Measuring health improvements for a cost effectiveness analysis

1. Introduction

This is the second of two case studies about how a study of economics is used to inform decision making about new investments in *health services*. This case study focuses on measuring effectiveness for a cost effectiveness (CE) analysis (CEA). The companion case study is called *Counting the Cost of Effective Health Policy* and focuses on cost estimation for the same purpose. It also explains why care is needed in interpreting the evidence from such an analysis.

After studying this case study successfully, you can expect to improve your ability to describe and calculate: index numbers; percentages and aggregated effects; and discounted present values, and to interpret probabilities.

You will also gain experience in identifying and describing limitations of the data and the mathematical techniques for use in their real-world context.

2. Summary index measures of multiple outcomes

It is assumed from the outset that the costs and outcomes of an economic activity, such as a health service, are measurable. CE can then be quoted from a series of figures over a range of quantities. The figures are presented as cost divided by outcome quantity. If the only outcome is `health improvement', then `a unit of health gain' means a quantifiable improvement in health. Explanation of how quantification is achieved is included below, as part of this exercise.

Apart from the usual difficulties of obtaining adequate data and in working with any limitations of those data, other complications are often encountered in calculating a useful set of CE estimates.

One set of complications arises from the attractions of an investment opportunity often being its potential to generate more than one distinct type of outcome. If so, the measures of CE required are of cost per `set of various outcomes'. Consequently, one increasingly standard way to obtain measures of service effectiveness (that is, how much of various outcomes is achieved from an investment in services) is by compiling and using a scale of index numbers.

The scale could be compiled, for example, in `units of good quality health'. The units could take into account degrees of both pain and disability. Aggregating these units could measure life expectancy (quantity of life) as well as the quantity of patients affected by a health service and the quality of their health.

To this extent, such a scale is comparable with using a metre scale to measure the surface area of a table, from its length and breadth dimensions, by one figure (square metres).

In other ways, any health scale is a far more ambitious creation than the metre scale and its limitations should be recognised when interpreting the figures for decision-making purposes.

These index numbers enable different health services to be compared in terms of their (cost) effectiveness in producing units of good health: that is, in generating improved health for patients, even if the precise effects on health differ somewhat from one service to another.

For health services, index numbers of health gain (i.e. health improvement) can be compiled by various methods which have some grounding in economic principles. These methods include time trade-off and standard gamble techniques.

3. Time trade-off and standard gamble methods

In the time trade-off method, we represent a year in `full health' by the figure **1** (one) and immediate death by **zero**. Each figure in Table 1 indicates how long in `full health' seems as good as being in an *intermediate* health state (somewhere between `full health' and dead) for a whole year. For example, a year in 'moderate pain and disability' equates to 90% of a year in full health. The hypothetical figures in Table 1 are unlikely to reflect your own perceptions of these health states exactly.

Table 1

		Pain		
		Nil	Moderate	Severe
Disability	Nil	1	0.95	0.80
	Moderate	0.95	0.90	0.70
	Severe	0.80	0.70	0.60

The standard gamble is an alternative means of achieving the same purpose as the time trade-off method described above. It indicates what probability of being in `full health' for the next year seems as good as being in an intermediate state of health for that year with certainty.

For example, a 90% probability of `full health' throughout the next year equates to the certainty of being in `moderate pain and disability' instead. We can again arrange the figures for every intermediate state as in Table 1. The two methods may in practice generate different figures.

4. Quantifying Gains from a Health Service Investment

We can use a completed matrix of health state figures (as compiled above) to quantify the overall health gain from an investment in health services for 100 similar patients who receive that service. For example, suppose they would all spend equal time within the next year in each of the 8 intermediate states represented within Table 1 (shaded cells). After one year, the patient regains `full health' for 2 years and then dies (to keep this hypothetical example simple).

Suppose also that the only less costly alternative for these patients is nil health service and a year in the health state of `no pain but severe disability', followed by death. The relevant figures are shown in Table 2, using the index numbers in Table 1.

Table 2

		Pain		
		Nil	Moderate	Severe
Disability	Nil	1 x 2	0.95/8	0.80/8
	Moderate	0.95/8	0.90/8	0.70/8
	Severe	0.80/8 (0.80)	0.70/8	0.60/8
	Dead			0 (0)

Adding up all the health state figures for a patient who receives the service, we get a total of 6.40/8 + 2 = **2.80 units**. For a patient denied the service, we get **0.80 units**. The difference between these two figures is a measure of the health advantage a patient gets from receiving the service: 2.80 – 0.80 = **2 units**. This amount is equivalent to 2 extra whole years in `full health'. Therefore, the figure representing total health gain for 100 similar patients = **200 units** in this case.

5. Investment Cost Effectiveness calculation

Suppose it is known in this case that the cost of providing this service

effectively for 100 similar patients is £10million and that the cost, to the decision maker, of providing none of this health service is zero.

