Cost Utility Analysis

cost-utility analysis (CUA) a subset of CEA because the outcomes are assessed using a special type of clinical outcome measure, usually the quality-adjusted life-year (QALY). A CUA takes patient preferences, also referred to as utilities, into account when measuring health consequences,with perfect health is assigned a value od 1.0 utility(u) per year and death is assigned a value of 0.0.

The advantage of a CUA is that

1.different types of health outcomes and diseases with multiple outcomes of interest can be compared (unlike in CEA)

2.using one common unit such as the QALY

3. CUA incorporates morbidity and mortality into this one common unit without having to determine or estimate the monetary value of these health outcomes (unlike CBA).

The disadvantage of this method is that

1. it is difficult to determine an accurate utility or preference weight value.
2. the methods for estimating utilities/QALYs may not be fully understood or embraced yet by many US providers or decision makers

When Is Cost-Utility Analysis Appropriate?

1. When health-related quality of life is the important outcome—for example, when comparing interventions that are not expected to have an impact on mortality, but a potential impact on patient function and well-being (eg, treatments for osteoarthritis).

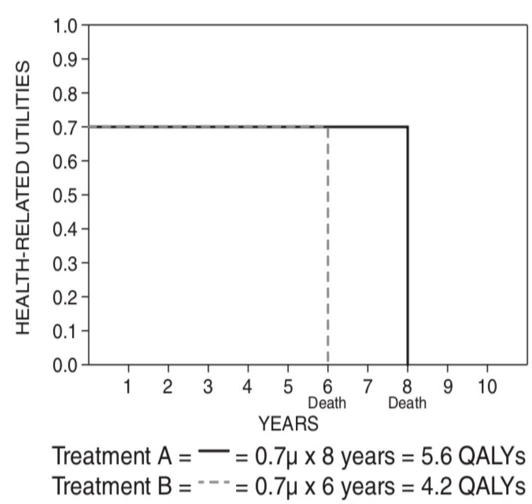
2. When health-related quality of life is an important outcome—for example, evaluation of the outcomes associated with the treatment of acute myocardial infarction. Not only is lives saved an important outcome measure, but also the quality of the lives saved (eg, the impact of a treatment-induced stroke in a survivor).

3. When the intervention affects both morbidity and mortality and a combined unit of outcome is desired—for example, evaluation of a therapy, such as estrogen use by postmenopausal women, that can improve quality of life may reduce mortality from certain conditions (eg, heart disease), but may increase mortality from other conditions (eg, uterine cancer).

4. When the intervention being compared have a wide range of potential outcomes and there is a need to have a common unit of outcome for comparison. This is most commonly the case when a decision-maker must allocate limited resources among interventions that have different objectives and resultant benefits—for example, the choice between providing increased prenatal care or expanding a hypertension screening and treatment program. 5. When the objective is to compare an intervention with others that have already been evaluated in terms of cost per QALY (or equivalent) gained.

Examples for use of cost utility analysis:

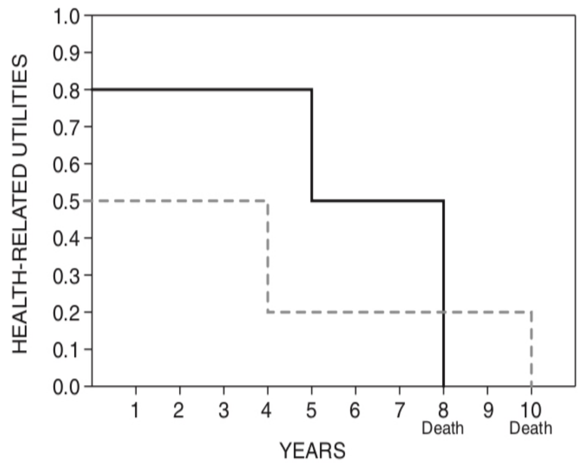
1. For some research questions, utility adjustments may not be warranted. For example, if two pharmaceutical products have different outcomes based on the number of life-years saved (LYS), but the quality of each year of life for those on the two treatments are thought to be the very similar (see Fig. 6.1A), quality adjustment may not be as crucial.



A

2. in many cases—for example, cancer treatment—both the length of life and the quality of life are different, depending on the therapy selected.

