Health Economics

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Week – 09

Lecture 45- Costing, Discounting & Evaluation under Uncertainty

Welcome friends once again to our NPTEL MOOC module on health economics. So far, we have been explaining economic evaluations and their various theories and principles, especially in the context of health and healthcare. In this lecture, we are taking off the topic of 'Costing, Discounting and Evaluation under Uncertainty'. If you remember, this topic is connected to the last lecture. In the last lecture, we discussed about outcome measures in health economics. We discussed both revealed and stated preferences (we discussed in the previous lectures). We discussed about these revealed and stated preferences, as well as we discussed about non-monetary evaluations, including QALY and DALY.

So, in this lecture, we will emphasise 'Costing, Discounting and Economic Evaluation under Uncertainty'. Given the aspect of economic costing, we know that resources are limited, so the resources should be properly managed. So, the devotion of resources to any existing or proposed healthcare intervention necessarily diverts resources from some alternative uses. Hence, it is crucial to understand the approaches of costing to know the best opportunity that has been forgone.

When we discuss about economic costing, the process involves three steps. First one is to identify the changes in resource use. In the next step, we need to quantify the changes in resource use in physical units. And the last one is to understand their value. The implementation of these steps is subject to the 'type of healthcare market and their availability'. That includes where the market is available, whether it has a competitive structure, and whether it ensures rational distribution and price structuring (such that the price must reflect the opportunity cost). In an example, we are clarifying here what happens to economic costing in the presence of the market. For example, the disposable rubber gloves used in healthcare market. They are brought and sold in a proper market and so they viable enough. Disposed rubber gloves reflect the price and explain the cost correctly. So, the economic costing in this case is:

Economic costing = Quantity (Q) x Price (P)

However, where the market is imperfect, due to some intervention there will be a deviation of the prices from the opportunity cost, or whatever is the opportunity cost. If the competitive structure is not prevailing, then the pricing deviations are noted. Like for example, doctors' wages can be a reflection of the lobbying power of medical associations

rather than the value of their skills or even the drug prices that reflect government regulation. In such cases, prices should be adjusted to reflect the opportunity cost.

Where there is no market at all. For example, 'patient time' or 'care provider timing', etc. Here, the opportunity costs are difficult to calculate, sometimes referred to as shadow pricing. So, the valuation of such types of non-market activities is indeed a part of the shadow pricing structure, and valuation of these requires some heroic assumptions. Hence, it is important to take up sensitivity analysis to remove the possible uncertainties in the healthcare market. This will be taken off in the next lecture).

Coming to different methods of estimating cost. Broadly, this falls into two categories. One is the macro, and another one is the micro. When we say macro, that means we have some aggregated information (at the top), and then we may come down, i.e., the top-down costing method. When we have micro information, we will use the reverse approach, and in ascending format, we will find out the gross reality. So, micro largely follows bottom-up costing. So, the main distinction between these two is based on their level of desegregation, where resources are measured and valued separately. So, I think we have already given this, you can just follow between the lines.

So far as the top-down approach is concerned, this involves using pre-existing data for total or average cost and further apportioning them in some way to the options being evaluated. Here, the costs are not decomposed into their constituent quantities and prices. However, in another approach (bottom-up), it is through disaggregated values (we will discuss in detail). Hence, each cost element is estimated individually and summed at the end to represent the larger picture. Among the two, the latter, i.e., the bottom-up approach, provides greater insights about the reality.

There are some specifications related to healthcare services. We are just categorising their type of costing in the bottom-up approach.

