} + \frac{$20,000}{1.10^2} + \frac{$20,000}{1.10^3} + \frac{$20,000}{1.10^4} = $83,397 \]

(2) Do calculations using financial functions in Excel

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<td>=B3+NPV(SB$1,B4:B7)</td>
<td>=C3+NPV(SB$1,C4:C7)</td>
<td>=D3+NPV(SB$1,D4:D7)</td>
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<td>Net present value at baseline (Year 0)</td>
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a) Explanation of Excel formula: =C3+NPV($B$1, C4:C7)

Baseline + Net present value of...(discount rate, cell block with cash flow information)
- Note: NPV in Excel is the net present value at the end of each year, starting with year 1

c. Program level - two (cost-benefit analysis)

(1) What is the net present value (NPV) at baseline over a 10-year planning horizon of treatment for disease X among 100,000 children being served by a government health clinic?
(a) Assume the following parameter values...
   i) The discount rate is 0-5 percent per year for money and 0-3 percent for deaths
   ii) The annual incidence is 15 cases of disease X per 1,000 children
   iii) The case-fatality rate for disease X is 40 percent if untreated and 1 percent if treated
   iv) The current treatment cost is $30 per case
   v) The current value of a saved life is $25,000

(2) Excel spreadsheet tables (two levels of money discounts and two levels of death discounts)
(a) Note that no funds were allocated at baseline and instead are generated from treatments during the year
### Spreadsheet 1. Costs and benefits of treating children for disease X, assuming annual money discount of 0% and annual death discount of 0%.

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### Spreadsheet 2. Costs and benefits of treating children for disease X, assuming annual money discount of 5% and annual death discount of 0%.

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### Spreadsheet 3. Costs and benefits of treating children for disease X, assuming annual money discount of 5% and annual death discount of 3%.

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Spreadsheet formulas. Costs and benefits of treating children for disease X (spreadsheets 1-3).
(b) Formula for NPV in cost-benefit analysis

\[ NPV = \sum_{t=1}^{n} \frac{Benefit_t - Cost_t}{(1 + r)^t} \]

Where \( n \) = the number of years being considered in the analysis and \( t \) = years from 1 to \( n \).

(c) Findings

i) With a cost of $30 per treated case and a value of $25,000 per life saved, the benefit is $145.8 million more than the cost of treatment. Assuming a 5 percent annual discount rate for money and a 3% annual discount rate for deaths, the net present value over a 10 year planning horizon of the benefit minus the treatment cost is $124.3 million

(d) Sensitivity analysis

i) Since placing a value on human life is difficult, you should do a sensitivity analysis comparing the NPV of benefit minus cost for varying levels of current value of a prevented death

![Figure 2. Sensitivity analysis of NPV by current value of prevented death.](image)

d. Individual level - two (cost-effectiveness analysis)

(1) Two groups of 5 newborn children are randomly assigned to a vaccinated and susceptible group to a deadly disease that usually strikes in the first 15 years of life
   (a) The vaccine cost $3 and is considered 80% effective
   (2) The discount rate for future lost lives is 3%
### Figure 3. Data for cost-effectiveness analysis of vaccination program with 5 children each in the susceptible and non-vaccinated groups.

1. **Cost-effectiveness**
   - (a) $5.00 per prevented death
   - (b) $11.19 per discounted prevented death

## IV. Treatment of Costs

1. **Costs**
   a. The total money expenditure required to achieve something

2. **Capital costs**
   a. Costs for items that have a life of more than one year
   b. **Examples**
      1. Land, buildings and equipment

3. **Fixed costs**
   a. Costs which do not vary with the level of output in the time period under consideration (usually one year)
   b. **Examples**
      1. Construction of rural health clinics
      2. Purchase of refrigeration units

4. **Operating costs**
a. Those costs of providing a service that vary with the level of output
b. Examples
   (1) Purchase of condoms
   (2) Hiring of anti-smoking counselors

5. Marginal cost
   a. The change in total cost when a little more or a little less output is produced
      (1) Often used in cost-benefit and cost-effectiveness analysis to determine
          potential health benefits associated with additional resources
   b. Example
      (1) Cost per additional immunized child
      (2) Cost per additional year of healthy life gained

6. Unit cost
   a. The average cost per unit of output
      (1) Total costs divided by total number of units of output
   b. Example
      (1) Average cost per immunized child
      (2) Average cost year of healthy life gained