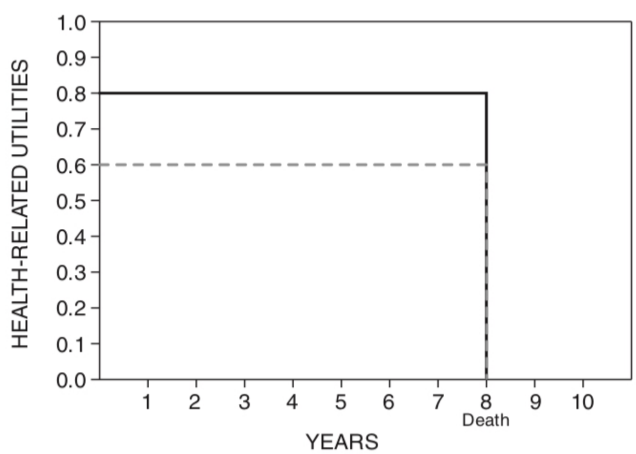
Sometimes the treatments that extend life the longest are also the most toxic, so a measure that incorporates both length of life and quality of life is needed in these cases (see Fig. 6.1B).



Treatment A = —— = (0.8μ x 5 yrs) + (0.5μ x 3 yrs) = 5.5 QALYs

B Treatment B = - - - = (0.5μ x 4 yrs) + (0.2μ x 6 yrs) = 3.2 QALYs

3. Many health conditions do not have an impact on patients' length of life, but only on the quality of their life, and CUA may be a good choice for comparing treatments for these conditions (see Fig. 6.1C). Examples include conditions such as hearing loss, seasonal allergies, and erectile dysfunction.



Treatment A = —— = (0.8μ x 8 yrs) = 6.4 QALYs

C Treatment B = - - - = (0.6μ x 8 yrs) = 4.8 QALYs

Figure 6.1. Examples estimating and comparing quality-adjusted life years (QALYs). A: Example illustrating when two treatment options produce different outcomes on the basis of the number of life years saved (LYS), but the quality of each year of life for those on the two treatments are thought to

be the very similar (quality adjustment not needed). B: Example illustrating when both the length of life and the quality of life are different depending on the therapy selected (quality adjustment appropriate). C: Example illustrating options that do not have an impact on patients' length of life but only on the quality of their life (quality adjustment appropriate).

Methods used to derive CUA

They are preference-based, which means that they allow individuals to indicate the direction and strength of their preference for a particular health state.two broad methods are used to elicit, or generate these scores:

1. Direct elicitation (rating scale, standard gamble, time tradeoff)
2. Indirect elicitation methods, using standardized weighting(e.g EQ-5D and SF-3D surveys)

Steps in Calculating QALYS

To calculate QALYs, the following steps apply:

1. Develop a description of each disease state or condition of interest.

2. Choose a method for determining utilities.

3. Choose subjects who will determine utilities.

4. Sum the product of utility scores by the length of life for each option to obtain QALYs.

Step 1: Develop a description of each disease state or condition of interest

The description should concisely depict the usual health effects expected from the disease state or condition. It 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.

Examples describing hospital-based kidney dialysis and diabetic retinopathy are presented below: 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 nuisances and restrictions, and some feel they are being kept alive by a machine.

Step 2: Choose Method for Determining Utilities

The three most common methods for determining preference, or utility, weights are rating scales (RS), standard gamble (SG), and time tradeoff (TTO). For each of these methods, a disease state or condition or multiple disease states or conditions are described to subjects who help determine where these disease states or conditions fall between 0.0 (dead) and 1.0 (perfect health).

1. **Rating Scale**
   An RS consists of a line on a page with scaled markings, somewhat like a thermometer with perfect health at the top (100) and death at bottom (0). An instrument called the Visual Analog Scale (VAS) is similar to the RS, but it does not have any markings between the best and worst scores, and subjects are told to mark an "X" somewhere between the two extremes to indicate their preferences. Different disease states or conditions are described to subjects (see the two examples above for dialysis and retinopathy), who are asked to place their estimated preferences for the different disease states or conditions somewhere on the RS, indicating values relative to all diseases described. As an example, if they place a disease state at 70 on the scale, the disease state is given a utility score of 0.7.figure 6.2 shows an example of how a subject might estimate some values from various conditions using an RS.

