Cost Utility Analysis

Chapter 6

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Objectives

- Upon completing this chapter, you will be able to:
  - define and describe cost-utility analysis (CUA)
  - address advantages and disadvantages of CUA
  - list the steps of quality-adjusted life-year (QALY) calculation
  - compare the different methods used in estimating utilities
  - compute QALY calculations

- Cost utility analysis (CUA) is a method for comparing treatment alternatives that integrate patient health related quality of life (HRQOL)

- CUA is used to compare cost, quality, and the quantity of patient-life years

- In health economics, the term ‘utility’ is used to refer to the preferences individuals or society may have for any particular set of health outcomes (e.g. for a given health state, or a profile of states through time)

- in CUA, outcome is commonly measured in quality adjusted life years (QALYs) rather than in natural units

  - this offers the potential to compare interventions in different areas of health care, such as treatments for heart disease and cancer, and to assess the opportunity cost (on the budget) of adopting interventions

- Cost utility analysis (CUA) is a special form of CEA

- Difference:
  - CUA is conducted when two or more interventions have different outcomes in terms of both the length of life and the quality of life
    - Outcomes are measured in QALYs or DALYs

  - CEA is conducted when two or more interventions have different outcomes based on the number of life-years saved (LYS), but very similar quality of each year of life saved
    - outcomes measured in natural units

Advantages of a CUA:

- CUA combines length of life years (quantity) gained as a result of an intervention with quality of life

- interventions that have different types of health outcomes can be compared (unlike in CEA) using one common unit such as the QALY
  - For example: when comparing antihypertensive and antidiabetic treatments

- many health problems such as, hearing loss, seasonal allergies, and erectile dysfunction, do not have an impact on patients' length of life, but only on the quality of their life
  - CUA is a good choice for comparing t/ts for such conditions

Disadvantage of CUA:

- it is difficult to determine an accurate utility score

When to use CUA?

- CUA is the most appropriate method to use when:
  - comparing programs and treatment alternatives that are life extending with serious side effects (e.g., cancer chemotherapy)
  - comparing those programs and treatment alternatives which produce reductions in morbidity rather than mortality (e.g., t/t of arthritis), and
  - HRQOL is the most important health outcome being examined

What is Utility?

- a term used by economists to signify the satisfaction accruing to a person from the consumption of a good or service
- this concept is applied in health care to mean the individual's valuation of their state of well-being deriving from the use of health care interventions
- in brief, utility is a measure of the preference for, or desirability of, a specific level of health status or specific health outcome

- utility in healthcare is numerical estimate of quality of life (QOL)
- by convention:
  - perfect health is assigned a value of 1 utility and
  - death is assigned a value of 0 utility
- if a person's health is diminished by disease or treatment, the utility is valued somewhere between 0 and 1
- there are disease states worse than death, so negative utility weights may be needed to depict these values

- Quality of Life
  - a generic concept reflecting concern with the modification and enhancement of life attributes, e.g., physical, political, moral and social environment; the overall condition of a human life

What is QALY?

- Units of measure of utility which combine life years gained as a result of health interventions/health care programs with a judgment about the quality of these life years

- A common measure of health improvement used in cost-utility analysis, it measures life expectancy adjusted for quality of life

Calculating QALYs

- QALY is life expectancy adjusted based on utility

QALY = time in health state × utility score of the health state

QALYs interpretations

- QALYs are interpreted as the number of healthy years lived
  - 1 QALY = living 1 year being disease free or on perfect health
  - 0.5 QALY = living half a year being disease free or on perfect health
  - 0 QALY = dead
  - **negative** QALY = worse than dead

- QALYs measure years of healthy life adjusted/discounted for lower quality of life

Steps in Calculating QALYS

1. develop a description of each disease state of interest
2. choose a method for determining utilities
3. choose subjects who will determine utilities
4. measure Health-Related Quality of Life (HRQOL) and multiply by the length of life for each intervention to obtain QALYs

Step 1: Develop a Description of Each Disease State of Interest

- a disease state or condition should be described to subjects who help determine the utility value

- the description should concisely depict the usual health effects expected from the disease state or intervention

- The description of disease state should include:
  - the amount of pain or discomfort
  - any restrictions on activities
  - the time it may take for treatment
  - possible changes in health perceptions (worry or concern), and
  - any mental changes

Example: Description of Hospital-Based Kidney Dialysis

- you often feel tired and sluggish.
- a piece of tubing has been inserted into your arm or leg, which may restrict your movement.
- there is no severe pain but rather chronic discomfort
- you must go to the hospital twice a week for 6 hours per visit
- you must follow a strict diet (low salt, little meat, no alcohol)
- many people become depressed because of the pains and restrictions, and some feel they are being kept alive by a machine

Step 2: Choose a method for determining utilities

- two broad methods are used to estimate measure Health-Related Quality of Life or utility scores for various health states:
  - direct and indirect methods

- Direct utility measurement methods include:
  - rating scale
  - standard gamble
  - time tradeoff, etc.

- Indirect HRQOL measurement methods include:
  - EQ-5D
  - SF-6D
  - HUI, etc.

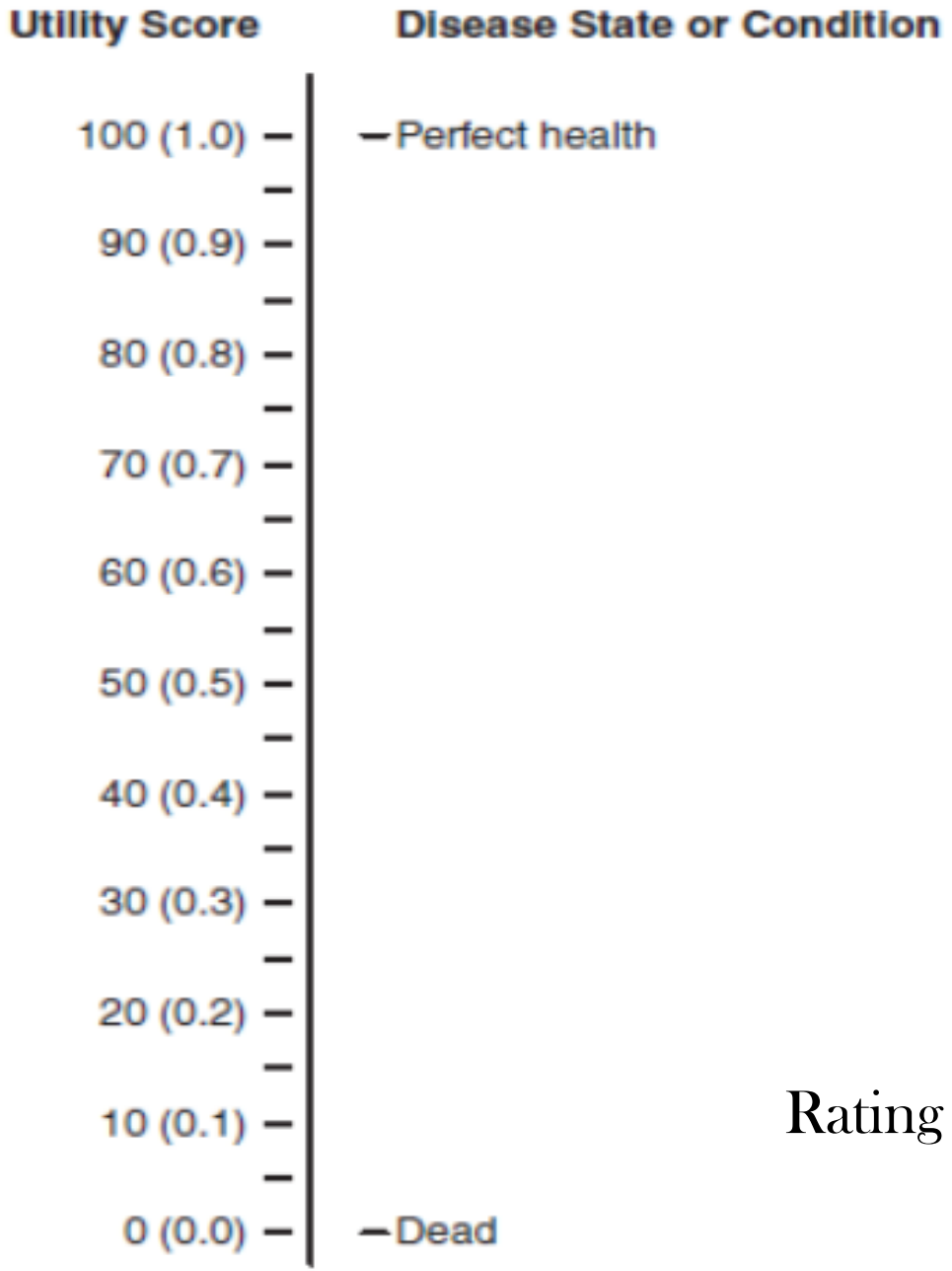
- The choice of utility measurement method matters as the valuation approach can lead to differences in utility estimates

