Health Economics

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Week – 05

Lecture 22- Uncertainty and Risk: Health Insurance-I

Welcome, friends, to this NPTEL MOOC module on Health Economics. In week number 5, unit number 5, we are discussing the important aspects of health economics called health financing. The last lecture discussed the background of health financing and its need. Now, we need to address how the individual as a patient or the household is trapped under certain forms of burden and that burden and how it is dealt with through health insurance. So largely, the burden is conceptualized in the economic literature through uncertainty and risk. So we will emphasize uncertainty and risk here and how far health insurance is addressing is true.

So, as a recap of our previous lecture, we discussed healthcare financing, national health accounts in particular and identified the impoverishment effect of healthcare payments and out-of-pocket expenditure. Health is uncertain, and coping measures are required to prevent impoverishment due to unexpected high health spending. So, the learning goals of this lecture are the uncertainty of health risk, risk pooling, health insurance, and patient payments. So, we will be discussing patient payments through various types of payments and their distributional effects, and we will also talk about the policy option of applying negative patient payments to increase the utilization of some types of healthcare.

So what are your expectations, then? After going through a couple of lectures on financing, yes, you can apply for various consulting work. Maybe you can apply these latest arguments in your research or in our project writing. Besides that, I think the hands-on numeric examples we have given here would be highly useful for answering the questions, especially for the final exam and internal assessments. So, we have tried our best to present the discussions carefully, and our TAs are dedicated to developing the content. Your queries will be addressed carefully. So let us go further and in order to understand healthcare financing and the risk in particular, we need to take the help of probability, expected utility, expected value, variance standard deviation etc.

So the first obvious question is, what is uncertainty? We do not know the future and are also quite uncertain about it. Do you know if your house is burned or will burn down, the car you own may be stolen, or if you may get sick? In that case, uncertainty is attached in every sapling of our life, which used to occur at friction, which is hardly projected. However, some average tendencies of the uncertainties can be projected. Hence, the insurance company might take an average value of our predictions regarding and may address the issue of risk.

So, there is uncertainty in healthcare, in particular, where consumers do not know if they will ever need healthcare, where the incidence of health needs is very random, and they do not even know the full financial implications of illness. And we will also talk about here what is this full financial loadings and whether the post-payment loading is better than that of the prepayment reservation of health needs through payment of premiums, which one is really beneficial; we will be addressing in detail. So, to avoid financial uncertainty, consumers took out the health insurance. Can you ensure that the risk is covered in all events and that insurance against financial implications is possible? We will discuss all sorts of things.

Hence, we need to compare the uncertainty and risk. Uncertainty refers to, as per the famous American economist Frank Knight, a situation in which many outcomes are possible, but the likelihood of each is unknown, where the risk is really discussed in the context of quantifiable uncertainty. Therefore, it says that as per the definition by Frank Knight, risk refers to a situation in which we can list all possible outcomes and also know the likelihood of each occurring. We have mentioned some examples here. A new infectious disease outbreak often involves a high degree of uncertainty, whereas the risk assessment of a patient developing diabetes is based on factors such as age, family, history, lifestyle etc.

So, we can predict or calculate the possible outcome of diabetes through cofactors. So we will address all sorts of things. Let us start with a direction called risk pooling and insurance to address the risk issues. So what do you mean by insurance, then? It is a pooling of individual financial risk across all members of the pool, large and unpredictable individuals. In that case, if it is this case, then we will have, through risk pooling, a small and predictable individual risk.

So, risk pooling is indeed required to reduce the risks. Participation and risk pooling is either voluntary through private insurance or compulsory through tax-funded or social insurance. So if it is compulsory or voluntary, patents and insurance are basically a contract in which an individual of entity pays an insurance company in exchange for financial protection or embarrassment of losses resulting from a covered event. Here we are discussing these things how money pooling really helps. We start with an example where Pragya and three of her friends had a cool idea to make their own health insurance funds, and they pool their share of money to their class teacher with the condition that one who gets sick will get all the money.

Pragya's three friends were staying at the school hostel, but she went home every day. One day, when it was raining heavily, Pragya got completely wet on her way back to her home and ended up getting sick with a fever. She got all the money to pay for her treatment due to the pooling of funds. In this picture, in this interactive one, we have explained how pooling really helps someone who is attached to some form of risk. So you can just have a check once again.