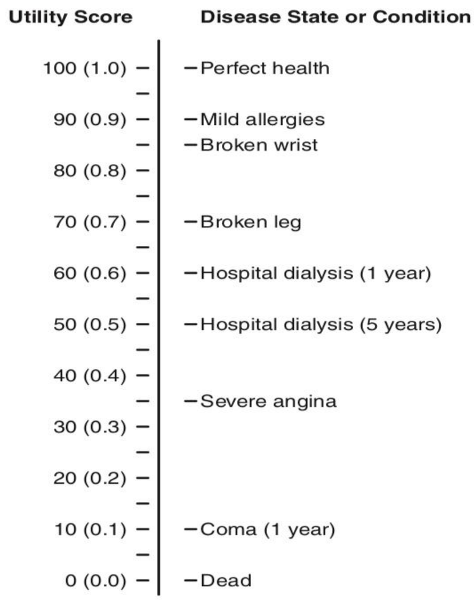


FIGURE 6.2. **Rating scale (RS) with example estimates for various disease states or conditions.** The RS uses a thermometer-like illustration to ask respondents to estimate the utility of different health states ranging from 0 (dead) to 1.0 (or 100; perfect health). In this example, the respondent estimated that being in a coma for 1 year has a lower utility (0.1) than having hospital dialysis for 1 year (0.6). Both are lower than the utility estimate for mild allergies (0.9).

2. Standard Gamble

The second method for determining patient preference (or utility) scores is the SG method. 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 the certain outcome of a chronic disease state for life based on a person's life expectancy (Fig. 6.3). The probability, or p, of normal health (versus immediate death, or 1− p) for Alternative 1 is varied until the subject is indifferent between Alternatives 1 and 2 (living with the disease state or condition). As an example, a person considers two options: a kidney transplant with a 20% probability of dying (80% chance of returning to normal health) during the operation (Alternative 1) or certain dialysis for the rest of his or her life (Alternative 2). If the person says he or she would have the operation if the chance of the successful operation p is 80% (chance of immediate death, 20%), the percent chance of success is decreased until the person reaches his or her point of indifference (the point where the two options are nearly equal and the person cannot decide between the two). If the person says he or she would not have the operation if the percent chance for success was 80% (chance of dying, 20%), the percent chance of success is increased until the person reaches his or her point of indifference. Let us say that the first person chooses a 70% chance (p) of a successful operation (with a 30% chance [1− p] of immediate death) as the point of indifference between having a kidney transplant and living with kidney dialysis for life. The utility score for this person for this disease state or condition (kidney dialysis) would be calculated as the probability (p) of living a normal life after the operation, or 0.7.

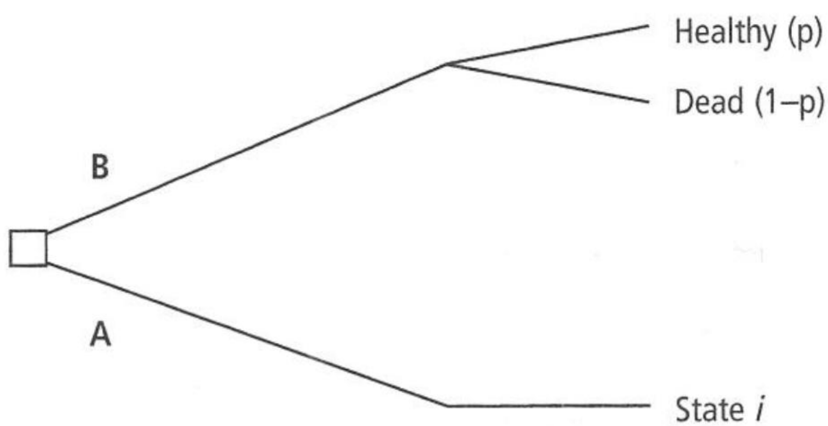


Figure 6.3. Standard gamble (SG). Using the SG approach, the respondent is asked to think about being in a chronic health state and then told that he or she could gamble on an intervention (e.g., an operation) that could either cure the condition (probability = p), although he or she might die from the intervention (probability = 1− p). A base probability is given and the respondent is asked whether he or she would have the intervention 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 associated with the condition.

3. Time Tradeoff

The third technique for measuring health preferences, or utilities, is the TTO method (Fig. 6.4). Again, the subject is offered two alternatives. Alternative 1 is a certain disease state for a specific length of time (t), the life expectancy for a person with the disease, and then death. Alternative 2 is being healthy for time x, which is less than t. Time x is varied until the respondent is indifferent between the two alternatives. The utility score for the health state is calculated as x divided by t. For example, a person with a life expectancy of 40 years is given two options:

Alternative 1 is having a chronic condition (e.g., kidney disease or diabetes) for 40 years, and Alternative 2 is being healthy (no disease) for 20 years followed by death. If the person says he or she would rather have the disease for 40 years (t) than be healthy for 20 years, the number of years (x) in the healthy state is increased until the person is indifferent between the two alternatives. If the person would rather be healthy for 20 years than have the disease for 40 years, the number of years (x) in the healthy state is decreased until the person is indifferent between the two alternatives. Let us say that for a person who expects to live 40 more years, the person's point of indifference is 30 years of health versus 40 years of kidney disease. The utility score would be x/ t = 30 / 40 or 0.75. As with the SG method illustrated above, these calculations are for chronic diseases or conditions, and calculations for a temporary health state are more complex and can be found elsewhere.

