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Comorbidities and the willingness to pay for health improvements

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Abstract

We show that the willingness to pay for health improvements increases with the severity and probability of occurrence of comorbidities. This result, which is obtained under mild restrictions on the shape of the utility function, has important implications for cost benefit studies applied to health care. In particular it implies that the discrimination of the elderly, believed to be implicit in cost benefit analysis, is less of a problem than commonly thought.

JEL classification: D1; D8; I10

Keywords: Willingness to pay; Cost benefit analysis; Risk aversion, health

1. Introduction

Consider two patients A and B who have the same probability of developing a specific disease called the 'index condition' (e.g. coronary artery disease—CAD for short). These two patients are identical in all respects except for the fact that patient A might also develop another disease—the 'comorbidity condition'—(e.g. diabetes) while patient B does not face this possibility.

Suppose that there exists an efficient treatment for preventing the index condition but that only one individual is allowed to benefit from the treatment (e.g. because of the scarcity of resources). Should the treatment be allocated to patient A or to patient B?

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Intuition suggests that patient B should receive the treatment because for patient A the benefits of the treatment might be jeopardized by the occurrence of the comorbidity condition.

There have been little theoretical or empirical investigations of the impact of comorbidities on the value of treating the index condition. To the best of our knowledge, the literature on these matters is recent and little developed. In two almost simultaneous papers, Harris and Nease (1997) and Fryback and Lawrence (1997) observe that many studies do not account for the morbid conditions that the patients experience other than the index condition being studied. They both conclude that ignoring comorbidities makes a comparison between cost-effectiveness ratios of different interventions problematic.

While these papers mostly refer to cost-effectiveness studies, we examine here the impact of comorbidities in cost benefit analyses (CBA). More specifically, by considering the patient's utility functions for health and wealth we examine how willingness to pay (WTP) for an improvement in the index condition is influenced by the comorbidity risk. We essentially show that the intuition mentioned above is not always valid. Indeed, under quite plausible assumptions about the utility function, WTP for an intervention on a targeted disease increases with the severity and likelihood of the comorbidity condition.

This conclusion has implications for cost benefit analyses of health care. For instance, it is often claimed that because WTP falls with age (see e.g. Shepard and Zeckhauser (1984) for a theoretical approach and Cropper et al. (1994) or Johannesson and Johansson (1997) for an empirical analysis), application of cost benefit analysis leads to health policies that discriminate old people. However, in a recent study of comorbidity conditions among cancer patients Coebergh et al. (1999) found that comorbidity conditions were present in only 12% of adult cancer patients below 45 years of age, but in 63% of patients over 75 years of age. Hence, comorbidity risk clearly increases with age and since comorbidities may increase WTP this effect can compensate at least partially for the negative age effect on WTP.

The paper is organized as follows. The general model is presented in Section 2. The effect of the comorbidity condition is discussed in Sections 3 and 4. In Section 3 we deal with a comorbidity condition that is present with certainty. This assumption is relaxed in Section 4 where both the index and comorbidity condition are random. Section 5 introduces a form of complementarity between the probabilities of the two conditions by considering the effect of an increase in the covariance between the two health risks. It appears that more specific assumptions about the shape of the utility function are necessary to sign the impact of an increased covariance. The paper ends with a short conclusion.

2. The general model

Consider an individual who derives utility from his wealth (W) and his health (H), so that

$$U = U(W, H). \tag{1.1}$$

Although health is basically a multidimensional concept, we assume for the sake of simplicity that it can be collapsed into a single variable in order to avoid more than two arguments in the utility function U. A widely used single variable health measure is the number of quality adjusted life years (QALYs).

