4. Evaluation Methods

What are Evaluation Methods? What are they used for?

Methodologies that allow decision makers (health authorities, hospitals, physicians, laboratories, etc) to make optimal choices given the limited resources available. That is to assign resources such that they maximize benefits.

4. Evaluation Methods

The most common Evaluation Methods can be characterized by the way they measure health:

1. In natural units or uni-dimensional scale: **Cost – Effectiveness**
2. In utility units: **Cost – Utility**
3. In monetary units: **Cost – Benefit**

Cost - Effectiveness

Health is measured in natural units.
Examples: a clinical parameter/scores – blood pressure, life years

note: this method is better used in those cases where there are no know side effects (positive or negative) of the treatment/program under evaluation

$$t_{CE} = \frac{Cost \text{ (measured in monetary units)}}{benefit \text{ measured in natural unis}}$$ = Euros per unit of blood pressure

Cost - Effectiveness

Usage: It is used to compare alternative projects. The best one is the one with the lowest t_{CE}

Limitations:

1. Should not be applied to projects with several effects (positive or negative) if these effects cannot be aggregated in a single measure
2. Ranks the different projects but it cannot say whether the best one should be realized or not. It can only give a relative valuation not an absolute one. The method is therefore not useful to evaluate single projects. The best application is the distribution of a fixed budget across projects.
3. The distribution of the benefits across the population, just as is the case for other methods, is irrelevant for this method.

Cost - Effectiveness

An example

Programs	Cost	Effectiveness	C/E
A	2000	0.2	10000
B	8000	0.4	20000
C	18000	0.6	30000

Which projects should be chosen according to its cost-effectiveness?

Cost - Utility

Utility scale [0 = death, 1 = perfect health]

$$t_{CU} = \frac{\textit{Cost} \text{ in monetary units}}{\textit{benefit} \text{ in QALY}}$$ = Euros per QALY

QALY = Quality Adjusted Life Years

Usage: It is used to compare alternative projects, the best one is the one with the lowest . The cost utility method has the great advantage over the cost-effectiveness in that it allows the aggregation of several "outputs" of a given project. This advantage allows t_{CU} the comparison of projects t_{CE} in very distinct areas for example health and education.

Limitations:

1. Ranks the different projects but it cannot say whether the best one should be realized or not. It can only give a relative valuation not an absolute one. The method is therefore not useful to evaluate single projects. The best application is the distribution of a fixed budget across projects.
2. The distribution of the benefits or QALYs across the population, just as is the case for other methods, is irrelevant for this method.
3. One has to decide on a utility function.

Cost - Utility

QALYs

What are the QUALY? QALYs stand for "quality adjusted life years". QALYs are the number of years in perfect health that are equivalent in terms of total utility to a given number of years *n* with a health status *h* (less than perfect)

Life has two dimensions:

1) time;
2) Quality of life or health status.

How do we compare 7 years in perfect health with 15 years going through dialysis for example? QUALYs allow this comparison because they allow the transformation of the two dimensions of life in a single one where the quality of life is fixed at perfect health. 15 years with dialysis are equivalent to a much number of years in perfect health.

Example of **Cost - Utility**

TABLE 4-3 Cost Effectiveness Tools Applied to Study of Two Treatments

		Blood Category					
		HbA1c = 7%			*HbA1c = 9%*		
Age	*Treatment*	*Total Costs*	*QALYs*	*$/QALY*	*Total Costs*	*QALYs*	*$/QALY*
20 yrs	Early	125,169	21.603		142,588	20.455	
20 yrs	Standard	121,614	21.496		140,488	20.303	
20 yrs	Difference	3,555	0.108	32,972	2,100	0.152	13,814
25 yrs	Early	122,234	20.998		137,970	19.941	
25 yrs	Standard	118,894	20.914		135,847	19.801	
25 yrs	Difference	3,341	0.085	39,530	2,124	0.140	15,169
30 yrs	Early	118,158	20.255		132,095	19.290	
30 yrs	Standard	114,739	20.170		130,053	19.175	
30 yrs	Difference	3,419	0.086	39,912	2,042	0.115	17,778

Source: Dong et al. (2004), with permission from ADIS.

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Cost - Utility

Another Example :

Regimen	QALYs	Cost	Total			Cost-utility
			Population	QALYs	Cost	Ratio
1	9	3800	15	135 (9*15)	57000 (3800*15)	422 (57000/135)
2	8.6	2300	30	261	69000	264
3	8.3	1000	5	42	5000	119
4	7.5	5200	70	525	364000	693
5	3.8	300	50	190	15000	79

Adapted from Eddy（1996）

Which one is chosen according to the cost-utility method?

Cost - Utility

How do we compute the QALYs? There are two methods which given some assumptions are equivalent.