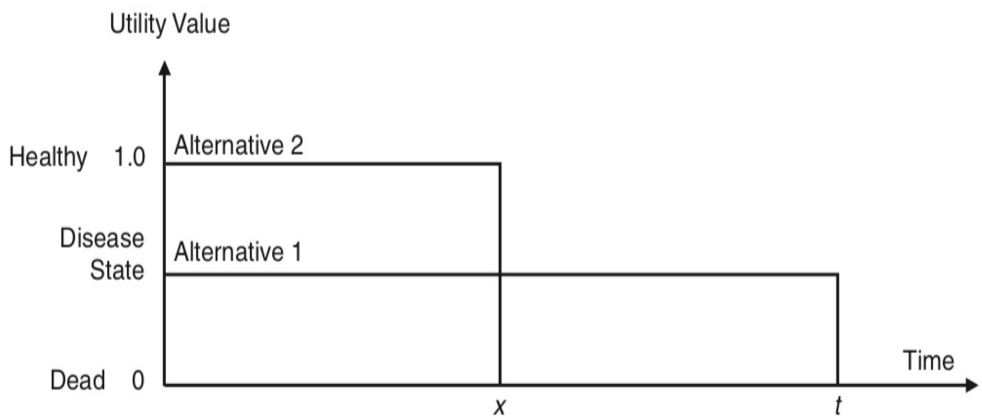


Figure 6.4. Time tradeoff (TTO). This TTO schematic represents the choice a respondent makes about trading off years of life for better health for a shorter period of time. The respondent is given the choice of living a full life (to time t) with a specific condition or living fewer years (to time x) without the condition (being healthy). The time of living healthy is varied until the respondent is indifferent between living in full health x years and living with the condition for t years. The utility calculated for the condition is x/t.

Comparisons of the Three Methods

The advantage of using the **RS method** to determine utilities is that

1. many disease states or conditions can be described to each subject
2. this method can be conducted via a questionnaire without face-to-face interaction.
3. it is less cognitively demanding than the other two methods.

disadvantage of using the **RS method** is that

1. it does not incorporate time into the utility score as easily as the other two methods.
2. It also may be biased in that people do not tend to cluster their values at the extreme ends of the scale

The advantage of using the SG method is that

1. it is the "gold standard" and based on economic theory

disadvantages of SG

1. people have difficulty understanding probabilities
2. subjects need to be asked repeated questions ,infleunced by how the questions are phrased or presented
3. It is time consuming
4. It is better administered in a face-to-face setting, or through an iterative process, which takes more resources than a self-administered questionnaire
5. Treatment of most chronic diseases does not approximate the gamble.

advantages of **the TTO method** are that

it is more adaptable to diseases states than the SG, and it incorporates the time in the disease state or condition more easily than the RS.

Diadvantage of the **TTO**

1. It is time consuming,subjects need to answer repeated questions.
2. Require face-to-face adminstration or an iterative process.

Indirect elicitation method:

1. **Generic measures**:are more useful when looking at groups of patients who may have different illnesses, and can be used to compare outcomes in different patient groups. One of the most widely used is the Short Form (SF)-36 health survey. This looks at:
2. • Physical functioning
3. • Physical role
4. • Bodily pain
5. • General health

6. • Vitality
7. • Social functioning
8. • Emotional role
9. • Mental health.

Vitality Domain

Answer choices are 1) all of the time, 2) most of the time, 3) a good bit of the time, 4) some of the time, 5) a little of the time, and 6) none of the time.

Questions: *How much of the time during the past 4 weeks*:

Q9a. Did you feel full of pep?

Q9e. Did you have a lot of energy?

Q9g. Did you feel worn out?

Q9i. Did you feel tired?

Role—Emotional Domain

Answer choices are 1) yes and 2) no.

Questions: *During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?*

Q5a. Cut down on the amount of time you spent on work or other activities.

Q5b. Accomplished less than you would like.

Q5c. Did work or other activities less carefully than usual.