Categories of resource use in micro or bottom-up costing

Type of cost	Quantity of resource	Value of resources: prices, imputed prices, or unit costs
Health service		
Staff (by type of staff)	Time	Wages + on-costs
Consumables (e.g. food; medicines; syringes)	Number/amount	Price
Overheads (shared institutional costs)	Proportion of total (or an approximation, e.g. m^2 floor space for the programme)	Proportional allocation
Capital items	Number of uses/proportion of total lifetime uses	Market price/rental value/replacement value
Other services For example, social services, ambulance services, voluntary agencies)	Amount (as above, for health services)	Price (as above, for health services)
Patients, families and carers		
Time	Hours	Wage rates/imputed values
Out of pocket costs	Amount	Price
Changes in production and earnings	Time	Wage rates

Source: Book → Morris, S et al., (2012)

Out of the complete picture (you just see), that we have taken from the Morris et al., (2012) book. 'Health services' we have just highlighted it (you can just have a check), and 'other services', and 'patients, families and carers'. We have actually clubbed all those variety of costs or resource uses in broadly these three categories. Health services (that includes overhead cost, capital items) and 'parents and families' (that includes out-of-pocket cost and time etc.) and other costs (that includes Staff, consumable food, overheads etc., of health system). So, we will cite somewhere in our understanding.

Coming to the data sources in costing. The top-down costing in particular relies on secondary data, routine accounting data, and management data are also part of the top-down costing. In the case of bottom-up costing, clinical trials can design costing into research design so that data on resource use or costs are collected alongside clinical data. So, which cost would be included then? Selection and inclusion criteria (if any) are important aspects of making a decision. In this case, the analysts are responsible for drawing a line in costing. In economic evaluation, we are usually interested in incremental cost that is common in all. There are methods for cost inclusion criteria like 'reduce list method' by 'Knapp and Beecham' in 1993, but they have their own criticism given by other authors, which we have cited here.

So far, we have discussed just the cost at a point in time. Over time, the cost or the benefit must have also been included evaluation, in the sense that there must be some forms of discounting in the evaluation patterns, whenever we are supposed to find out.

People usually prefer to postpone cost and enjoy benefits now. This phenomenon is known as positive time preference.

❖ Given an option, say→ to spend a budget of ₹10,000 on any one of the two diseases (named- **Disease 1** & **Disease 2**).
Disease 1→ Cost= ₹10,000, Benefit= 10 QALYs **now**
Disease 2→ Cost= ₹10,000, Benefit= 10 QALYs in 10 years' time

Given an option, for example, (we are just giving an arbitrary example at this moment) to spend a budget of rupees 10,000 on any of the two decisions, namely, decision 1 and decision 2. In 1, let the cost be 10,000. We are just presenting benefits over time and at the present time. So, on the case A (i.e., decision 1 case), you see the benefit is in terms of QALY (which we have already discussed in our previous lecture). So, if 10 QALYs are now as per the decision 1. Whereas, in decision 2, if the cost is 10,000 and the benefit is though 10 QALYs, but it is distributed over 10 years' time (10 QALYs in 10 years' time). So, in the first year, they receive some QALYs, then second year, but in 10 years it is of 10 QALYs.

Then in this case, which one should be preferred? As we all know, consumers preferred and lived in the short period. So, consumers, of course, will prefer decision 1 because that is going to at least not discounting in the present period, and the entire 10 QALYs are reserved. In the decision 1 case, we refer to the context called 'positive social time preference'. Whereas, in the other case (that is case B), it is based on discounting because 10 QALYs are derived in 10 years. Hence, that is less preferred. However, there are some conflicts in the individual patients' minds regarding decision-making, even if there are some discounting in different periods. We will just clarify this one by one.

Coming to the understanding of discounting. There is a formula which you used to do in a present value calculation:

Discounting formula

$$PV = FV\left(\frac{1}{(1+r)^t}\right)$$

where,
PV = present value,
FV = future value,
r = discount rate (**conventionally** *(Samuelson, 1937)* **assumed to be constant**),
t = time period, &
the expression $\frac{1}{(1+r)^t}$ is known as discount factor

It is the same one in fact, i.e., - $PV = FV\left(\frac{1}{(1+r)^t}\right)$ (t stands for the time period). In this case (previous example of 10 QALYs), it is of 10 years period. r is basically the discounting rate. Usually, we do it in our calculation for interest rates and when money is invested over time period, we calculate what is the present value of that total amount, so r used to be the interest rate in that case. But here, the discounting rate has to be calculated and derived by some approaches.