We try to pool it first. There are four friends, including Pragya. They started pooling their money, and at the time of some catastrophe or some form of disease, as we have mentioned here, Pragya faced rain, and due to that, Pragya got sick, and we changed the colour. You can just mark it here. All the amounts have now been shared with Pragya.

This is how the friends or the pooling of money really helps in the time of need. We are explaining pooling across equal income and pooling across differential income. If there is a risk, it might be low risk or high risk. Here, we are mentioning pooling to redistribute health risk. So the contribution would be like this with low risk.

Individuals' transfer will also be highly useful for high-risk individuals. You can compare that some of their funds are also useful for the patients who are attached with high risk. So this will be useful. So, in this diagram, we explain cross-subsidization or cross-subsidy across equal risk. Now you can just have a check.

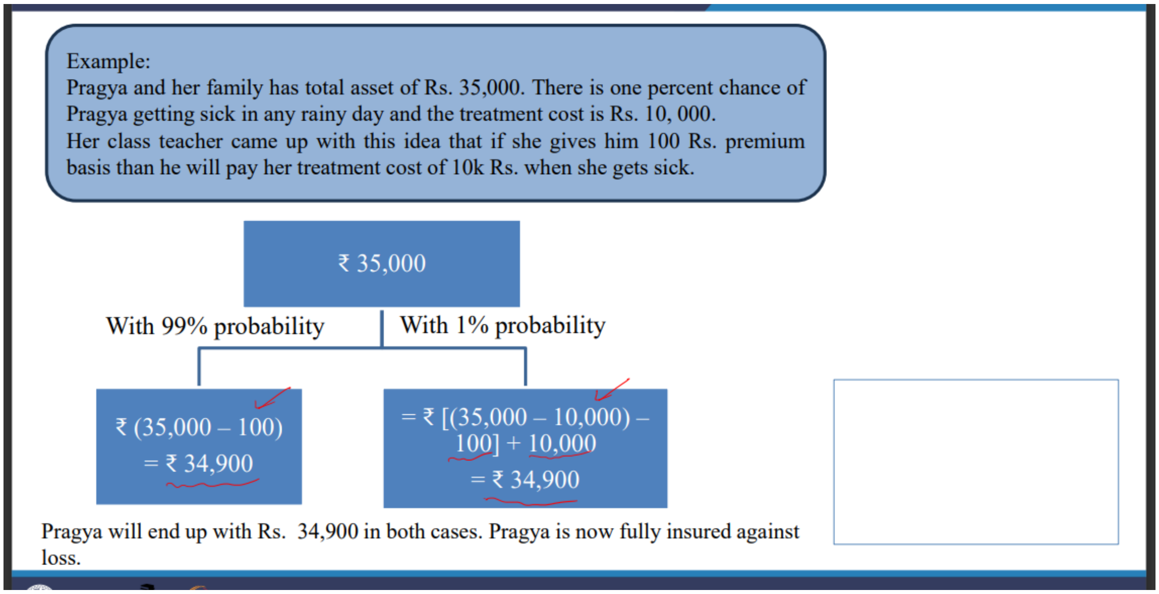
Cross-subsidy for greater equity. Income with those who have high income. In the previous one, we started with risk. So risks are of two types, and how the contribution is redistributed. In this one, we are discussing about income.

There are two categories: low and high. However, income is redistributed in high-income categories through sharing with the premium, which is useful for those with low income. So, the net transfer from the high one is highly useful. In this case, that helps with redistribution, income, and welfare. So now we are explaining the microeconomics of health insurance.

We will cite the example of Pragya. Once again, Pragya and her family have a total asset of 35,000, and there is a 1 percent chance of getting sick on any day; the treatment cost is rupees 10,000 as per assumption. So three things I have mentioned. One is starting with the W, I have mentioned wealth, then risk is 1 percent and the cost of treatment because of getting sick is 10,000. So out of 35,000, with 99 percent probability that Pragya will be in good health, hence there will be no expenditure.