Rating Scale (RS)

- RS consists of a line with scaled markings with perfect health at the top (100) and death at bottom (0)

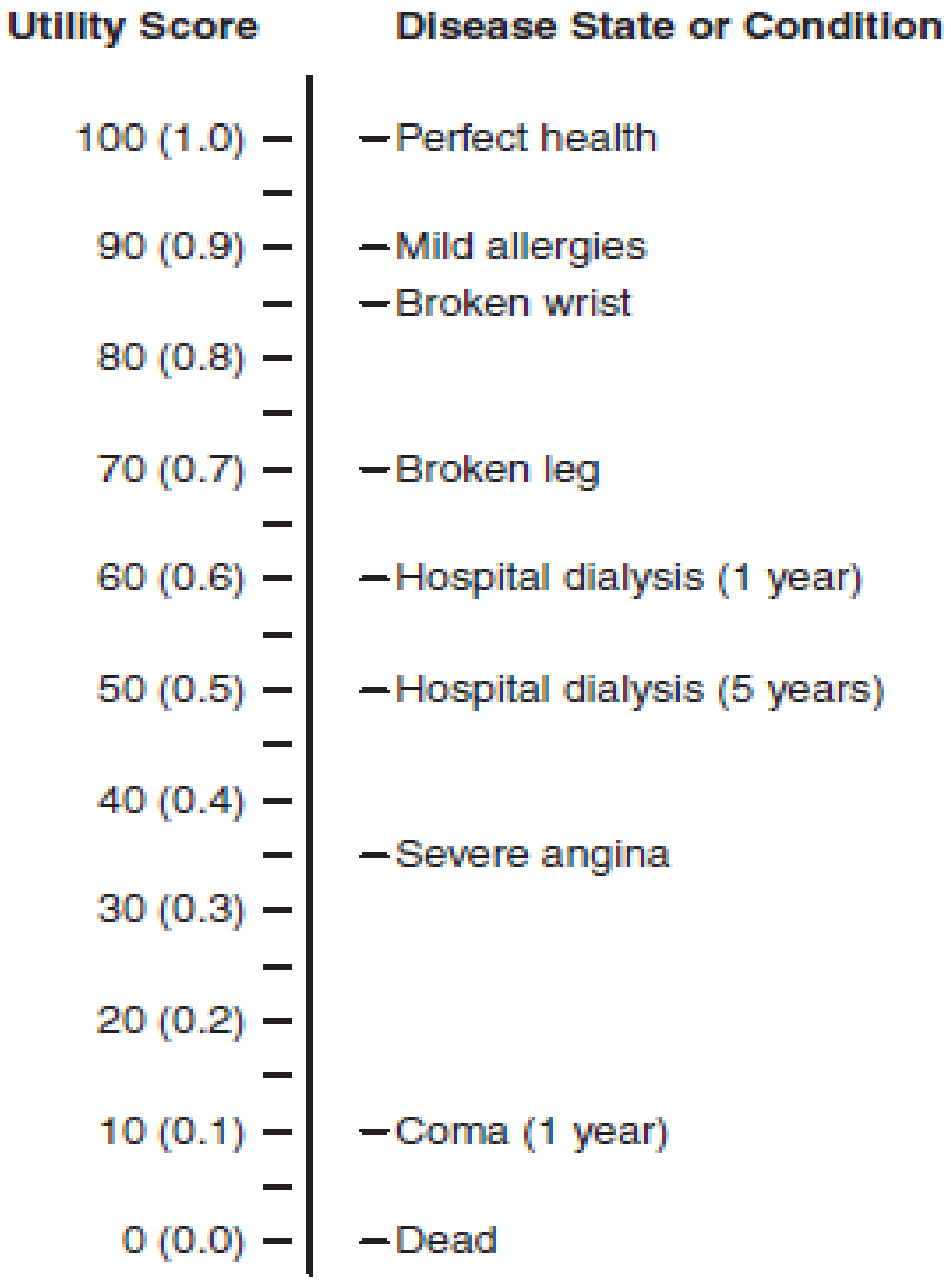
- subjects are told to mark an "X" somewhere between the two extremes to indicate their preferences

- to use this method, the disease states or conditions will be described to subjects who are asked to place their estimated preferences for the disease states somewhere on the RS



Rating scale (RS)

- For example, if they place a disease state at 50 on the scale, the disease state is given a utility score of 0.5



Rating scale (RS) with example estimates for various disease states

- According to the above example, which one has the highest utility estimate?
  a. being in a coma for 1 year
  b. having hospital dialysis for 1 year
  c. mild allergies

- RS has the least grounding in economic theory
  - the least reliable

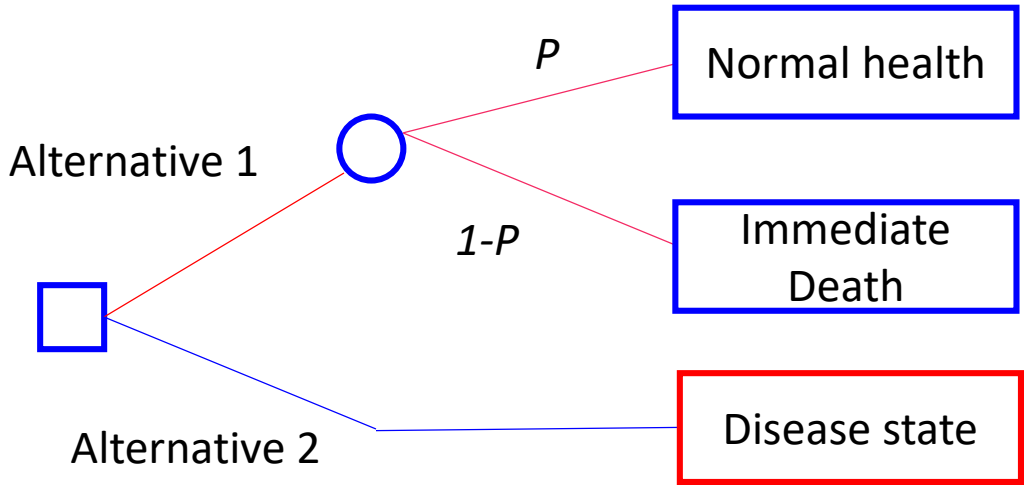
- How ever, due to its simplicity, it is often used as a ‘warm-up’ to a TTO or SG exercise, as it allows the respondent to become familiar with comparing the health states

Standard Gamble (SG)

- For this method, each subject is offered two alternatives
- Alternative 1 is treatment with two possible outcomes:
  - either the return to normal health or
  - immediate death

- Alternative 2 is a chronic disease state for life expectancy

- the probability (p) of normal health versus probability of immediate death ($1-p$) for Alternative 1 is varied until the subject is indifferent between Alternatives 1 and 2 (living with the disease)



Standard gamble (SG)

- to use the SG approach, the respondents will be asked to think about being in a chronic health state and then told that they could gamble on an intervention (e.g., an operation) that could either cure the condition (probability = p), or he might die from the intervention (probability = $1-p$)