Fig 6-5 examples of items from the SF-36 general HRQOL instrument

Using these types of tool can give a much better indication of the impact of the treatment or service on the patients QOL than using effectiveness measures

2.The EQ-5D (1997) is a standardized instrument for use as a measure of health outcome. Applicable to a wide range of health conditions and treatments.

EQ-5D has five dimensions: mobility, self-care, usual activities, pain/ discomfort and anxiety/depression. There are three levels per dimension and respondents/patients describe themselves within this system. The EQ-5D dimensions are shown in Table 4.3:

EQ-5D Quality of Life instrument (from http://www.euroqol.org):

1. Mobility
   - ☐ I have no problems walking.
   - ☐ I have some problems walking.
   - ☐ I am confined to bed.

2. Self-Care
   - ☐ I have no problems with self-care.
   - ☐ I have some problems washing or dressing myself.
   - ☐ I am unable to wash or dress myself.

3. Usual activities (e.g., work, study, housework, family or leisure activities)
   - ☐ I have no problems with performing my usual activities.
   - ☐ I have some problems with performing my usual activities.
   - ☐ I am unable to perform my usual activities.

4. Pain or discomfort
   - ☐ I have no pain or discomfort.
   - ☐ I have moderate pain or discomfort.
   - ☐ I have extreme pain or discomfort.

5. Anxiety or depression
   - ☐ I am not anxious or depressed.
   - ☐ I am moderately anxious or depressed.
   - ☐ I am extremely anxious or depressed.

Step 3: Choose Subjects Who Will Determine Utilities

Utility values can be obtained from healthcare **professionals**, **patients** and **the general public**. There are advantages and disadvantages associated with each group.

• **Healthcare professionals** are more informed about the health states and interventions but may provide a biased value owing to their continued exposure to that illness or intervention. **Healthcare professionals have been shown to assign lower ratings than patients or the general public.**

• **Patients** are informed about the health status and interventions that they have experienced. They will not be informed about interventions they have not experienced. **Patients tend to attach higher value of health status than do healthcare professionals and the general public**. This may be because people in a health state gradually develop ways of dealing or coping with that health state, whereas the **general public** are less informed or are valuing their fear of experiencing that he state.

• Sometimes the health state has to be valued by **proxy**, such as the health state of a **newborn baby** or a person with advanced **Alzheimer's disease**. Therefore, it is important to remember -proxy values may be lower than the patient's values would have.

Step 4. Multiply Utilities by the Length of Life for Each Option to Obtain QALYs

When comparing the options, the difference in the length of life permitted by each option is multiplied by the utility scores obtained above. For example, in Table 6.1, we will assume that 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 (see Fig. 6.1B). In Table 6.1, we compare two treatment options, drug A and drug B. Although drug B extends the person's life for more years, the quality of life for those years is lower than with drug A. If a CEA were conducted, option B would be relatively cost-effective at an incremental cost per year of life of $5,000. If the quality of those years is incorporated into the equation by calculating QALYs, option A becomes dominant in that it costs less and provides a better outcome (more QALYs).

TABLE 6.1. QALY CALCULATIONS

	Cost for Treatment (dollars)	*Years of Life Saved*	*Utility for Each Year of Life Saved*	*QALYs*
Drug A	$10,000	5	0.8	4.0
Drug B	$20,000	7	0.5	3.5
	Calculation		*Result*	
CEA	($20,000 – $10,000) / (7 years – 5 years)		$5,000 per extra year of life	
CUA	($20,000 – $10,000) / (3.5 QALYs – 4.0 QALYs)		Drug A dominant	

CEA = cost-effectiveness analysis; CUA = cost-utility analysis; QALYs = quality-adjusted life-years.

WORKED EXAMPLE 6.1 (ex: 5.2 contin…)

Economic evaluation of management of anaemia in haemodialysis patients:

Patients with chronic renal failure who are on haemodialysis suffer from profound anaemia, which is often extremely debilitating. This is due to a reduction in the production of erythropoietin in these patients, and loss of blood during haemodialysis. Historically, these patients have been managed by the use of blood transfusions. Now, synthetic erythropoietin is available. It is considered to be highly effective, but is very expensive. So the alternatives are to either give erythropoietin or to give blood transfusions when the patient's "haemoglobin level is below 8g/dl.

1. What is the difference in cost between the two alternatives for the 1000 patients?

£2,419,100.