So 35 is intact with a 1 percent probability. If Pragya is sick, then 10,000 will be deducted, and what is left is 25,000 with her income or wealth. Now we are discussing another case. Her class teacher came up with this idea that if she gives him rupees 100 as premium basis, he will pay her treatment cost of 10,000 rupees when she gets sick. So if Pragya pays the 100 rupees as a premium to her class teacher, then the class teacher will reimburse 10,000 rupees.

Hence, Pragya will end up with that 99 percent probability of good health since 100 rupees is paid as a premium, so 34,900 is the income left with her. However, in the case of sick, 1 percent probability we have attached and we know that 10,000 is paid for health treatment and if the premium is already taken, in that case, 10,000 is going to be reimbursed by her teacher. However, rupees 100 is paid. Hence, the total income still remains the same as against the good health case. Hence, in this case, Pragya will end up with 34,900, and Pragya will be fully insured against loss.



I will discuss a generalized context by taking the nth possibilities one by one. In general, if Pragya purchases insurance for rupees K with a premium, maybe we should say 100 as a certain percentage of the insured amount. So, we have said it is gamma times a certain proportion of the assured amount, which is called gamma (ϒ), so gamma times K (ϒK) is to be paid. The probability as we already attached is 1 percent; hence it is 0.01 percent of getting 25,000 plus K, K is the insurance of rupees K minus gamma K and probability of good health, so that means only this much is deducted that, is in our case it is of 100.

In general, if Pragya purchases insurance of Rs. K with premium of Rs. γK, then she faces gamble-

Probability 0.01 of getting Rs. $25,000 + K - \gamma K$
and
Probability 0.99 of getting Rs. $35,000 - \gamma K$

If you purchase Rs. K worth of insurance, you give up Rs. γK of consumption possibilities in the good state in exchange for Rs. $K - \gamma K$ of consumption possibilities in the bad state.

→ **Individual preferences matters while choosing insurance plans**. Three types of risk preferences:

- Risk neutral
- Risk seeking
- Risk averse

One very common example would be those who smoke and those who don't.

So, 34,900 in both cases we have seen that once insurance is reserved from the beginning of the period, the wealth is considered reserved and equivalent. If you purchase rupees K worth of insurance, you give up ϒK of consumption possibility in the good state. The exchange of K- ϒK of consumption is possibly in a bad state; hence, individual preference matters when choosing insurance plans. And we know that there are three possibilities of risk, and we can estimate in which context the consumer or the patient is ready to or the normal individual is ready to bear the insurance. So, there are perceptions are different; one is maybe the neutral type, risk-averse type and risk seeker or risk lover type consumer.

In this case, some of the examples you can cite are the person who used to smoke and who did not. So, in that case, you can easily predict who will be more risk-lover and who will be risk-averse. Of course, the one who does not smoke or does not smoke regularly will prefer to be risk averse. Hence, our utility functions are presented as follows: We have a probability function and consumption in different health states.

And C_1, C_2 in this case are mutually exclusive states of nature. It is mutually exclusive consumption if you are consuming one state and we have to compromise and compensate for the other. Let C_1 are utility function; hence it will be probability and its consumption function. So, we know that there are two probabilities and two states of consumption based on the risk the person is bearing. So, C_1 and C_2 represent consumption in a health state in one and two conditions, and Π_1 and Π_2 are the probabilities of state 1 and state 2, if any, occur.

And so, we need to emphasize some contexts in the perfect substitute case. So, the utility function is projected to be linear, as we used to see in our consumption function. So, our utility function, the probability times its consumption in state 1 and its consumption state 2 in probability time. And this is indeed called the expected value since we have attached their probabilities in both conditions and this tends to be our average level of consumption.

Another condition of the utility function is of Cobb-Douglas type, Cobb-Douglas utility function.

So, it is, in fact, C_1 to the power, and its respective probabilities are converted into C_2 to the power Π_2. So, it is; hence, this can be linearized for the expected value. We can take its log-linear function and find the average value. And the expected utility functions we have presented so far are on average using the Cobb-Douglas utility function. But the most important referred context for the expected utility function is through Von Neumann and Morgenstern utility function.

Utility functions

$$U = U(\pi_i, c_i) = \text{U}(\pi_1, \pi_2, c_1, c_2)$$

c_1 and c_2 are two mutually exclusive states of nature

Let c_1 and c_2 represent consumption in health states 1 and 2 and let π_1 and π_2 be probabilities that state 1 or state 2 occurs.