- a base probability is given and the respondent is asked whether he chose to receive t/t or live with the chronic condition

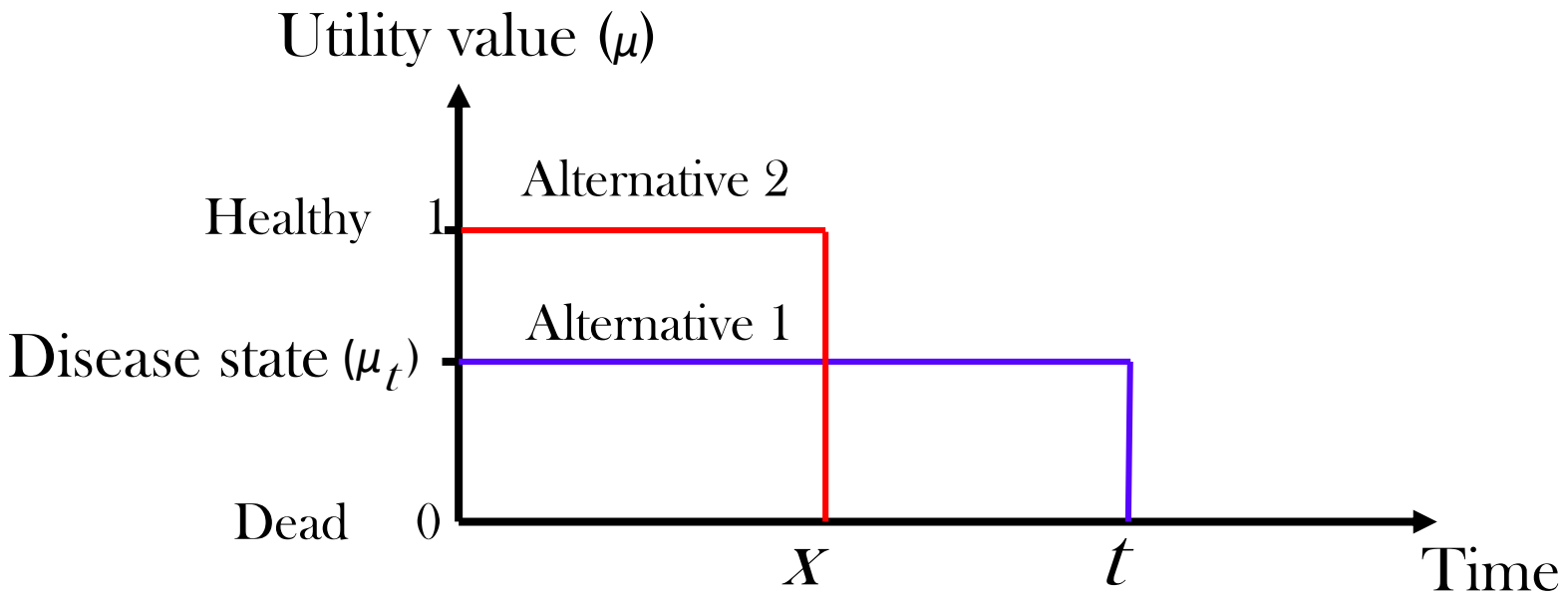
- this probability is varied until the respondent is indifferent (the two options are difficult to chose between)

- the probability at this indifference point is the utility score of the disease

- Example 1: 6. Using the standard gamble method, respondents were presented with a choice between frequent migraine attacks and a gamble with intervention which has two possible outcomes, either normal health or death. The respondents were found to be indifferent between remaining with the migraine state for life or receiving a treatment which has a 0.8 probability of achieving normal health or a 0.2 probability of immediate death. How much is the utility value of migraine for these respondents?

Time Tradeoff (TTO)

- in this method like the SG, the subject will be offered two alternatives:
  - alternative 1 is a given disease state for the life expectancy (t)
  - alternative 2 is being healthy for time x, which is less than t, and then death



Time Tradeoff

- the respondent will be given the choice of living a full life (to time *t*) with a specific condition or living fewer years (to time *x*) without the condition (being healthy)

- then the time of living healthy will be varied until the respondent is indifferent between living in full health *x* years and living with the disease for *t* years

- finally, the utility score for the health state is calculated as x/t

- Example 2: a person with a life expectancy of 40 years is given two options:
  - Alternative 1 is having a chronic condition for 40 years, and
  - Alternative 2 is being healthy for 30 years followed by death

- if the person chose living with the disease for 40 years (t) than living healthy for 30 years, the number of years (x) in the healthy state will be *increased* until the person is indifferent between the two alternatives.

- if the person chose living healthy for 30 years than living with the disease for 40 years, the number of years (x) in the healthy state will be *decreased* until the person is indifferent between the two alternatives

- for this example, let us say the person's point of indifference is 35 years of health versus 40 years of chronic condition

then, the utility score would be $x/\ t = 35/40$

$= \underline{0.87}$

Comparison of the direct utility measurement methods

- health economists support the use of choice-based methods
  - they recommend SG or TTO over the RS
- however, the SG approach is relatively time-consuming and people often have difficulty understanding the concept of probabilities
- the TTO method represents a reliable and practical middle way

Indirect utility measurement methods

- indirect utility measurement methods are used to determine utilities for both temporary and chronic health states
- direct methods are more appropriate for chronic diseases

- two categories of indirect utility measurement methods:
  - generic (general) methods and
  - specific methods

Generic utility measurements

- used to determine utility values for set of non-disease-specific health states, based on a combination of general attributes, using a general public sample

- three commonly used generic utility measurements:
  - EQ-5D (Euro Quality of life 5 dimension)
  - SF-6D (Short Form six dimension) and
  - the HUI (Health Utilities Index)

- the generic utility measurements differ in the specific general dimensions/attributes used for their descriptive systems in the method of valuation applied

- a large amount of research effort by separate EQ-5D, SF-6D and HUI research teams has gone into the development of standard, off-the-shelf questionnaires that can be completed in a few minutes by patients in randomized clinical trials or observational studies

- for each of indirect instrument, the public values a limited number of health states and a scoring algorithm is developed using econometric modelling to predict utilities for other health states not directly valued

- patients with any health condition then complete a simple questionnaire which defines the generic health state they are in, and then the corresponding utility will be determined from the scoring algorithm

EQ-5D

- includes 5 health dimensions/attributes:
  - mobility
  - self care
  - usual activities
  - pain/discomfort
  - anxiety/depression
- each attribute has three levels of functioning (1 = no problems, 2 = moderate problems, 3 = extreme problems)

- The EQ-5D method incorporates these 5 attributes into a single health state description

- Specific Questionnaire for EQ-5D is presented in the next slide

Mobility

1. I have no problems in walking about ☐
2. I have some problems in walking today ☐
3. I am confined to bed ☐

Self care

1. I have no problems with washing or dressing my self ☐
2. I have some problems with washing or dressing my self ☐
3. I am un able to wash or dress my self ☐

Usual activities

1. I have no problems with performing my usual activities ☐
2. I have some problems with performing my usual activities ☐
3. I am unable to perform my usual activities ☐

Pain/discomfort

1. I have no pain or discomfort ☐
2. I have moderate pain or discomfort ☐
3. I have extreme pain or discomfort ☐

Anxiety/depression

1. I am not anxious or depressed ☐
2. I am moderate anxious or depressed ☐
3. I am extremely anxious or depressed ☐

- to use this method, the subjects are asked to score:
  - 1, if they choose the first (best) response
  - 2, if they chose the second response, and
  - 3, if they choose the third (worst) response for each of the five dimensions

- then the utility value will be read off from scoring algorithm

- Example 3: EQ-5D questionnaire completed for a given health problem is presented in the next slide. Determine the utility score for this health state from the following scoring algorithm.