1. Time tradeoff

2. Standard gamble

Cost - Utility

1. Time tradeoff Method

We compare 2 alternatives:

Alternative 1 (treatment 1): Allows the individual to live T years with a health status h (strictly lower than perfect health)

Alternative 2 (treatment 2): Allows the individual to live in perfect health for t<T years.

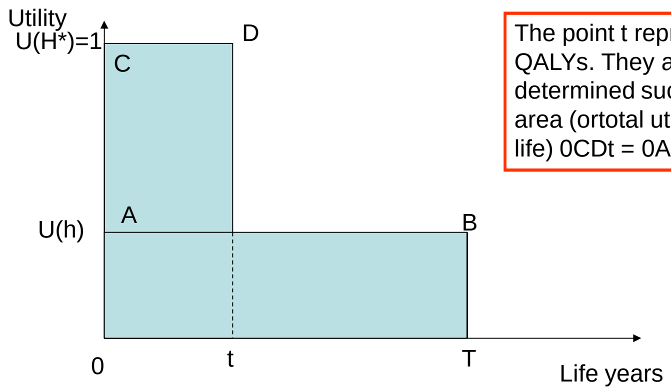
Cost - Utility

The number t<T of years such that the individual is indifferent between the two alternatives is the QALYs correspondent to alternative 1 i.e. to live T years with health status h.

…. Let's see it graphically.

Normalize: U(H*)=1 (utility with perfect health)
U(0)=0 (utility if death, could be negative)

Cost - Utility



The point t represents the QALYs. They are determined such that the area (ortotal utility over a life) 0CDt = 0ABT.

Cost - Utility

$$\boxed{W_a(1,h) = \frac{t(T,h)}{T} < 1}$$

Number of years in perfect health equivalent to 1 year in health status h. If we multiply Wa by the number of years with health h we obatain the QALYs according to the time tradeoff method.

Cost - Utility

2. The Standard Gamble Method

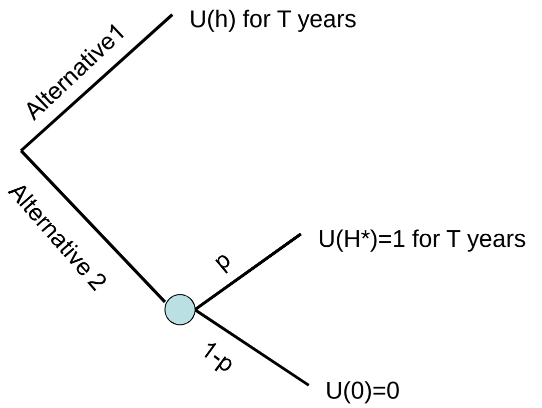
We compare 2 alternatives:

Alternative 1 (treatment 1): Allows the individual to live T years with a health status h (strictly lower than perfect health)

Alternative 2 (treatment 2): With probability p the individual lives with perfect health for T years and with probability 1-p he dies instantly.

Cost - Utility

Graphically:



Cost - Utility

The chosen value of the probability p is what will convert years into QALYs corresondent to Alternative 1. p adjusts until the individual is indifferent between alternative 1 and the lottery correspondent to alternative 2.

The Expected Utility of alternative 1 is:

$1\times U(h)\times T$ (certain event)

The Expected Utility of alternative 2 is:

$p\times U(H^*)\times T+(1-p)\times 0=p\times U(H^*)\times T=pT$

We then compute p such that:

$U(h)T=pT \Leftrightarrow p^*=U(h)$ note that the value of p is independent of T.

Cost - Utility

$$\boxed{W_b(1,h)=p^*(h)<1}$$

Number of years in perfect health equivalent to 1 year in health status h. If we multiply Wb by the number of years with health h we obatain the QALYs according to the standard gamble method.

Cost - Utility

Limitations of the 2 methods for computing QALYs:

a) The answers of the people who are asked may vary according to:
   a) Mood in a particular day or moment
   b) Results from previous treatments
   c) Climate
   d) Way the question is asked and order in the survey

b) The function U(h) is different for different individuals. We must take a representative sample.

c) There is an implicit assumption that utility is proportional to time i.e. U(h, T years)=T×U(h, 1 year)

d) QALYs of a child count the same as those of an old man, etc.

Cost - Utility

Assumption c) proportionality with respect to time the two methods are equivalent to QALY.