Examples of Utility functions

1. Case of perfect substitutes:

$$U(c_1, c_2, \pi_1, \pi_2) = \pi_1 c_1 + \pi_2 c_2$$

→This is known as **expected value** since it is average level of consumption that you would get.

2. Cobb-Douglas utility function

$$U(c_1, c_2, \pi_1, \pi_2) = c_1^{\pi_1} c_2^{\pi_2}$$

$$\equiv \ln(U(c_1, c_2, \pi_1, \pi_2)) = \pi_1 ln\, c_1 + \pi_2 \ln c_2$$

And in that case, it is presented as Π_1 and a function of C, and it is linearized through its respective utilities. Hence, utility can be written as a weighted sum. So basically, the weighted sum is taken and the expression represents the average and expected utility of the pattern of consumption C_1 and C_2. Hence, we have presented just now that in our case, V(c) stands for C here and in another case, V(c) stands for ln(C). So, let us apply the expected utility framework to a simple choice problem.

Expected utility functions (von Neumann-Morgenstern utility function)

$$U = U(\pi_i, c_i) = \mathrm{U}(\pi_1, \pi_2, c_1, c_2) = \pi_1 v(c_1) + \pi_2 v(c_2)$$

Here, utility can be written as a weighted sum of some function of consumption in each state.

Also, expression represents the average utility, or the expected utility, of the pattern of consumption (c_1, c_2)

Examples of Utility functions

$v(c) = c$

1. Case of perfect substitutes:

$$U(c_1, c_2, \pi_1, \pi_2) = \pi_1 c_1 + \pi_2 c_2$$

→This is known as **expected value** since it is average level of consumption that you would get.

2. Cobb-Douglas utility function

$v(c) = \ln c$

$$U(c_1, c_2, \pi_1, \pi_2) = c_1^{\pi_1} c_2^{\pi_2}$$

$$\equiv \ln(U(c_1, c_2, \pi_1, \pi_2)) = \pi_1 \ln c_1 + \pi_2 \ln c_2$$

Suppose Deepak has a wealth of rupees 10, and he thinks of a gamble that gives him a 50 percent probability of winning either rupees 5 or 50 percent probability of losses of that is minus 5 or 5. So, the expected value of the wealth can be calculated with the probability of 0.5, 0.5 times, which is either minus 5, 10 minus 5, or 10 plus 5.

Hence the expected value of wealth is 10. And the utility of the expected value is basically utility of this expected value that is utility of 10 and expected utility of wealth. What is this? Basically, we multiply the probability and its expected value. So, it is indeed this 0.5 of this one, 0.5 of this, so 0.5 of utility of 5. So, this is precisely the change in the value of wealth, but here we are saying even if it is as it has been changed, it has been reduced, the utility might have been increased. So, the expected value is considered to be different. This is how the expected value of wealth is presented. We will be presenting a diagram to explain it very clearly.

Let's apply expected utility framework to simple choice problem:
Suppose Deepak has wealth of Rs. 10 and he thinks of gamble that gives him a 50% probability of winning Rs. 5 and 50% probability of losing Rs. 5.

Expected value of wealth:

$$\Rightarrow E(w) = 0.5 * (10 - 5) + 0.5 * (10 + 5) = 10$$

Utility of expected value:

$$\Rightarrow U\big(E(w)\big) = U(10)$$

Expected utility of wealth:

$$\Rightarrow 0.5 * U(10 - 5) + 0.5 * U(10 + 5)$$

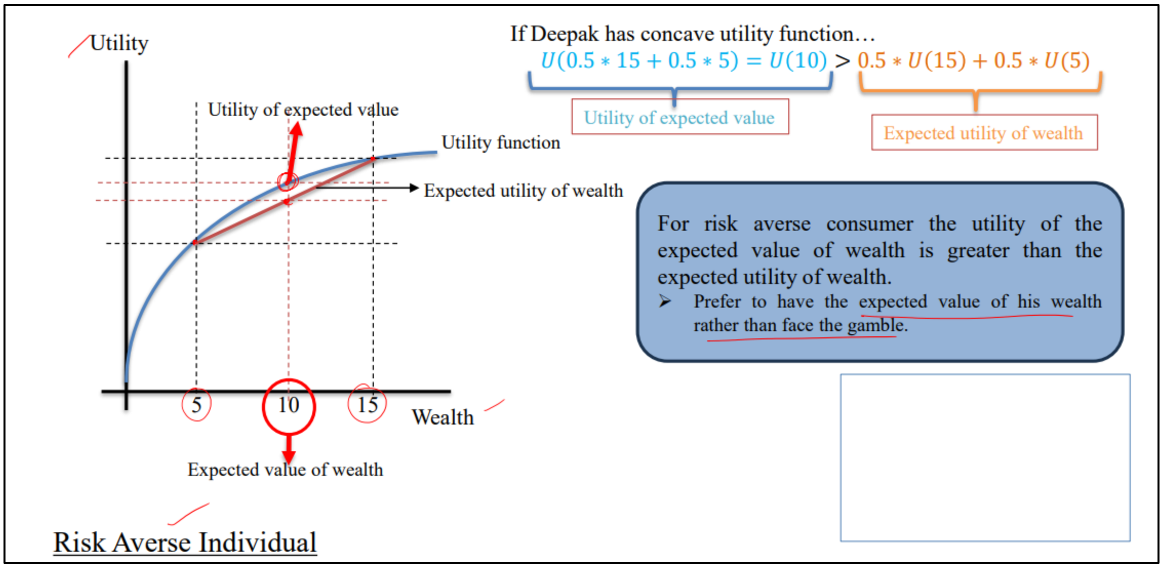
$$\Rightarrow 0.5 * U(5) + 0.5 * U(15)$$

We start by citing the case of a risk-averse individual. A person who is risk averse has the utility function, which is concave to the origin, and we will also give you the example of its equation form at the end which used to be the square root of the utility or the value. I will come to it. At this moment, you can just have a look if the utility function like this, we have taken wealth and its utility and we know that the utility level increases at an increasing rate initially, then decreases after a certain level of wealth and then there might be a maximum possible points.

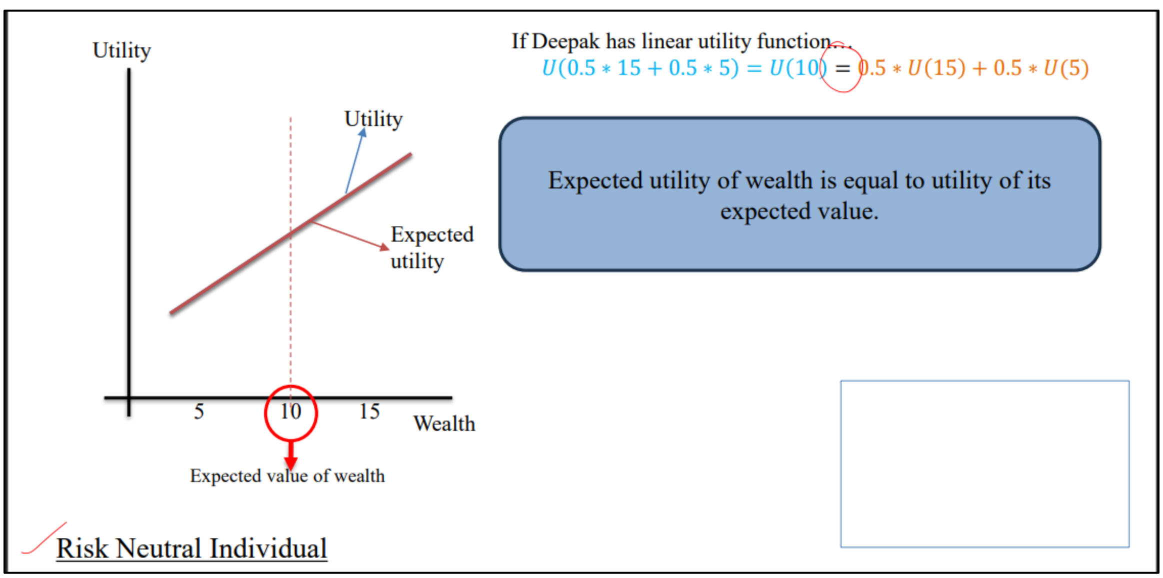
So, we will discuss all sorts of things. I will emphasize this. Here, we have presented its average value, the expected utility or expected wealth by taking the maximum possibility at 5 level at 5 and 15, 10 minus 5 that is 5 and 10 plus 5 at a 50 percent probability case. So, we will discuss this now. You can just have a check. This is our 15 here and 10, 5 there, and we have projected it accordingly. The expected value, the utility of the expected value, is at this point highlighted, and the expected wealth is 10, but the expected utility is higher than that of the expected value of wealth.