Health State	Utility Value
31311	0.344
23213	0.337
22323	0.333
23322	0.331
21332	0.331
32221	0.330
12331	0.329
31312	0.327

Mobility

1. I have no problems in walking about [1]
2. I have some problems in walking today [ ]
3. I am confined to bed [ ]

Self care

1. I have no problems with washing or dressing my self [ ]
2. I have some problems with washing or dressing my self [2]
3. I am un able to wash or dress my self [ ]

Usual activities

1. I have no problems with performing my usual activities [ ]
2. I have some problems with performing my usual activities [ ]
3. I am unable to perform my usual activities [3]

Pain/discomfort

1. I have no pain or discomfort [ ]
2. I have moderate pain or discomfort [ ]
3. I have extreme pain or discomfort [3]

Anxiety/depression

1. I am not anxious or depressed [1]
2. I am moderate anxious or depressed [ ]
3. I am extremely anxious or depressed [ ]

The health state description is

Health state	1	2	3	3	1

To determine the utility score, read off the corresponding value from the scoring algorithm, which is 0.329

Health State	Utility Value
31311	0.344
23213	0.337
22323	0.333
23322	0.331
21332	0.331
32221	0.330
12331	0.329
31312	0.327

- **Domains included in Health Utilities Index (HUI)—Mark III**
  - Vision
  - Hearing
  - Speech
  - Dexterity
  - Cognition
  - Pain and discomfort
  - Emotion

- the specific utility measurement methods can be:
  - Disease specific (e.g., diabetes)
  - Population specific (e.g., frail older adults)
  - Function specific (e.g., sexual functioning)
  - Condition or problem specific (e.g., pain)

- Examples of Disease-specific utility instruments include:
  - Arthritis Impact Measurement Scales (AIMS)
  - Asthma Quality-of-Life Questionnaire (AQLQ)
  - the Cambridge Pulmonary Hypertension Outcome Review (CAMPHOR)
  - Functional Assessment of Cancer Therapy-Colorectal (FACT-C) Scale
  - Kidney Disease Quality-of-Life (KDQOL) Instrument
  - Quality of Life in Epilepsy (QOLIE)
  - Medical Outcomes Study HIV Health Survey (MOS-HIV)
  - the International Index of Erectile Function (IIEE)

Step 3: Choose Subjects Who Will Determine Utilities

- the term subject refers to the person who would be questioned to determine the utility, or preference scores
- choice of subjects is important because there is some evidence that utilities differ between different population groups

- who should be the subject?
  - the patient with the disease?
  - the caregiver?
  - the health care professional? or
  - people from the general public?

- the reason for selecting the general public as subjects is that in a publicly funded healthcare system, it is society's resources that are being allocated and so it is the views of the general population that are most relevant

- the reason for selecting health care professionals as subjects is speed and practicality/feasibility
  - because these professionals are easily accessible for interviews
  - utilities obtained from health care professional may not be valid predictors of utilities
  - professionals may not represent a valid or reliable source for utilities

- if the patient is not convenient to determine utilities (e.g., a young child or person with dementia), the parent or caregiver may need to estimate values on behalf of the patient

- the reason for selecting patients as subjects is that they are the people who experience the impact of the disease and t/t, so it is their preferences that should be considered of most importance
  - therefore, utility measurement should ideally be based on direct patient experience
  - it is more challenging to recruit patients with the specific health states of interest

Step 4: Measure Health-Related Quality of Life (HRQOL) and Multiply by the Length of Life for Each Intervention to Obtain QALYs

QALY = time in health state × utility score of the health state

- Example 3:
  - Drug A is available as IV preparation, has large side-effects, requires weekly hospital visits, and causes nausea. It extends the life expectancy of an individual by 12 years. It also results in the individual surviving the years in a health state with a utility score of 0.4.

  - Drug B is available as oral formulation, and has some side effects. It extends the life expectancy of an individual by 10 years. It also results in the individual surviving the years in a health state with a utility score of 0.65.
  - Treatment costs for both drugs are equal, $100.

Interventions	Treatment Cost ($)	Life Years Saved (LYS)	Utility value for Each Life year Saved
Drug A	100	12	0.4
Drug B	100	10	0.65

a. calculate the QALY for both drugs.
b. how do you interpret your result?
c. which drug would you recommend?
d. compare the two drugs using CEA assuming that the utility score for both dr ugs are equal?

a. Since the outcomes from the two drugs differ both in quantity and quality of life years, to compare the two drugs, life years saved must be adjusted for quality.

QALYs for Drug A = 12 years(0.4) = 4.8 QALYs

QALYs for Drug B = 10 years(0.65) = 6.5 QALYs

b. Interpretation:

- drug A saves the equivalent of 4.8 years of healthy life

=living for 12 years using drug A is equal to living for 4.8 years on perfect health

- drug B saves the equivalent of 6.5 years of healthy life

=living for 10 years using drug B is equal to living for 6.5 years on perfect health

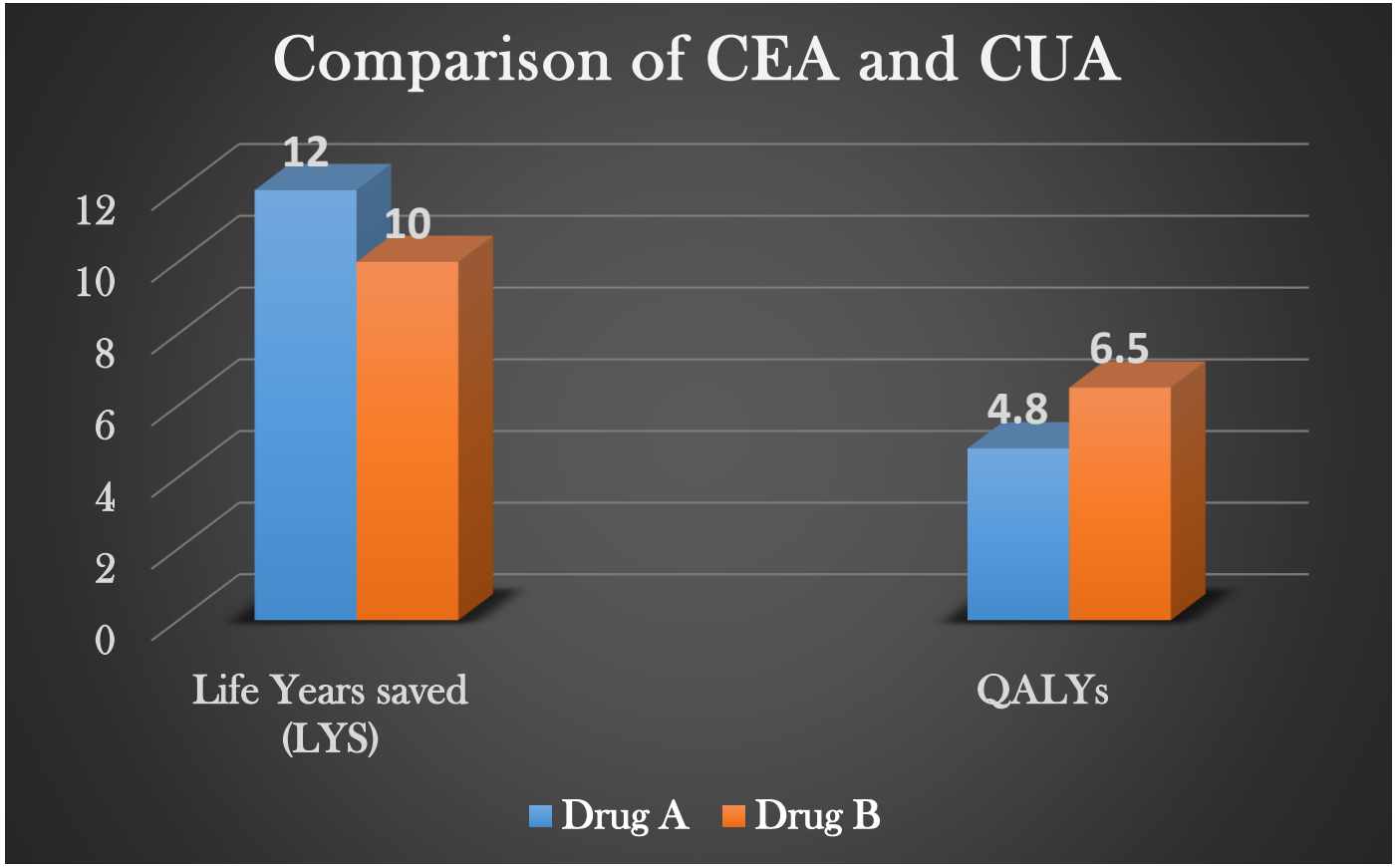
c. costs of the two drugs are equal. Therefore, only outcomes will be compared