Patients, of course, would incur extra costs associated with their ill health if they do not get this service. To keep this introductory example clear, however, imagine that the decision maker chooses to ignore those costs in this CE calculation.

Suppose it is also known (from other CE studies) that the investment proposed is the least costly way to achieve this many new health gains. We can then calculate an estimate of cost per unit of health gain for 100 similar patients, based on the figures in Table 2. £10million/200units of health gain for 100 similar patients = **£50,000**.

Suppose decision makers approved this new investment in health services, based entirely on the evidence of our figures.[1] By doing so, it indicates a value of at least £50,000 in money terms per health gain unit being placed on the extra units achieved. This figure is an *implicit value*: it emerges from our calculations and from a decision based on them, not from anything said by decision makers about how valuable they think these health gains are.

6. Effects which will happen in the future

Another challenge, in calculating CE, arises if any significant costs and outcomes are expected to occur in the future, rather than immediately the initial commitment to the investment activity has been made. The effect on the overall CE figures is especially large if different costs or outcomes are expected to occur years apart.

The standard way to take account of these time-specific costs and outcomes

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[1] It is seldom a good idea to rely on just one such piece of evidence for decision making

is to calculate present values, as when calculating discounted cash flows.

The process of discounting future cash flows is the opposite of adding a rate of interest to an amount of cash to find how much cash it will return in the future if saved in a bank until then.

Instead of finding the future value of something which exists now, discounting does the opposite by finding the value **now** (the present value) of something which will exist only in the future.

The economics of discounting involves deciding how much lower is the value *now* of a cost or outcome if it happens in the *future*, compared with its value if it happened immediately.

The standard formula for calculating net present values (NPV) is:

$$NPV_A = \sum_{t=0}^{n} \frac{(B - C)_t}{(1 + d)^t} \ ,$$

where A denotes the investment option being considered (in this case, a particular health service). B and C in the numerator (the top line) are the symbols representing quantity of benefits and quantity of costs, respectively.

Accordingly, (B–C) represents quantity of `benefits net of costs', or quantity of net benefits for short.

1/(1+d) symbolises the discount *factor*: the discount *rate*, d, measures by how much the discount factor reduces one unit of NPV of net benefits (B–C) which are expected to occur one year into the future. In economic terms, NPV represents the value *now* of B or C, if it is thought certain to happen but only in the future.

For reasons outlined above in this section, one convenient measure of d is the market rate of return on savings. It is not necessarily the case, however, that the rate appropriate for

3

discounting units of health is the same as for units of cash.

The tiny letter t symbolises how many years into the future a quantity of B or C is expected to occur. The NPV expression has a summation sign in front of it: there will be one such expression for each period into the future that a B or C is expected to occur.

The letter t raised to a superscript on the bottom line indicates a compounded discount factor: for example, B or C happening two years into the future would be discounted by t squared; three years by t cubed, and so on.

Strictly speaking, our equation for discounting should also include a second summation: that one would represent the B and C to a multitude of different individuals who may experience health gains generated by this particular investment in health services.

In our simple example of discounting, we will consider only the health gains (represented by B in the equation), not the costs of achieving them (so C=0 in our example), although the process can be applied to costs in the same way.

In fact, there has been a debate in UK public policy circles about whether it is appropriate to present discounted future health gains figures in a CE study or to present them un-discounted instead.

Different patients will receive a health service at different times. We are using our index figures here to indicate the *size* of health gain from the service, not its *value*, although the distinction can seem blurred. If the size of health gain is the same for two patients treated at different times, then some would argue that the same figure should be included in CE estimates in both cases.

As our example, we take the figure for benefits (B) to be 200 units of health gain among 100 patients (the figure we calculated in section 4 above). These benefits are equally distributed between years 2 and 3 following receipt of the new service. Then, if t=3 (years into the future), and we suppose d=2%, our equation in terms of benefits (B) only (C=0) becomes:

$$NPV_A = 0 + \frac{100}{(1+0.02)^2} + \frac{100}{(1+0.02)^3}$$

= **190.35 health gain units**

The CE figure for 100 similar patients then becomes £52,535 (£10million /190.35 units of health gain). This can be compared with our original estimate in section 5 above – which did not discount benefits – of £50,000).

7. Task
Repeat the calculations described in sections **3-6** above with the following variations: the patient could expect to enjoy 3 years of `full health' from year 2 onwards; without the new service, the individual is expected to spend 6 months in `severe pain and no disability', then 6 months with `severe disability but no pain' followed by death; the discount rate (d) for health gains only = 3%.

If the two sets of calculations represent two different investment options, which of them is the cost effective option?

8. End note
Well done for completing this case study and improving both your mathematical skills and your awareness of how they can be used by economists for practical policy purposes. Please note, once again, that there is a companion case study in this series, called *Counting the Cost of Effective Health Policy*, which explores how to estimate the costs for a cost effectiveness study such as the one we have considered here.