So, Deepak has a concave utility function, as I have already mentioned. As presented over here, the utility function is 0.5 times 15 plus 0.5, which is half of the probabilities, half times 5. So, the utility is of the 10 is now greater than this is how it is highlighted, is greater than that of the expected utility of wealth.

So, initially said utility of expected value, which is the expected utility of wealth. This means that 0.5 times utility of 15 plus 0.5 of utility 5. So, the average value is lesser than that of the utility of the expected value.

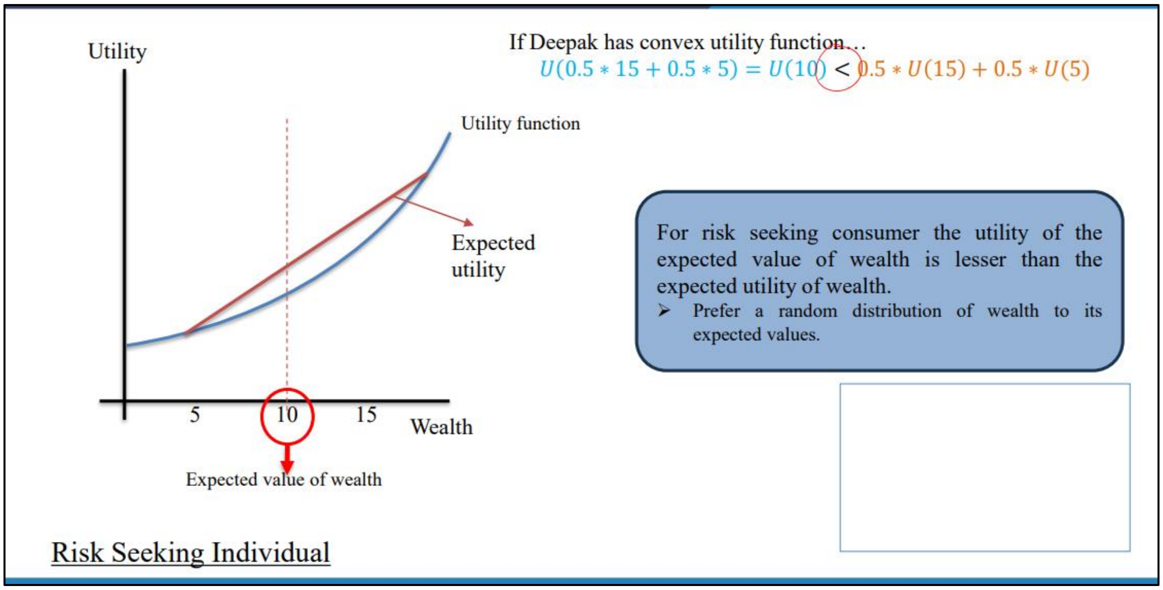


So, in this case for risk-averse consumers, the utility of the expected value of wealth is greater than the expected utility. So, the consumer will prefer to have the expected value of the wealth rather than face the gamble. The consumer will prefer to have the expected value of his wealth. we said that risk-averse individuals. In the next diagram, we mention risk neutrality, where the expected utility, the consumption function or the utility as a function of wealth will be straight line and expected of wealth is equal to the utility of its expected value.



So, here this is the utility function. We are presenting the expected value of wealth. This is expected utility and the utility we initially presented are the same. Hence, these two are equalized and since they are risk-neutral individuals. We are presenting risk seeker or lover individual. In that case, the utility function as a function of wealth is convex to the origin, and in that case, the average value of the wealth utility value is higher, and you can just check if it is just the reverse than that of the risk-averse individuals.