QALYs for Drug B > Drug A

 Drug B is recommended

d. If the utility score for both drugs are equal, they will be compared using CEA based on only the quantity of life years achieved. Therefore, drug A will be recommended since it saves more life years than drug B

- 12 years vs 10 years

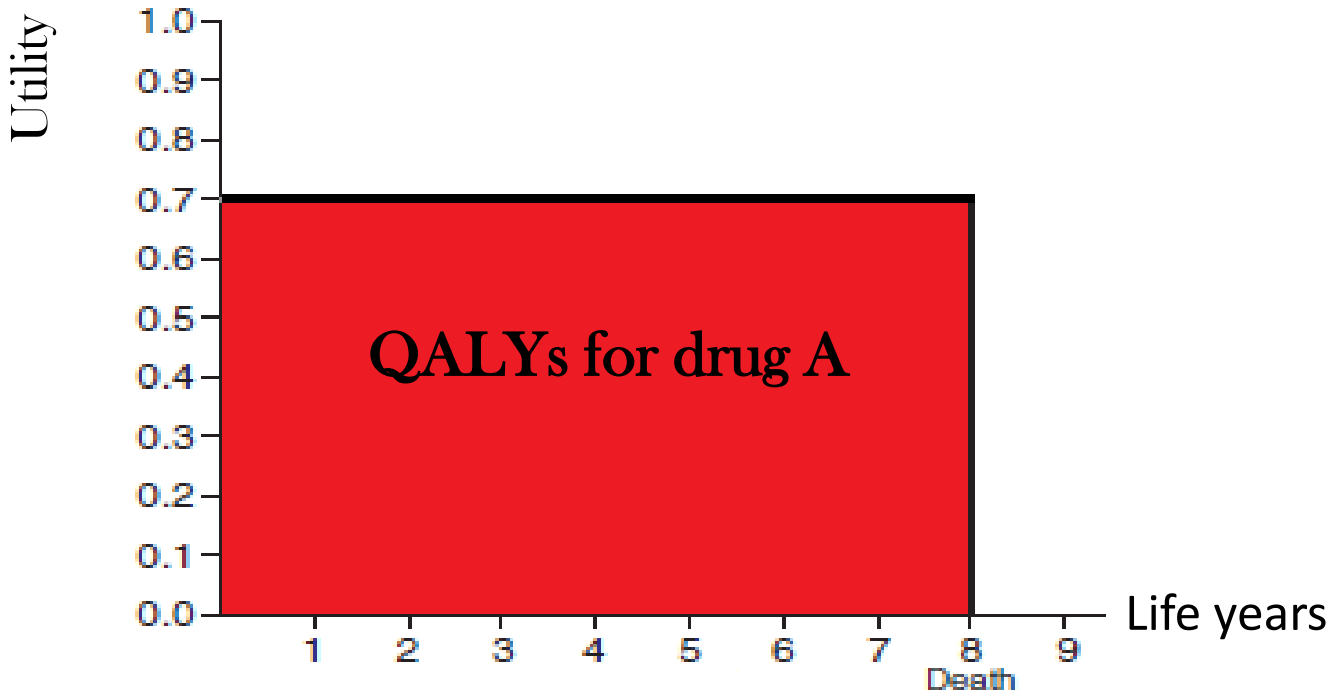


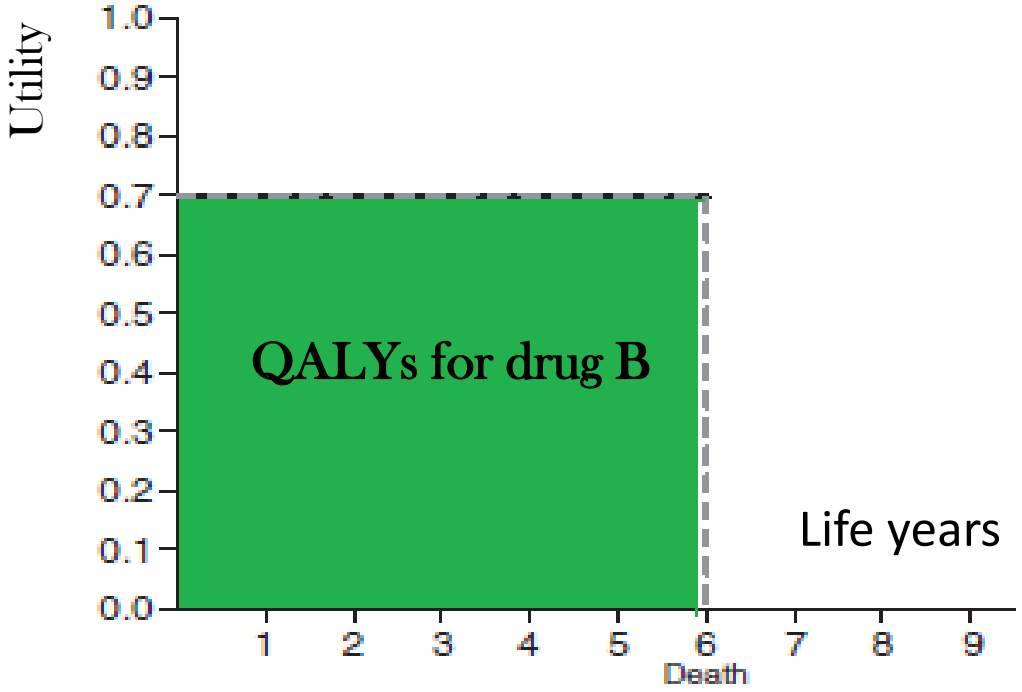
- although drug A extends the person's life for more years, the quality of life for those years is lower than with drug B