We adopt for U the following assumptions:

- U_1 and U_2, the marginal utilities with respect to each argument are strictly positive;
- U_{11} and U_{22} are negative so that the individual is risk averse towards a single risk on each argument of U;
- U_{12} the cross second derivative of U is nonnegative, i.e. the marginal utility of income does not decrease with increases in health. This is a common assumption in the literature (Carthy et al., 1999). Viscusi and Evans (1990) and Sloan et al. (1998) find support for the assumption in the case of severe injuries. For minor injuries, however, Evans and Viscusi (1991) find that U_{12} can also be negative.

Full health which is denoted H_0 is threatened by two illnesses (1 and 2), the severities of which are denoted M_1 and M_2, respectively. M_1 and M_2 occur with probability p_1 and p_2, respectively, and the two risks may or may not be independent. Consequently, there are four possible states of the world:

$$\begin{aligned}
&H_0 \text{ with probability } 1 - p_1 - p_2 + kp_1p_2 \\
&H_1 = H_0 - M_1 \text{ with probability } (1 - kp_2)p_1 \\
&H_2 = H_0 - M_2 \text{ with probability } (1 - kp_1)p_2 \\
&H_{12} \text{ with probability } kp_1p_2 \text{ where } H_{12} < \min\{H_1, H_2\}
\end{aligned} \tag{1.2}$$

If k is equal to unity, the two risks are independent. If k exceeds (falls short of) 1, the two risks are positively (negatively) correlated.[1]

As far as the level of H_{12} is concerned, three assumptions are possible. If the two diseases reinforce (mitigate) each other then $H_{12} < (>) H_0 - (M_1 + M_2)$. In the remainder of the paper and for the sake of brevity we consider the intermediate benchmark case where the two diseases are additive in their effects (i.e. $H_{12} = H_0 - (M_1 + M_2)$). All the results that hold true for the benchmark case are also valid when the diseases reinforce each other. When they mitigate each other the results are ambiguous and depend on the shape of U.

Under the assumptions made thus far, the patient's expected utility (EU) is given by:[2]

$$\begin{aligned}
E[U] = {} & kp_1p_2U(W, H_{12}) + p_1(1 - kp_2)U(W, H_1) + (1 - kp_1)p_2U(W, H_2) \\
& + (1 - p_1 - p_2 + kp_1p_2)U(W, H_0).
\end{aligned} \tag{1.3}$$

[1] A similar framework was adopted by Doherty and Schlesinger (1983) in their analysis of the relationship between an insurable and a non-insurable risk. Of course the value of k is bounded by the fact that a probability must be nonnegative and cannot exceed unity.

[2] A model similar to that of (1.2) can be found in Viscusi et al. (1987) and in O'Conor and Blomquist (1997). However the questions raised by these authors are different from those analyzed here. Besides, these authors did not consider the case of potentially dependent risks.

For notational convenience, $U(H_i)$ will from now on stand for $U(W, H_i)$ when no confusion is possible.

In the rest of the paper disease 1 will be the index condition and disease 2 the comorbidity.

Given (1.3) two WTP concepts can be developed for the index condition. The patient may be willing to give up wealth in order either to reduce p_1 or to reduce M_1 from their baseline levels. Although the expressions for these two concepts of WTP are different,[3] we will only present here the WTP for a lower probability of illness. The results concerning the WTP for a reduced severity are qualitatively equivalent.

The formal expression for the WTP for a reduction in p_1 is obtained by differentiating (1.3) with respect to W and p_1 while keeping $E[U]$ constant. This yields:

$$\begin{aligned}\frac{\mathrm{d}W}{\mathrm{d}p_1} &= \frac{kp_2(U(H_2) - U(H_{12})) + (1 - kp_2)(U(H_0) - U(H_1))}{E[U_1]} \\ &= \frac{N}{E[U_1]} \text{ for short.}\end{aligned} \tag{1.4}$$

Here $E[U_1] > 0$ is the expected marginal utility of wealth. Because U is increasing in H, N is positive so that $\mathrm{d}W/\mathrm{d}p_1$ is positive.