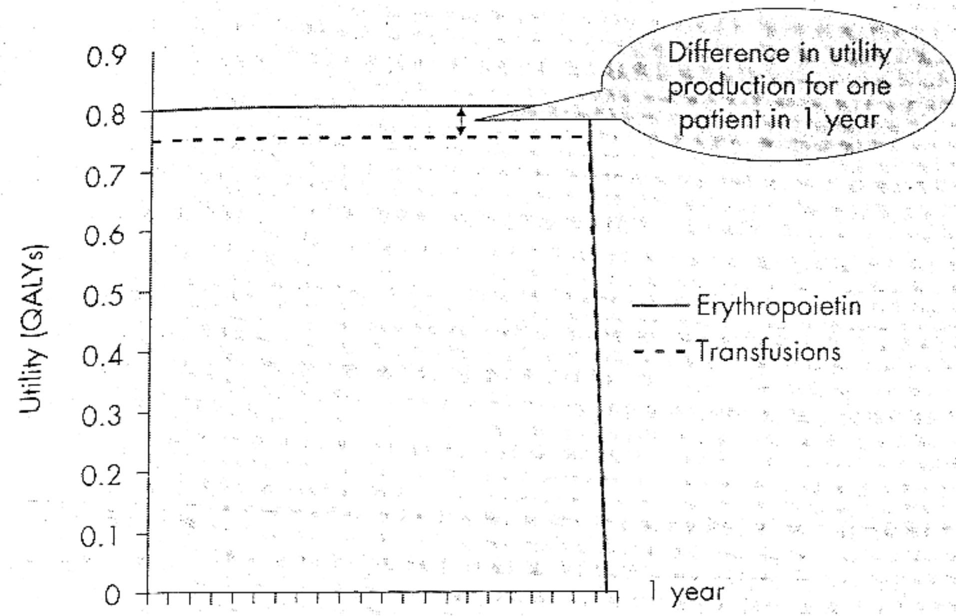
2. What is the difference in utility production of the two alternatives, i.e. how many extra QALYs are produced by erythropoietin per year of treatment, for the 1000 patients?

Change in utility = 0.80 - 0.75

= 0.05 QALYs per patient per annum

= 50 QALYs per 1000 patients per annum.

Figure 6.1 illustrates the difference in utility production for the two alternatives.



QALYs (transfusions) for 1000 patients = 1000 × 0.75 = 750 QALYs
QALYs (erythropoietin) for 1000 patients = 1000 × 0.80 = 800 QALYs

Figure 6.1 Utility produced over 1 year for erythropoeitin vs blood transfusions.

3. Calculate an incremental cost–utility ratio for erythropoietin.

$$\text{ICER} = \frac{\text{Change in cost}}{\text{Change in outcome (utility)}}$$
$$= \frac{£2{,}419{,}100}{50}$$
$$= £48,382 \text{ per extra QALY gained by erythropoietin.}$$

This cost per QALY can be plotted on a cost-effectiveness plane (Figure 6.2). You can see that this ICER is in the northeast quadrant because erythropoietin is more effective and more costly.