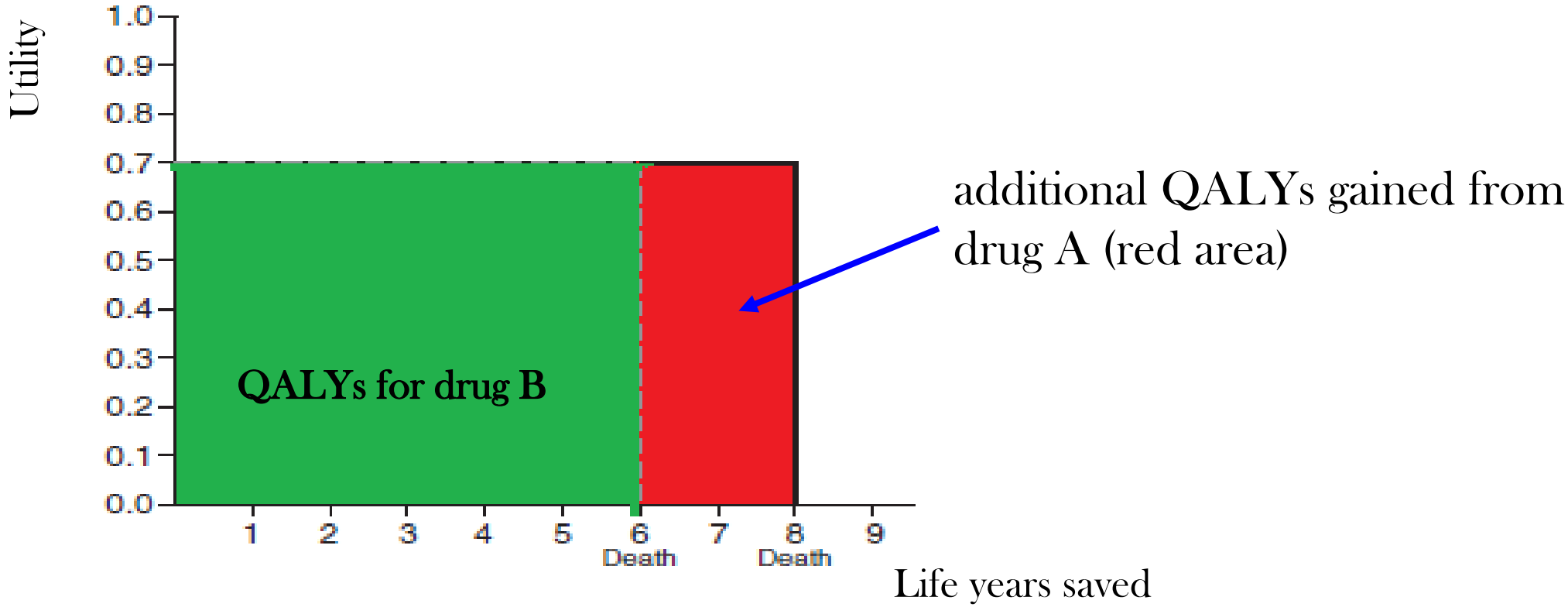
QALY Diagrams and QALY Gains

- QALY diagrams are sketched with the life years on the x axis and utility (health related quality of life) on the Y axis
- The area under the curve represents QALYs

- Example 4: Drug A prolongs life by 8 years at estimated utility value of 0.7. Drug B prolongs life by 6 years at estimated utility value of 0.7. Sketch the QALY diagram of both drugs and determine how many additional QALYs are gained if We choose drug A.


Utility
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
QALYs for drug A
1
2
3
4
5
6
7
8
9
Death
Life years

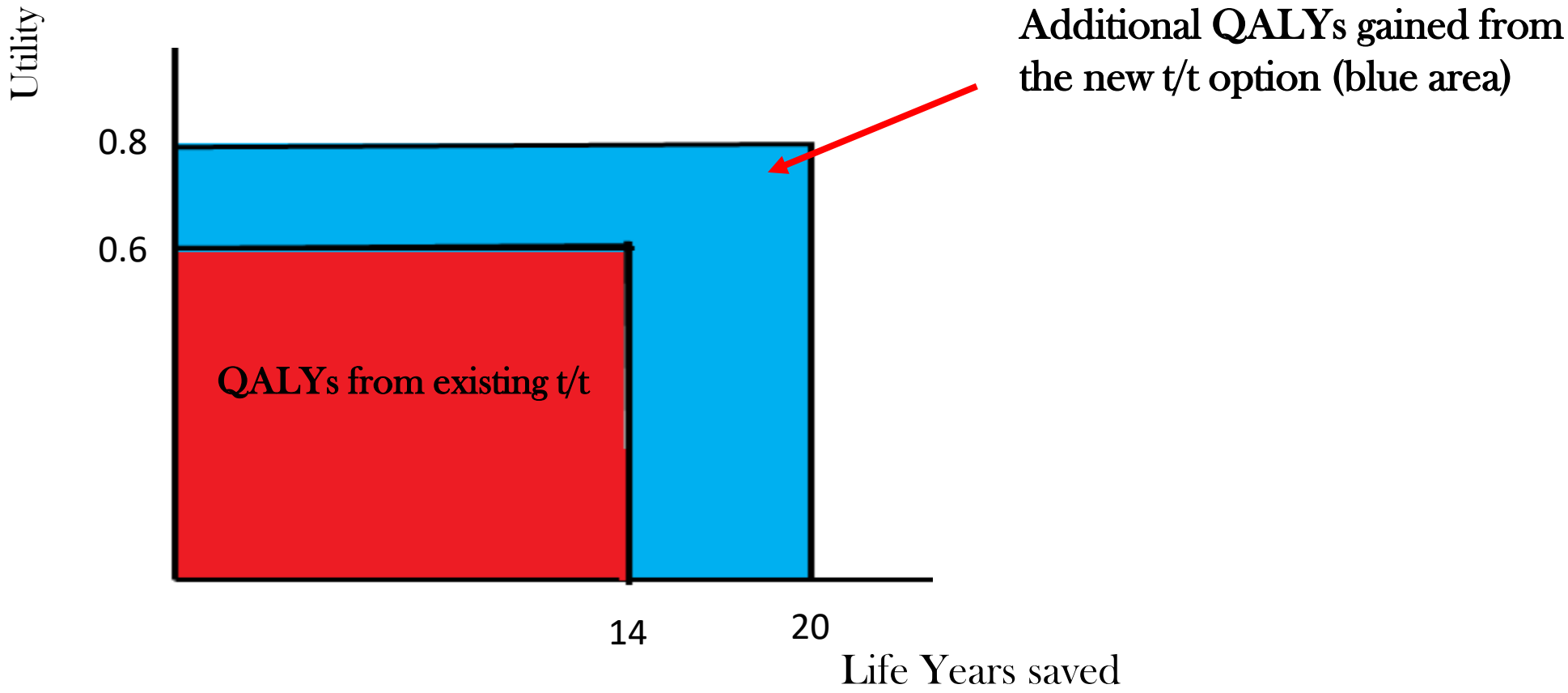

Utility
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
QALYs for drug B
1
2
3
4
5
6
7
8
9
Death
Life years



Additional QALYs Gained from drug A (red area) = QALYs for drug A - QALYs for drug B

= (8)(0.7) – (6)(0.7) = **1.4 QALYs**

- Example 5: an existing treatment saves 14 life years with quality of life weight of 0.6 and a new treatment prolongs life by 20 years with quality of life weight of 0.8.
- Sketch the QALY diagram of both treatment options and determine how many additional QALYs are gained from the new treatment.



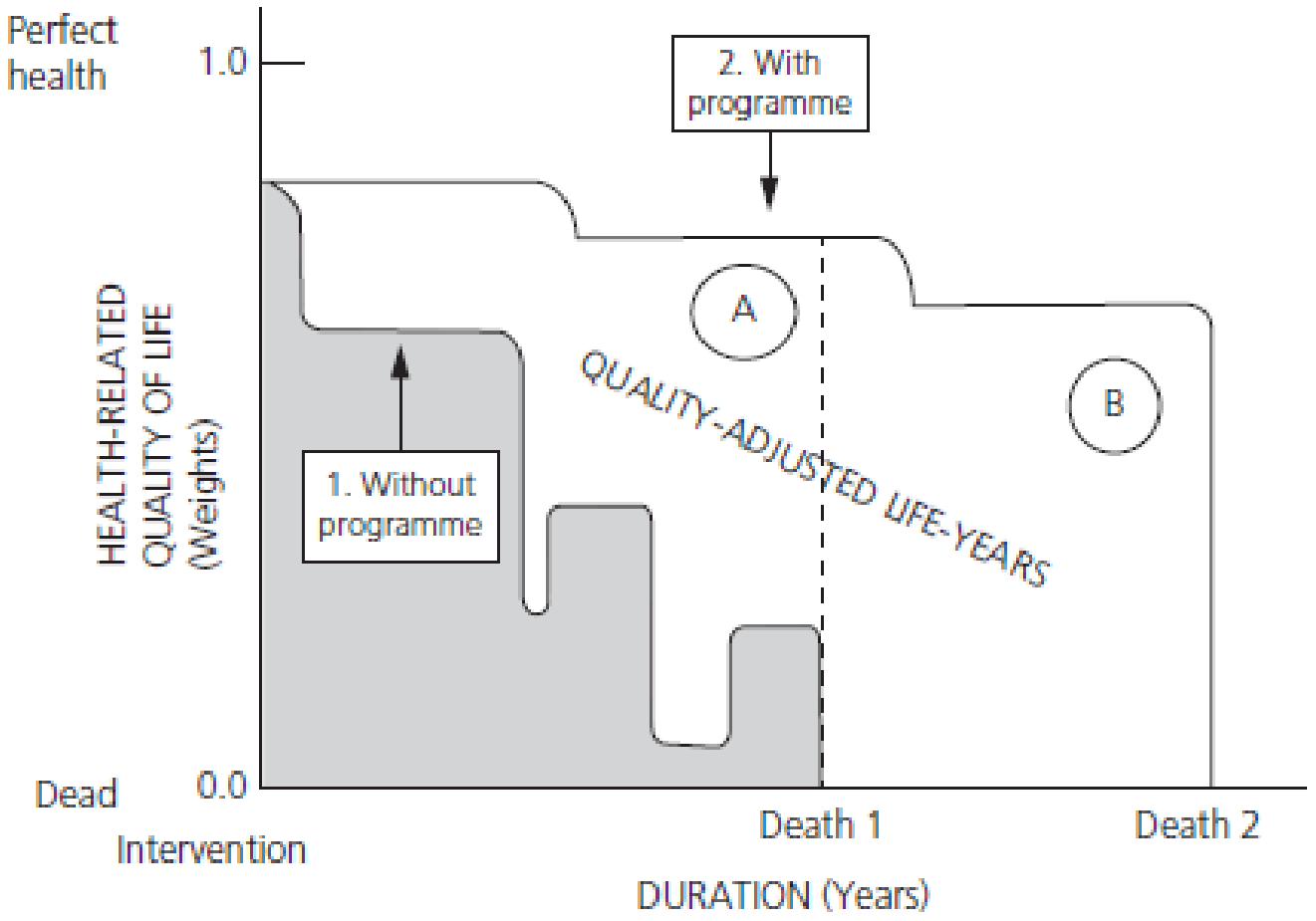
Additional QALYs from the new t/t = QALYs for new t/t - QALYs for existing t/t