Conventionally, discount rate is considered to be constant, as mentioned in also the work of Samuelson in 1937. So, we will clarify. However, in reality, discounting rate is no longer constant. So, some alternative models are considered for discounting rate to be included, that is, sometimes it is called hyperbolic (as mentioned by Henderson and Bateman in 1995), and proportional or slow discounting etc., by other authors. I have just cited their name, you can follow. Under each of these, the discounted declines as time proceeds. However, changing rate violates the assumption of economic stability. So, it makes also convenient for considering discounted to be constant.

Here, we are considering an example of discounting a future stream of costs on how projects are incurred and which project is going to be beneficial.

Example of discounting a future stream of costs:
Given scenario→ Project incurs costs of **₹100 million** for the current year and for each of the next 4 years→ represented as→

t_0	t_1	t_2	t_3	t_4
₹100 Million	**₹100 Million**	**₹100 Million**	**₹100 Million**	**₹100 Million**

t_0 = current time
t_1 to t_4 = subsequent time

To estimate total cost of project → need to sum up all these costs→ but each cost occurs in a different period→ So, we must discount future values and convert them into current values.

Given→ r= 5%= 0.05, Discounting will result in→

t_0	t_1	t_2	t_3	t_4
₹100 M $\times \frac{1}{(1+0.05)^0}$ = ₹100 M	₹100 M $\times \frac{1}{(1+0.05)^1}$ = ₹95.24 M	₹100 M $\times \frac{1}{(1+0.05)^2}$ = ₹90.70 M	₹100 M $\times \frac{1}{(1+0.05)^3}$ = ₹86.38 M	₹100 M $\times \frac{1}{(1+0.05)^4}$ = ₹82.27 M

At this moment, you can just see five periods, starting from the present (as t_0), and here, the project incurs at the cost of 100 million rupees for the current year. For each of the next four years, the project's cost is mentioned. So, in terms of the cost of all five years, all are same. To estimate the total cost of the project, it seems to be the same, it seems to be 500 million rupees. But indeed, there will be a discount on this amount in the future, so far as the total cost is concerned. Hence, that has to be also included in the model. But each cost incurs in a different period, so we must discount future values and convert them into current values. So, when we say discounting, we have to take a rate, which is the discounting rate.

Let this be 5%. Hence, we can calculate it in different years using the PV formula. So, 100 in the first period will be similar because 'to the power 0' has to be taken. So, then, it equals to 100 million rupees. In the second year, it is 95.25, in the third year and so on. Till t_4 it is 82.27 million rupees. So, you can see, if you add all these five periods, it is of course not 500 total. In total, it is actually 454 million rupees. This is called the present values if you are including 5% discount rate. So, compared to the total (with the constant without discount

rate or zero discounting rate), that was 500 million rupees, discounting values are important and that gives better evaluation.

So, the choice of the discounting rate, that is r (we have taken) is important. It affects the magnitude of the cost of the evaluations. The larger the value of r, the less weight is given to future events. So, the present value of costs incurred in the future is smaller and vice versa. In practice, it is admissible to select central based estimates (base case value) and vary it systematically in a sensitivity analysis to determine the effect of choice in the conclusion of the study. For a choice of base case, we can follow the government-recommended rates, or it should include the rates suggested in other published literature.

So far as discounting health is concerned, we know that health involves subjective well-being aspects, and many of the issues regarding health outcomes are quite debatable. So, although it is acceptable to discount future monetary benefits like discount costs, it is debatable when the benefits are health outcomes.