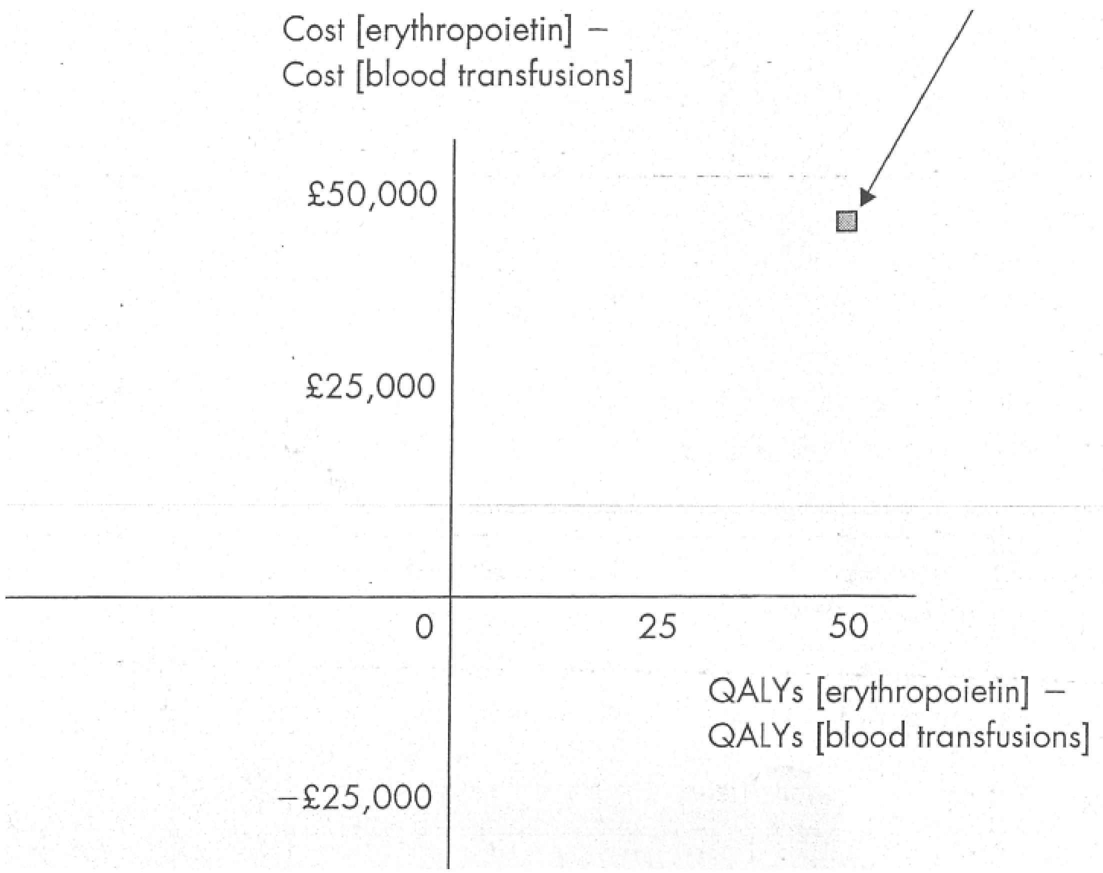


Figure 6.2 Cost-effectiveness plane for erythropoietin Vs blood transfusions

WORKED EXAMPLE 6.2 Cost–utility analysis of two different types of service

A group of community nurses (Group A) wants to set up an asthma patient monitoring service for a GP practice which has 200 asthma patients.

Results from a study suggest that the practice will have cost reductions and the patients will have improved outcomes (Table 6.1)

Table 6.1 Impact of a nurse-led asthma monitoring service

Costs and outcome measures for 1 year	*Before asthma service*	*With asthma service*	*Difference*
Prescribing costs (£)	20,000	16,000	−4,000
Hospital costs (£)	2,000	1,000	−1,000
Nurse service costs (£)	0	4,000	4,000
Total costs (£)	22,000	21,000	−1,000
Emergency hospital admissions due to asthma	20	10	−10

Another group of community nurses (Group B) wants to set up an ischaemic heart disease (IHD) patient monitoring service for the same GP practice, which has 250 IHD patients. Results from a study suggest that the service will be cost neutral and the patients will have improved outcome (Table 6.2).

Table 6.2 Impact of a nurse-led ischaemic heart disease monitoring service

Costs and outcome measures for 1 year	*Before IHD service*	*With IHD service*	*Difference*
Prescribing costs (£)	25,000	20,000	−5,000
Hospital costs (£)	10,000	5,000	−5,000
Nurse service costs (£)	0	10,000	10,000
Total costs (£)	35,000	35,000	0
Emergency hospital admissions due to chest pain	50	25	−25

The practice has to decide whether to reduce emergency admissions due to asthma by 10 a year and save £1,000, or reduce emergency admissions due to chest pain by 25 a year at no change in costs to the practice.

How can the GP objectively compare and choose between improving the health of asthma and IHD patients?

Groups A and B elicit utility values from the 200 asthma and 250 IHD patients. Time trade-off was used to elicit the utility values and these were used to calculate QALYs.

The groups obtain the following results:

	Asthma patients	IHD *patients*
Mean QALYs before intervention	0.75	0.60
Mean QALYs after intervention	0.85	0.75
Incremental QALY change caused by intervention	0.10	0.15

The results refer to a 1-year period. The asthma patients improved their quality of life per year by 0.10 QALYs each. The IHD patients improved their quality of life per year by 0.15 QALYs each.

Incremental cost-effectiveness ratio (ICER):

$$\frac{\Delta Cost}{\Delta QALY} = \frac{Cost_{\text{IHD service}} - Cost_{\text{asthma service}}}{QALY_{\text{IHD service}} - QALY_{\text{asthma service}}}$$

$$= \frac{0 - (-1000)}{(250 \times 0.15) - (200 \times 0.10)} = \frac{1000}{17.5}$$

$$= \text{£57 per QALY gained from the IHD service over the asthma service.}$$

If the GP practice funds the IHD service it will cost them £1,000 per year more than the asthma service, but they will obtain 17.5 more QALYs for their patients.