= (20)(0.8) – (14)(0.6) = <u>7.6 QALYs</u>

- In examples 3, 4 and 5 above, the utility score for each year of additional life is constant

- In actuality, for many conditions, the utilities would change over time as the condition improves or worsens
- In such cases, the QALY diagrams have different shapes

- In the conventional approach to QALYs the quality-adjustment weight for each health state is multiplied by the time in the state and then summed to calculate the number of QALYs
- A simple example is displayed in the Figure shown in the next slide, in which outcomes are assumed to occur with certainty. Without the health intervention an individual's health-related quality of life would deteriorate according to the lower curve and the individual would die at time Death 1
- With the health intervention the individual would deteriorate more slowly, live longer, and die at time Death 2
- The area between the two curves is the number of QALYs gained by the intervention
- For instruction purposes the area can be divided into two parts, A and B, as shown. Then part A is the amount of QALY gained due to quality improvements (i.e. the quality gain during time that the person would have otherwise been alive anyhow), and part B is the amount of QALY gained due to quantity improvements (i.e. the amount of life extension, but adjusted by the quality of that life extension)

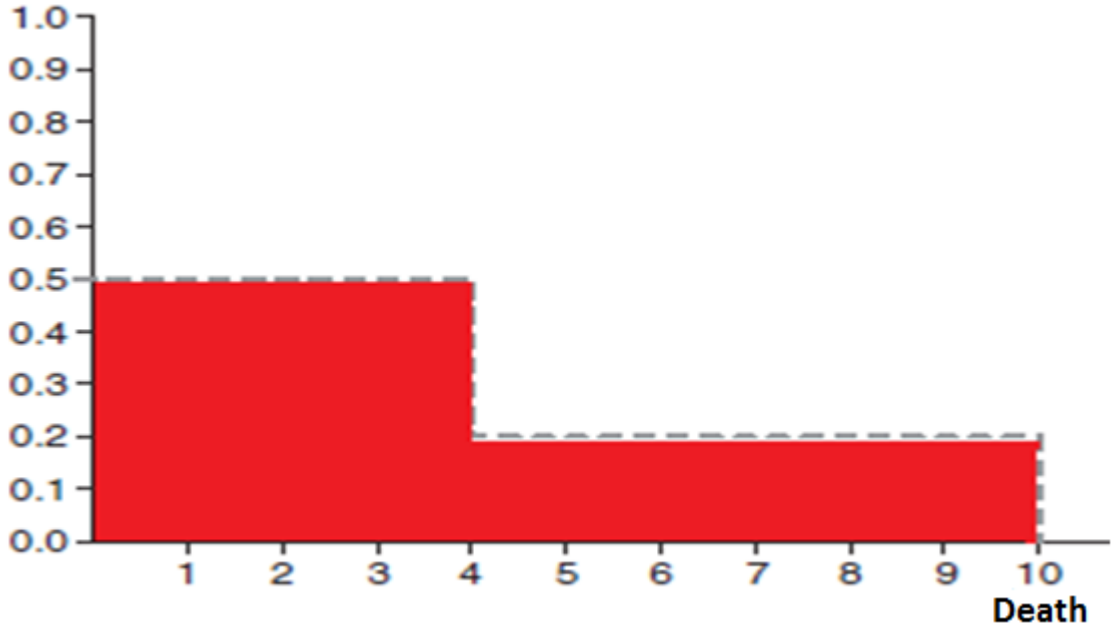


QALYs gained from an intervention

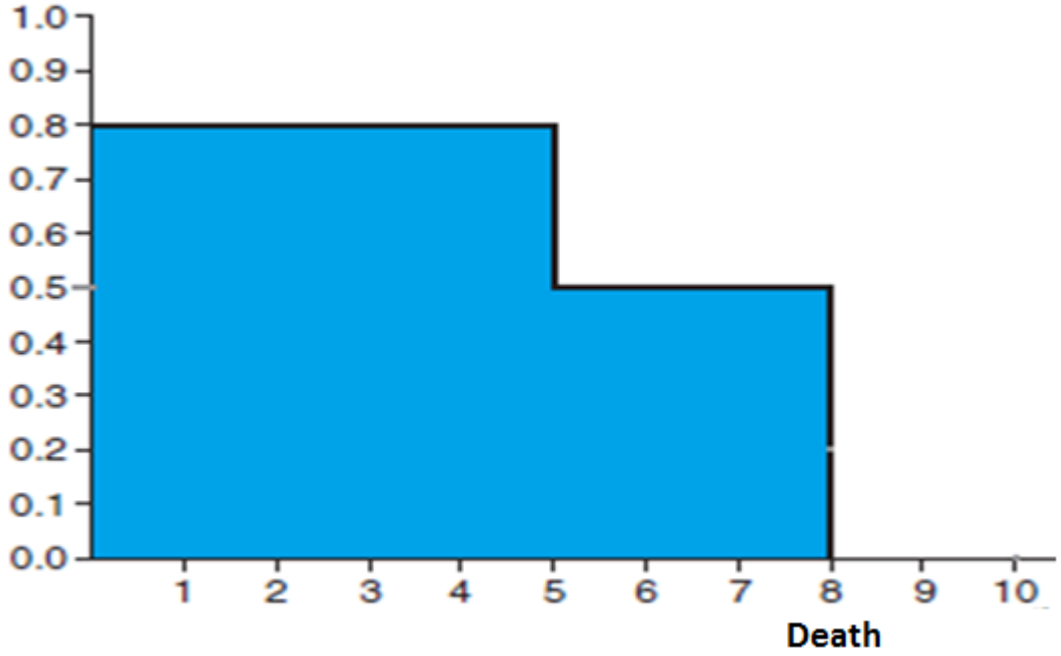
Example 6: A patient receiving treatment A lived for 4 years with a utility measure of 0.5. Then his quality of life decreased to a utility measure of 0.2 and lived for 6 years with this state of life and died at year 10.

If this person had been receiving treatment B, base line utility measure would be 0.8 and would live with this state of health for 5 years and then his utility measure would fall to 0.5 and with this state of health the patient will live for 3 years and will die at year 8. Sketch the QALY diagram and determine how many additional QALY are gained from treatment B.