Unlike money, health is not tradable as one cannot give up a year of life now and invest it and obtain more years of life in future (One of the important aspects you can think of for your quiz questions, for your multiple questions, we have covered this why it is not tradable and what are the problems of non-tradable and in terms of evaluations). Hence, why can't we have a time preference of receiving now rather than in the future, in the same way we have time preference for monetary benefits? The effect of not discounting health improves the cost-effectiveness of different healthcare programs as not discounting increases the magnitude of health benefits in future. And effect of discounting health makes those healthcare programs with future health benefit (like prevention) less cost-effective than those with benefits realised in present (like cure).

Hence, most national guidelines for pharmacoeconomic research recommend discounting both cost and benefit at the same rate (You can just note that it might be another possible question), backed by theoretical arguments. Theories backing same rate of discounting are of two types, one is called 'consistency argument' and another is called 'paralysing paradox' argument theory. We are just clarifying what is called consistency argument theory as proposed by Weinstein and Stason's 1977 work. They compare two programs A and B and their respective cost and benefit (one in present time and another in discounting time, over 40 years period).

❖ Suppose there are two healthcare programmes- **A** & **B**

Programme	Cost	Benefit
A	₹10,000 now	1 QALY in 40 years' time
B	₹10,000 now	1 QALY now

❖ To **argue→ Health** outcomes should **not be discounted→** is **equivalent** to saying**→ society is indifferent** between **A** & **B**

In the first case, it is one QALY in 40 years time, and in the case B, it is one QALY at that time only, or in the present period. Hence, what really happens? To argue that health outcomes should not be discounted is equivalent to saying that society is indifferent between A and B. However, because cost is discounted, this invokes an inconsistency problem. Let us see how. So I will show you. Given this example, we will just find out, so far as inconsistency problems are concerned. So, three more scenarios are coming or derived out of this case (A and B) one by one with a certain discounting rate. You can just see-

❖ Consider→ there are three more scenarios→ **A1, A2** & **A3** (each one is a variant of A)

Programme	Cost	Benefit
A	₹10,000 now	1 QALY in 40 years' time
A1	₹70,000 in 40 years' time	1 QALY in 40 years' time
A2	₹70,000 now	1 QALY now
A3	₹10,000 now	1/7th of a QALY now
B	₹10,000 now	1 QALY now

Case1: at r=5%, PV of cost for A1= ₹10,000 now for same benefit, so→ A = A1

Case2: if we could pull both cost and QALY of A1 in current period→ the CER of A1 = A2→ A=A1=A2

Case3: dividing both cost and QALY by 7 → So CER of A3 = A2→ A=A1=A2=A3
(none involve discounting health outcome)
However, **A3 ≠ B→ A=B,** therefore not discounting health → logically inconsistent

You can calculate the present value of the cost of the A (of course, since it is 40 years time) accordingly. Inthe first case, we are referring to A1 with 5 percent interest. If it is of 70000 in 40 years (so far as cost equivalent is concerned), then the A1 (with 5% discounting rate) will be of 10,000 rupees. For the same benefit, these two are now equal (A and A1), because we have compared that '10,000 now' is equal to '70,000 in 40 years' time and that is nothing, but at the present time it is of only 10,000. Hence, these two are equal. Therefore, it is usually suggested that people do not wait for 40 years. So, it seems to be very high (70,000), but it is lesser. Another comparison with two other cases. Instead of 70,000 in 40 years, if you have 70,000 now and one QALY now. So, if we could pull both cost and QALY of

A1 in current period (if both are pulled together), cost effectiveness ratios (of A1 and A2) are nothing, but A1 = A2. Now you can say, ratio A = A1 = A2. So, all are equal now, A equal to A1 equal to A2. So far as, the cost-effectiveness ratio, if you remember, we have already explained. So, these three are equal A, A1 and A2.