EXERCISE 1: Calculating a cost per QALY:

Several treatments exist to treat fungal toenail infections. Four oral medicines used are drugs A, B, C and D. The table below shows the costs (£) associated with treating one patient with each of these four treatments:

	Drug A	*Drug B*	*Drug C*	*Drug D*
Total costs (£)	1,301	1,503	1,570	1,200

You then find some evidence to suggest that two of these agents have differing effects on patients' quality of life owing to difference in their side-effect profiles. This evidence is summarized below:

Agents	Increase in QALYs per patient per year
Drug C	0.10
Drug D	0.05

What is the difference in utility production of the two alternatives, per year of treatment, for the 100 patients?

0.05 QALYs per patient per year = 5 QALYs per 100 patients per year.

Calculate an incremental cost–utility ratio for drug C compared with drug D.

$$ICER = \frac{\text{Cost (drug C)} - \text{Cost (drug D)}}{\text{Outcome (drug C)} - \text{Outcome (drug D)}}$$

$$= \frac{100(1{,}570 - 1{,}200)}{10 - 5} = \frac{37{,}000}{5}$$

$$= \text{£}7{,}400 \text{ per extra QALY.}$$

Draw a cost-effectiveness plane and place the ICER you have calculated on that graph. You should have a point plotted in the northeast quadrant (Figure 6.4).

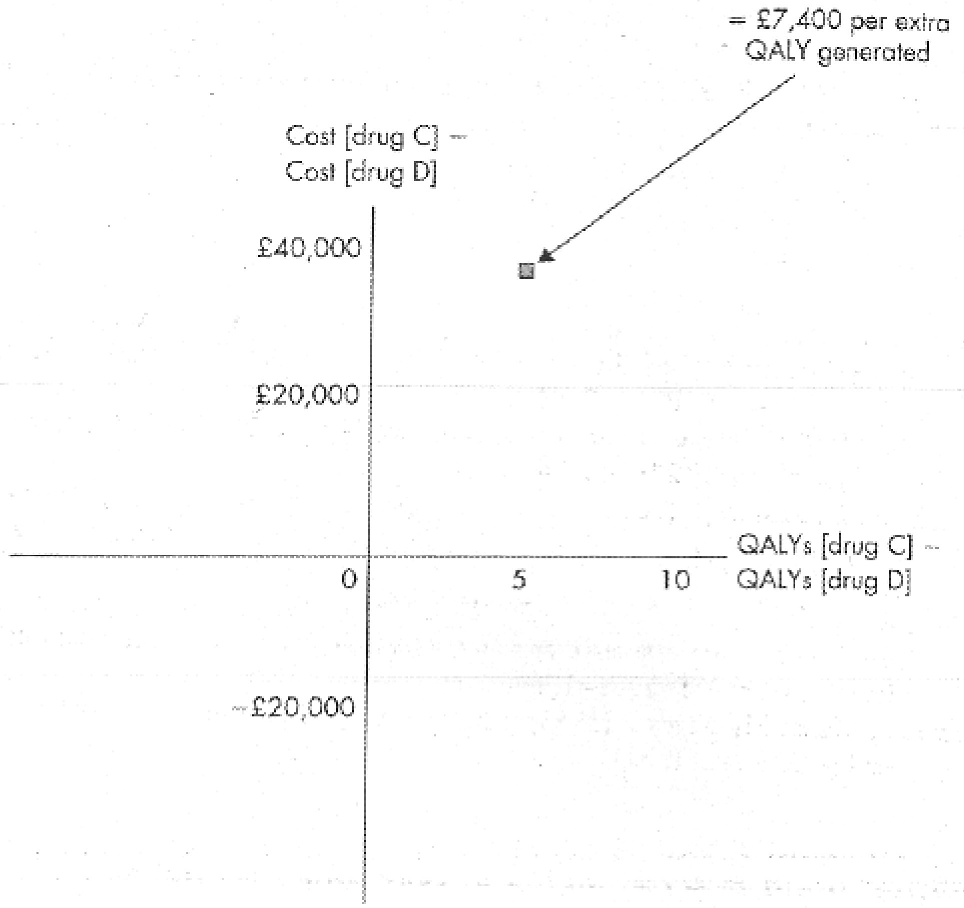


Figure 6.4 Cost-effectiveness plane for drug C versus drug D.

Which treatment will you recommend to your Trust, and why?

Either could be recommended, depending on the driving force for the choice. Is cost containment most important? Then choose drug D. Is improved patient outcome most important? Then choose drug C.