Model:

- The individual max his expected utility
- Maximum number of life years = T
- Utility is linear in time

Cost - Utility

Time tradeoff:

Alternative 1: $EU^1=1\times U(h)\times T=U(h)T$

Alternative 2: $EU^2=1\times U(H^*)\times t(T,h)=t(T,h)$

By definition t(T,h):

$EU^1=EU^2 \Leftrightarrow U(h)T=t(T,h) \Leftrightarrow U(h)=t(T,h)/T\in[0,1]$

$Wa(1,h)= t(T,h)/T= U(h)$

Cost - Utility

Standard Gamble:

Alternative 1: $EU^1=1\times U(h)\times T=U(h)T$

Alternative 2: $EU^2=p(h)\times U(H^*)\times T+(1-p(h))\times U(0)$

$= p(h)\, T$

By definition p(h):

$EU^1=EU^2 \Leftrightarrow U(h)T=p(h)T \Leftrightarrow U(h)=p(h)\in[0,1]$

$Wb(1,h)= p(h)= U(h)$

Cost - Utility

Therefore under these assumptions

Wa(1,h)=Wb(1,h) = U(h)

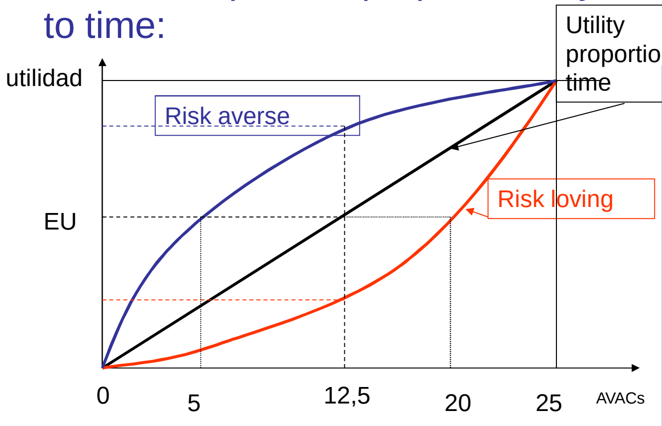
That is the two models are equivalent.

The numbers Wa and Wb are what allows going from life years to QALY as long as utility is proportional to time.

Example: If utility of 1 year under dialysis is 0,4 (=U(h)=p(h)) a life-expectancy of 8 years is equivalent to 8×0,4=3,2 QALY

Cost - Utility

The assumption of proportionality with respect to time:



An individual neutral with respect to risk values 12,5 QALYs without uncertainty as much as 50% probability of obtaining 0 QALYs and 50% 25 QALYs. The risk lover values the lottery as mucha as 20 QALYs without uncertainty and the risk averse as much as 5 QALYs without uncertainty

Cost - Utility

Computing the QALY

Example: An individual that has 10 more years of life

-5 years living in a health state valued at 0,75

-4 years living in a health state valued at 0,5

-1 year living in a health state valued at 0,25

¿How many life-years adjusted for quality do these 10 years of life correspond to?

$(5 \times 0{,}75)+(4 \times 0{,}5)+(1 \times 0{,}25)=6$ QALY

Cost – Benefit

$$t_{CB} = \frac{\textit{Cost} \text{ in monetary units}}{\textit{benefit} \text{ in monetary units}}$$

or alternatively:

$$T_{CB} = \text{benefit in monetary units} - \text{cost in monetary units}$$

The project should be realized if $t_{CB} < 1$ or $T_{CB} > 0$

Usage: It can be used to value isolated projects. Important to understand that when expressing life in monetary terms we are not giving it a price but instead we want to be able to express preferences.

Limitation: The main limitation is to have to give a monetary value to life or to health.

Cost – Benefit

2 methods to give a monetary value to life-years:

- The human capital method: The "value" of life equals the discounted sum of the value of its future work (basically we sum wages). The biggest advantage of this method is its simplicity. The main limitation is that it lacks a microeconomic (and moral) foundation example. Life of the retired people would not have any value.

Cost – Benefit

- The method of the willingness to pay : It has microeconomic foundations because it is based on an individual's preferences. To compute it one consider small or marginal variations in :
  - the probability of death π – how much a person is willing to pay to decrease the probability of death by $\Delta\pi$ (equivalent variation) or how much is willing to receive to compensate for an increase in the probability of death of $\Delta\pi$ (compensating variation). When $\Delta\pi \rightarrow 0$ we can compute the marginal rate of substitution between wealth and risk of death. The equivalent variation is limited by the individual's wealth while the compensating variation has no limits and therefore is preferable
  - In the number of life-years

Cost – Benefit

How to measure the marginal willingness to pay?

1. The direct method: The survey

Limitations:

a. According to the theory, one has to consider small variations of the probability of death ($\Delta\pi$) but this does not have meaning for the majority of the people => results are not valid.
b. People refrain from answering. If those that do not answer are those that value life the most, for example => the data will have a bias and will not be representative.
c. People cannot picture the situations, they are too hypothetical for them to be able to give a correct answer or taking it seriously.