In the third case, we are trying to divide both cost and QALY by 7, just to make the equivalent of each other because it is 70 in the present period. So, if you simply divide by 7 now these are equal. So, the CER of A3 is equal to A2 and so all four are equal, i.e., A, A1, A2 and A3, but none involves discounting health outcome because we are nowhere discussing, that they are discounting in terms of health outcome. However, A3 is not equal to B. You can just see, 'one seventh of a QALY now' is not equal to 'one QALY now'. So, these two are not equal. Therefore, not discounting health is logically inconsistent.

Another approach, that is to understand this (the discounting problems), is called the 'paralysing paradox concept' (mentioned by Keeler and Cretins in 1983). So, it refers to the context that when you have equal QALYs (return or the outcome is constant). You are going to get that constant in the next year.

Health Programme	Time period		
	t_0	t_1	t_2
Option1	$C_{t_0}/QALY_{t_0}$	→	→
Option 2		$C_{t_1}/QALY_{t_0}$	→
Option 3			$C_{t_2}/QALY_{t_0}$

Perpetual delay→ Option 3 > 2 > 1

So, your outcome is going to be same in the next year and if your cost is incurred in the next year, so better to defer your project or your program.

So, in that way t_0, t_1, t_2 (we have mentioned), if it is made like you want to treat your disease and you know that your outcome will be the same in the next year, it is better to deal with it in the next year. Usually, in the healthcare context, it is difficult to say that. But, in the general project context, if you are incurring same cost in the next year, but your return is same, so better to incur in the next year. Similarly, it keeps on postponing to the next period because your outcome is not going to be discounted. So, this keeps on actually deferred, or it gets deferred to the next year. And finally, the project is not getting to an end. Hence, that is called a paralysing paradox. So, as I already mentioned, given that cost is discounted, but if health is not, it is beneficial for the policymakers to delay if the benefit is not discounted. Hence, it has implication on the program implementation. Next year same health can be gained by using less cost. So, option 2 is preferred to option 1, and option 3 is preferred to

option 2. Hence, it implies that delaying the program always improves cost-effectiveness, making not discounting health questionable.

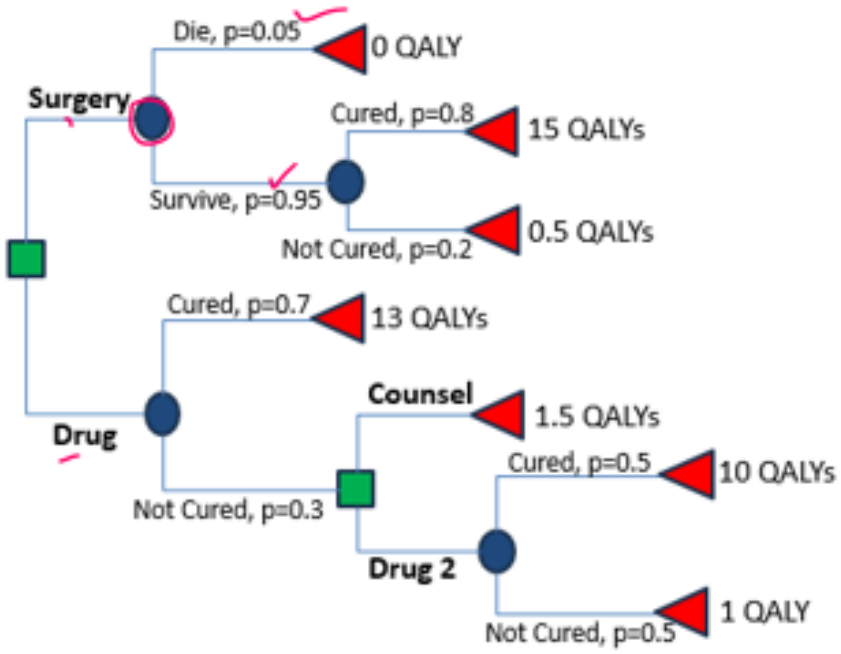
Now we are discussing economic evaluation and uncertainties. So far, we have discussed the costs and their discounting aspects of evaluation. We have repeatedly stated that health economic evaluations are more complex than just computing cost and benefits. Hence, in practice, all health economic evaluations use economic evaluation models, which embodies the rigorous calculation behind estimating cost and benefits.