So, rest we have presented here. This side we can see a greater than the left-hand side is less than the expected value. So, for risk-seeking consumers, the utility of the expected value of wealth is lesser than the expected utility. So, consumer prefer a random distribution of wealth to its expected values. Welfare gain from insurance: How do we present it? So, you can see this is how we present the equation. So, these are all details that mention welfare gains for risk-averse individuals.



Welfare gain from insurance can be illustrated by considering the relationship between an individual's wealth and their utility. So, if insurance is there, money loss due to illness will be compensated and cost of this guaranteed compensation is specified as the premium P. So, we have mentioned all those things. So, this is the total and minimum wealth left out of the risk attached. Hence, the expected values differ; we present this in the context of risk-averse individuals.

And in this case, we are discussing another context in another unit of our module. We will be discussing part of this in unit number 7 as well. Unit number 7 where the economics of health system we discuss about the actuarial fair premium etc. So, here the P we have used or are using is gamma times K. This represents the insurance company's expected payout, which is the loss's size multiplied by the probability of loss occurring.

At this premium, insurance can expect to pay out the same amount of compensation as they receive in revenue from premiums. This involves no profit and no cost of administering insurance. So, as P increases, the premium increases from p equal to γK or to Pp equal to p^*.

So, this is what is given so that we can get the higher utility of the expected value and p equal to p^*, which means this reaches the maximum premium the consumer will be willing to pay. We will be taking Some of these discussions in detail in unit number 7.

The latter two lectures of unit number 7 will be useful. Hence, the wealth after insurance premium will be W minus P, which is precisely equal to P is our gamma times K.

$$W - p \Rightarrow (W - \gamma K)$$

So, utility without insurance will be gamma times utility of W minus K plus 1 minus ϒ gamma times utility of W. So, this will be less than that of the utility with insurance. So, as premium increases from gamma times K to p^*, welfare gain decreases to 0.

$$\gamma U(W - K) + (1 - \gamma)\, U\,(W) < U(W - \gamma K)$$

So, you can just follow from our numeric example and further clarify all sorts of details.

This is what we have said if this tends to reach an equal level and welfare gain decreases to 0. So, this is basically called utility with insurance, which we have highlighted here. And the gap you can see, the gap which we emphasized and we are emphasizing again in our next lecture on actuarial payment and this vertical distance we also will discuss how much the actuarial payment is required to ensure the equivalent insurance package. I am sure you will clarify this in detail in our next unit. So, to clarify further, here are some questions and we will give you some directions.

One question here we have kept it for you is to draw the following utility function as a function of the wealth of individuals and identify which one is risk averse or risk neutral and risk seeking. So, three functions are there. The first is utility equal to w^2, and the other is W.

- $U\,(w) = w^2$
- $U\,(w) = w$
- $U\,(w) = \sqrt{w}$

The second one is, for sure, the linear function, and I am sure you can guess it from the equation. And this is of course, a neutral one and first one you can just look at how we have also given an answer in our case.

Suppose that Laura has a utility function, this is the $\sqrt{w}$, which means it is a concave function and an initial wealth of rupees 100 or 100 dollars is given here. How much of a risk premium would she want to participate in a gamble that has a 50 percent probability of raising her wealth to 120 and a 50 percent probability of lowering her wealth to 80. Since we have said that 50 percent probability, you will find these answers in each of our cases in the neutral case or in the risk-averse case you will get these answers. So, even further details we have kept it here for your reference.

I am sure you can understand and this is the risk-averse individuals. So, the risk premium we have highlighted, her utility expected would be this much, and this is what is given: her expected utility to be 100. This expected wealth of 100 dollars is indeed uncertain. We would like to know the amount that she would accept with certainty that would give her same level of utility as the uncertain 100 dollar. So, the expected level of utility with this risk premium we have mentioned as RP, which is nothing but 9.949 squaring both sides, gives us a risk premium as 1.011. In this case, Laura is indifferent between a certain income of 98.989 and an expected income of 100. She needs to pay risk premium of 1.011 to avoid the risk.

U(120) = 10.054; U(80) = 8.944; 9.949 2 = 98.989

I will be discussing other details like patient payments etc. I think we can keep it to our next class. I am sure you will get enough time for your preparation so that the rest of the details are a sequence to understand other payments we will take forward in our next class, and I think it will be very useful. So, I will cover patient payments and other details in the next class. So, it is time to close. Thank you for your participation. Thank you.