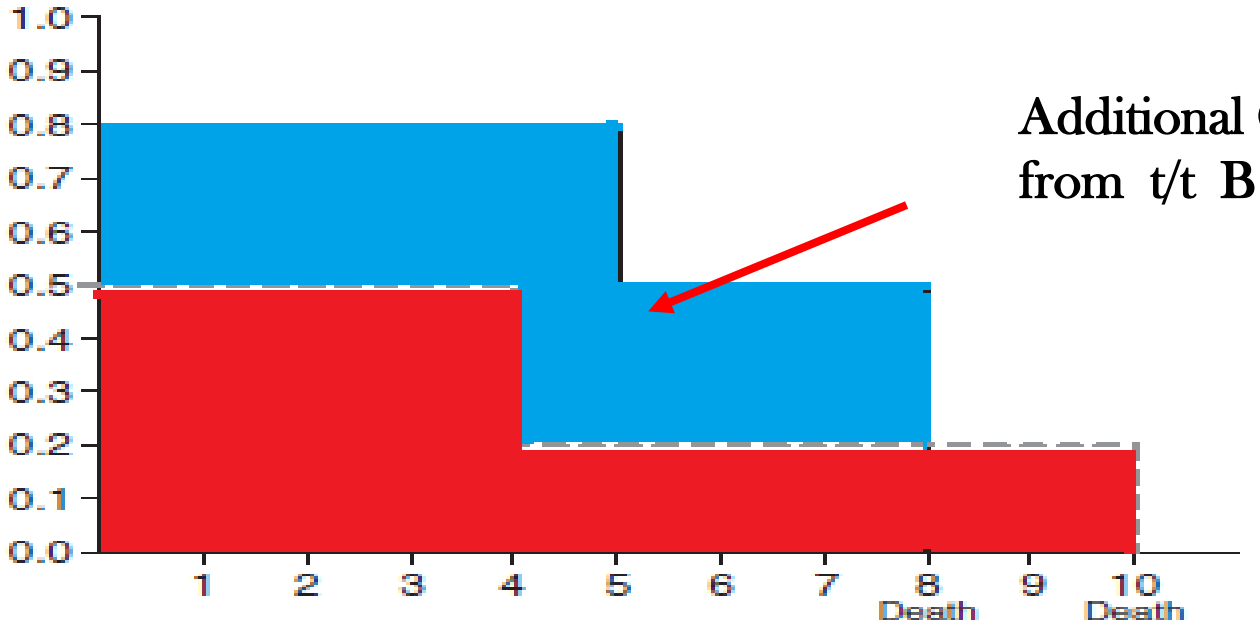
Options	Utility for Each health state	Duration with a health state
Treatment A	0.5	4 years
	0.2 0	6 years died
Treatment B	0.8	5 years
	0.5 0	3 years died



QALYs diagram treatment A



QALYs diagram for treatment B



Additional QALYs achieve from t/t B (blue area)

QALYs achieved by intervention = QALYs for t/t B– QALYs for t/t A

= (5)(0.8) + (3)(0.5) – (4)(0.5)+ (6)(0.2) = <u>2.3 QALYs</u>

- Example 7: the costs and outcomes of cost utility analysis of an HPV vaccination program targeted on women under the age of 25 relative to screening only (no vaccination) are shown in the table bellow. assume the country in which this pharmacoeconomic evaluation has been conducted has GDP per capita of $863.
  a. which intervention do you recommended for this country?
  b. what if the GDP per capita of the country is $1,300?

Mutually Exclusive Interventions	Outcomes (QALYs)	Total Costs ($)
Quadrivalent Vaccine	6,478,399	179,818,630
No vaccine (screening only)	6,476,910	174,340,679

Mutually Exclusive Interventions	Outcomes (QALYs)	Change in outcome (QALY)	Total Costs ($)	Change in cost ($)	ICUR
No Vaccine (screening only)	6,476,910		174,340,679		
Quadrivalent Vaccine	6,478,399	1,489	179,818,630	5,477,951	$3,680

$3,680 per 1 additional QALY gained

Interpretation: on average, it costs $3,680 to add one year of perfect health onto the life of a women using quadrivalent vaccine

Example 8: a clinical pharmacist working in an oncology unit of a hospital has been using drug A as a standard of care and now, a new chemo drug is to be considered for procurement by the hospital. Both chemo drugs prolong life and both cause side effects which reduce QOL. The standard drug (A) prolongs life by 1 year and reduce QoL of patients to 0.65 due to its side effects. The new drug prolongs life by 1.5 years at estimated utility value of 0.5.

a. Calculate the QALYs for both drugs
b. Sketch the QALY diagram and determine how many QALYs are gained from the new drug

if the full course of t/t costs for the existing and the new alternative drugs mentioned in example 8, above are1,200 ETH birr and 1,500 Eth birr respectively,

a. which drug would you suggest for a procurement office in Ethiopia?

b. how would you interpret your result?

Example 9: Sketch the QALY diagram and determine how many QALYs are achieved by a patient during a 20 year treatment period who has EQ-5D health state of 12331 for the first four years of treatment, EQ-5D health state of 22123 for the next ten years, and EQ-5D health state of 11221 for the last six years. (use the scoring algorithm shown below)

Health State	Utility Value
11221	0.9
21213	0.85
22123	0.8
23322	0.7
21332	0.65
32221	0.6
12331	0.5
31312	0.4

Example 10: a patient suffers from disease 'X' and has been receiving Drug therapy 'A' which has a survival benefits of 10 years. If the patient is left untreated, he/she will only live for 5 years. Estimated utility values with drug therapy 'A' and without therapy are 0.7 and 0.5respectively. The cost incurred by the patient with drug therapy 'A' and without t/t are 18,000ETB and 4,000ETB respectively.

Calculate:

a. QALYs with and without t/t?
b. ICUR and interpret your result?

Example 11: Presbyopia affects most people at age 40 years. It does not affect life expectancy but diminish visual functions. After vision declines at age 40, it does not (hypothetically) decline more with advancing age. There is anew surgical procedure for this condition that restore vision to normal with no complication and costs $ 10,000. Life expectancy at age 40 in the general population is assumed to be 42 years and time trade off (TTO) yields a utility value of 0.999 for presbyopia. Calculate:

a. the number of QALYs with intervention and without intervention

b. the cost per QALY

Example 12: For Questions 1-3 in the next slides, use the data available in the following table

Duration	Health State	Utility Weight
3 months	Hospital Dialysis	0.62
3 months	Home confinement for TB	0.68
8 years	Home Dialysis	0.65

1. Sketch the QALY diagram and determine how many QALY are gained if a person achieves an eight year life extension with utility score of 0.65 on home dialysis

    a. assuming no discounting

    b. assuming 5% discounting

2. Sketch the QALY diagram and determine how many QALY are gained if a person achieves a three month life extension with utility score of 0.62 on hospital dialysis

    a. assuming no discounting

    b. assuming 5% discounting

3. Sketch the QALY diagram and determine how many QALYs are gained by preventing a case of tuberculosis that would have been treated at home for three months. The estimated utility for tuberculosis is 0.68.

a. assuming no discounting

b. assuming 5% discounting

Example 13: Sketch the QALY diagram and determine how many QALYs are achieved during the year by a patient in a one year clinical trial who has a base line utility measure of 0.40, a six month utility measure of 0.87, and a one year utility measure of 0.92.

Calculating DALYs

- **D**isability **A**djusted **L**ife **Y**ears (DALYs) are the number of lost healthy years
- incorporate both time lost due to premature death and time spent disabled by disease
- one DALY is equal to one year of healthy life lost

$$DALY = YLL + YLD$$

Where YLL = expected or average number of Years of Life Lost due to premature death

YLD = Years Lived with Disability

- YLL = N x L

Where N = number of deaths

L = life expectancy at age of death

- YLD = I x DW X L

Where I = number of cases of a specific disease/disability

DW = disability weight (1 for death and 0 for perfect health)

L = average duration of disability until remission or death