There are two reasons for using evaluation methods. One is, economic evaluations are based on different sources of data which have to be linked together. Second, there are many uncertainties about numerical information used in evaluation, leading to uncertainty in results. So, in both cases, the use of the model is helpful and design is important. Hence, a solution is required. The first modeling framework where uncertainty is examined is called decision analysis.

Decision analysis is indeed a systematic approach to decision-making under conditions of uncertainty, using theories of probability and expected utility. Since a decision involves some probabilities and expected values, we will discuss this in the decision analysis. There are five steps largely involved. The first is on the structure of the problem by constructing a mathematical model that involves a series of connected events. This involves identifying decision alternatives, listing possible outcomes of each alternative and specifying the sequence of events. Decision might be to choose drug or surgery, for an illness etc. This is an example we have given. In the case of surgery or choosing a drug, we require number of decisions at different time and different level.

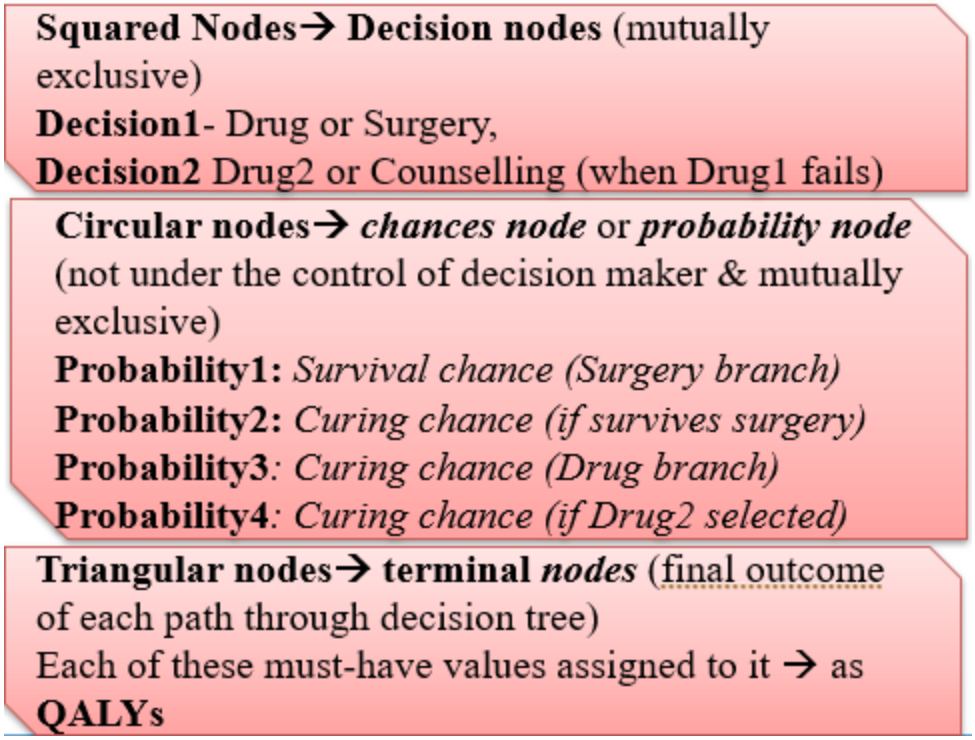
The second step is to quantify uncertainty by assigning probability to chance events or the probability of the events. Then the third one is to quantify preference by assigning values of all possible outcomes of chance events. The fourth one combines uncertainty and preference to make the best decisions of the person by calculating the expected value of each strategy. The fifth one is to perform sensitivity analysis, which again involves systematically changing the assumptions in steps 1 to 3 to see the impact on step 4. The first three steps can be envisioned using a decision tree. The tree is made of different nodes and branches. Nodes are basically called events, and branches connect those nodes. Let us use a hypothetical example to help you understand these steps.