Cost – Benefit

2. The indirect Method: Analysis of data. One can use revealed preference techniques. The idea is to estimate the necessary compensation to take in more risk through differences in wages of different occupations with different risk of death for example. Limitations:

a. Separating risk from other influential factors – example: education, communication skills, etc. that can justify the differences in wage.
b. Differences between the subjective probability of death (that affects people's decisions because they enter the expected utility) and the objective probability of death (observed in the data). The theory of the marginal willingness to pay uses subjective probabilities but we cannot observe these we only observe objective probabilities.
c. Representativeness of those that have risky jobs. May be these people have different preferences for risk and they are willing to take a lower premium on their wage then other people. We would in this case underestimate the premium that one needs to pay to take more risk Δp.

Estimations regarding the "value" of life

TABLE 4-1 How Much Is One Life Worth?

Range of implied values of a human life extrapolated from what people pay for various products, services, or regulations that can change the risk of death.

Basis for Calculation	*Value of Life ($1990, in millions)*
Labor Market Studies	
Leigh (1987)	$10.4
Moore & Viscusi (1987)	$2.5–$7.3
Kneiser & Leeth (1991)	$7.6
Gegax, Gerking, & Schultz (1991)	$1.6
Outside of Labor Market Studies	
Fire fatality risks	
Garbacz (1989)	$2.0
Automobile accident risks	
Atkinson and Halvorsen (1990)	$4.0
Cigarette smoking	
Ippolito and Ippolito	$0.7
Air pollution	
Portney (1981)	$0.8

Source: Viscusi (1993), various tables.

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Cost – Benefit

The Willingness to Pay Method (theory)

$U_1(y)$ = utility function when living

$U_0(y)$ = utility function if the individual dies

$y \equiv$ wealth

$\pi \equiv$ probability of dying

Assumption 1: U_1, U_0 are differentiable

$U'>0$

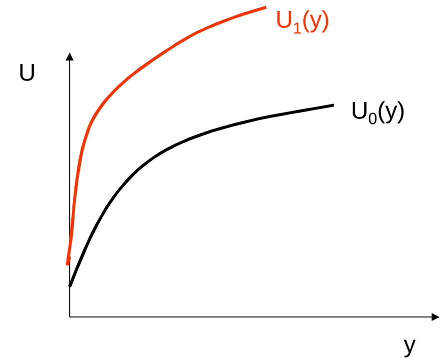
$U''<0$ (risk aversion, $U(E(y))>E(U(y))$

Assumption 2: $U_1(y)> U_0(y)$ for all wealth levels y

Assumption 3: $U'_1(y)> U'_0(y)$ for all wealth levels y

Cost – Benefit

Given the 3 assumptions

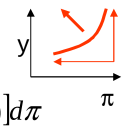


Cost – Benefit

The Expected utility is:

$$EU = (1-\pi)U_1(y) + \pi U_0(y)$$

Total differentiation (that is moving along an indifference curve between π and y)



$$0 = dEU = [(1-\pi)U'_1(y) + \pi U'_0(y)]dy + [U_0(y) - U_1(y)]d\pi$$

$$\Leftrightarrow \frac{dy}{d\pi} = \frac{\overbrace{U_1(y) - U_0(y)}^{+}}{(1-\pi)\underbrace{U'_1(y)}_{+} + \pi \underbrace{U'_0(y)}_{+}} > 0$$

If risk increases, my wealth has to increase so that I stay in the same indifference curve. This is the rate of substitution between wealth and probability of death.

Cost – Benefit

How does the substitution rate between wealth and probability of death varies with wealth? And with the probability of death π?

Variation with respect to π:

$$\frac{d}{d\pi}\left(\frac{dy}{d\pi}\right)=\frac{d^2y}{d\pi^2}=-\frac{\overbrace{(U_1(y)-U_0(y))}^{+}\overbrace{(U'_0(y)-U'_1(y))}^{-}}{((1-\pi)U'_1(y)+\pi U'_0(y))^2}>0$$

The willingness to pay for a marginal reduction of the risk increases with the level of risk. (the intuition is that when π increases it also increases the weight on U0 in the expected utility where the marginal utility of money is lower.)

Cost – Benefit

Variation with wealth:

$$\frac{d}{dy}\left(\frac{dy}{d\pi}\right)=\frac{d^2y}{dyd\pi}=$$

$$\frac{\overbrace{((1-\pi)U'_1+\pi U'_0)}^{+}\overbrace{(U'_1-U'_0)}^{+}-\overbrace{(U_1-U_0)}^{+}\overbrace{((1-\pi)U''_1+\pi U''_0)}^{-}}{((1-\pi)U'_1(y)+\pi U'_0(y))^2}>0$$

The willingness to pay for a marginal reduction of the risk increases with the level of wealth (because the marginal utility of money decreases with wealth)