We are actually citing a medical scenario of the patient who are supposed to choose for their treatment, either going for drug or surgery. If the person opts for surgery, they will reach an outcome. But, if they opt for drugs and if the drug fails, then there are probabilities involved like using drug2 or going for counselling with further treatment etc. We will explain these things in the decision tree. Here is our decision tree:



You start with this, starting with the persons taking an option (either going for drug or for surgery). You can see from the surgery that once the surgery is chosen, the probability is involved in whether the person is surviving or dying. If survived, then what percent survive matters? Then, again, chances and probabilities are attached. In this case, it is simply an event, so there is no question of chances.

Then further sequences are followed. These are also called sequential decisions, as far as healthcare is concerned.



In this case, square nodes (we have mentioned square nodes) refer to the decision nodes. They are usually mutually exclusive. Especially in decision 1 (related to the square nodes), you see either the person is going for drug or surgery. In decision 2, if drug 1 fails, then again, whether the person is taking a counselling method or drug 2.

There are circular nodes in this case as well. You can see some of them. Circular nodes are the chance or probability nodes, are not controlled by the decision maker, and are mutually exclusive. So, probability 1 (we have already mentioned), is survival rate (surgery branch). And the chances at this moment (we have mentioned as)- dying chance is 5 percent and the survival rate is 95 percent.

The next node you see is the Curing chance (if survived surgery), especially cured and not cured. Cured is, of probability 80 percent and not cured is 20 percent. Hence, the QALYs are attached based on the outcomes. So, probability 2 is curing chance. The first probability is just survival chance. The second probability is related to curing chance. Another case, i.e., in the case of drug (you can see probability 3 that we have mentioned) that has the curing chance. And probability 4, curing chance if drug2 is selected.

The last one to be referred in case of decision tree are triangular nodes, also called terminal nodes or the final nodes or the final outcomes of each path through decision tree. Each of these must have values assigned to it as certain QALYs, to take the final decisions. So, given this context, we are supposed to calculate their expected value. The formula for the calculation of expected value (in terms of QALY) is to combine the uncertainties (or the probabilities) with their preference (or the assigned values).

Formally, the expected values would be of course given as-

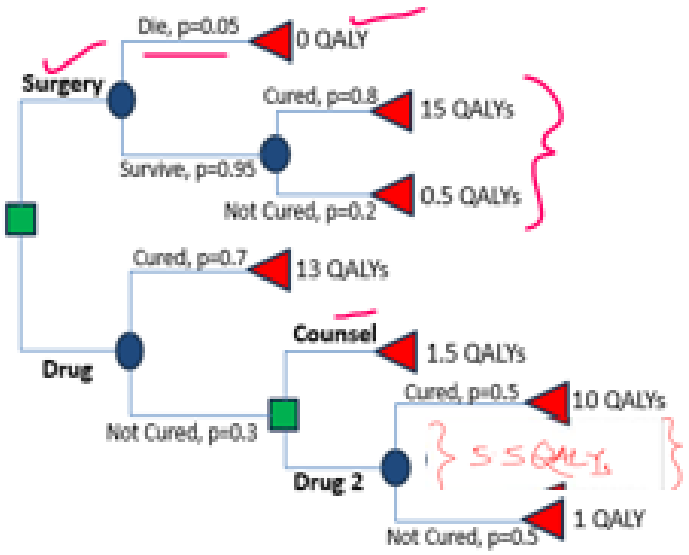
Formally→ $E(X) = p(X_1)U(X_1) + p(X_2)U(X_2)$

More generally→ $E(X) = \sum_{i=1}^{n} p(X_i)U(X_i)$

where→ X is event, p is probability, U shows utility (valued based on preference)

Using this, we derive the expected probabilities accordingly. A way in which this is often done is by folding back or pruning the decision tree from right to left. Starting with calculating the expected value of those who opted drug2.

E(Drug2)= (0.5 x 10) + (0.5 x 1) =**5.5**



So, expected value of drug2 is equal to 0.5 times 10 plus 0.5 (i.e., 50 percent of the chances of curing and 10 QALYs are resulting quality of life). So, taking drug 2, we get (0.5 x 10) + (0.5 x 1)= 5.5. So, this is what is marked. This gives us first decision to take a final decision that the expected value of drug2 (i.e., 5.5) is indeed greater than that of the counselling value. Counselling value: You can see how many QALYs there are. It is only 1.5 (you can see). Combining this (QALYs of Drug2 and Counselling), it is of 5.5 QALYs in this case. So, this is greater than the counselling values. So, choose drug2 if drug 1 fails to cure. So, we must go for taking drug2.

Similarly, first compute the expected value of those who survive surgery (you can just see in the case of surgery). The expected value of surgery again is at the final node with the QALYs are there.

E(S.Surgery)= (0.8 x 15) + (0.2 x 0.5) =**12.1**

So, 0.8 is the cured probability. So, 0.8 times 15 (15 is the QALYs) and 0.2 (i.e., 20 percent of the 0.5). So, this boils down to 12.1. So, you can decide whether this is better than the other or not. Of course (so far as QALYs are concerned), this seems to be better because we are getting much higher QALYs in the case of the other one. But if we do not have QALY details in the other one, since it is dying, of course, QALYs are 0, so it is quite certain that we need to decide accordingly.

In the next step using the estimated expected value of surgery survival.

Expected value of surgery (you can see) is basically against death and life or survive.

$$E(\text{Surgery}) = (0.05 \times 0(\textit{death})) + (0.95 \times 12.1) = \mathbf{11.495}$$

So, accordingly, it is 11.495. Similar to the expected value of surgery, now calculate the expected value of drug.

$$E(\text{Drug}) = (0.7 \times 13) + (0.3 \times 5.5) = \mathbf{10.75}$$

So, we are actually getting a reverse approach. We are starting from the right to the left and discovering all their expected values.

So, what we are interpreting at this moment is that the expected value of surgery is greater than that of the expected value of drug medication. We can also compute the advantages of surgical treatment. So, you can just compare this to the expected value and find out how many QALYs are still gained because of surgery.

However, there are limitations. The decision analysis model describes a process with a fixed sequence of events leading to an outcome, expecting they remain in sequence. However, it does not involve a time dimension which exists in reality. Since the discounting are also attached to the time dimension, its sequences should have been discounted by the time factor. So, that can be derived by using the Markov models in the next class. We will be doing it in the next class with some solutions.

So far, we have discussed all sorts of things. I am just giving you a summary and leading you to a conclusion of this lecture. In this lecture, we discussed economic costing and emphasised the role of the market. There are two types of costing methods, usually top-down and bottom-up. Usually, the bottom-up is preferred in disaggregated settings and even for program evaluation purposes. Even we also discussed data sources in costing. Then, we emphasised about discounting. We talked about the choice of discounting rate, discounting health issues as against in normal projects, and theories of the same rate, discounting of health and their cost, and we also emphasised in this lecture on economic evaluation uncertainties, where the decision analysis is emphasised.

I think we just did it. I hope you are enjoying the lecture, and I expect your questions in the next class. So, as I already mentioned, the next class will be on uncertainty and economic

evaluation using a dynamic model. We will be explaining the Markov model. Finally, we will also approach the explanation of dynamic evaluation using sensitivity analysis, which also gives a robustness check of the decision tree using earlier methods. These are the readings. The most important reading we have highlighted in bold letters. I hope you will enjoy it. Thank you.