Before analyzing in the next two sections the impact of the comorbidity on $\mathrm{d}W/\mathrm{d}p_1$, let us notice that (1.4) contains the value of a statistical life (VSL) concept as a special case. If $p_2 = 0$ and if $U(H_0)$ and $U(H_1)$ stand for the utilities in the states of life and death, respectively, (1.4) reduces to the VSL expression defined by Dreze (1962) and Jones-Lee (1974).

3. Comorbidity for certain

Consider the following extreme and simple case. Suppose patients A and B have the same probability of developing the index condition with equal severity (identical p_1 and M_1). However, patient A has diabetes for certain while patient B is definitively safe from diabetes. Who will be willing to pay more to reduce p_1? The answer is obtained by substituting in (1.4) $p_2 = 1$ for patient A and $p_2 = 0$ for patient B.[4] We obtain:

$$\left(\frac{\mathrm{d}W}{\mathrm{d}p_1}\right)_{\mathrm{A}} = \frac{U(H_2) - U(H_{12})}{p_1 U_1(H_{12}) + (1 - p_1)U_1(H_2)} = \frac{N_{\mathrm{A}}}{D_{\mathrm{A}}} \tag{2.1}$$

$$\left(\frac{\mathrm{d}W}{\mathrm{d}p_1}\right)_{\mathrm{B}} = \frac{U(H_0) - U(H_1)}{p_1 U_1(H_1) + (1 - p_1)U_1(H_0)} = \frac{N_{\mathrm{B}}}{D_{\mathrm{B}}}. \tag{2.2}$$

[3] For definitions of the WTP concept in the health economics literature see e.g. Johansson (1995) or Zweifel and Breyer (1997).

[4] Of course when $p_2 = 1, k$ also has to be equal to unity.

It is straightforward to see that under the assumptions made, the WTP for a health improvement in the index condition is higher for patient A. Indeed:

- if $U_{12} = 0, U_1(H_i)$ the marginal utility of wealth is constant for all health levels H_i so that $D_A = D_B$. Then risk aversion towards health risks $(U_{22} < 0)$ implies that $N_A > N_B$ yielding the result just indicated;
- conversely, if patients are risk neutral towards health risks $(U_{22} = 0), U_{12} > 0$ produces the same result.[5]

More generally, the combination of $U_{22} \leq 0$ and $U_{12} \geq 0$ leads to the conclusion that patient A has at least as high a WTP as patient B, contradicting the common intuition. Notice that even if U_{12} were negative—but not too negative—this conclusion might still be true, provided that the aversion to health risks is strong enough.

The observation that WTP to prevent the index condition might plausibly be greater for the individual with the comorbidity condition is analogous to the observation that WTP to reduce mortality risk may be greater for an individual with a chronic condition than for someone without it (Hammitt, 2000).

4. Random comorbidity

With the help of simple but tedious algebra, the results of the previous section can be extended to the case where disease 2 is also random.[6] In this situation, the comorbidity becomes more serious when either its probability of occurrence (p_2) or its severity (M_2) increases.

The main result is collected in the following proposition.

Proposition 1. *If $U_{22} \leq 0$ and $U_{12} \geq 0$ then $\partial/\partial p_2(\mathrm{d}W/\mathrm{d}p_1)$ and $\partial/\partial M_2(\mathrm{d}W/\mathrm{d}p_1)$ are nonnegative.*

The analysis shows that when the comorbidity conditions deteriorate through increases in p_2 or M_2 the patient is willing to pay more to improve the index condition. Quite interestingly, this result holds true even if $U_{12} = 0$, that is, when there is no complementarity between health and wealth.

5. Increased covariance between the risks

It is not hard to think of comorbidity conditions (e.g. respiratory problems) the likelihood of which increases with the presence of the index condition (CAD). Besides

[5] Under expected utility, U is defined up to an increasing linear transformation. Hence the sign of U_{12} is not affected by a linear transformation and thus $U_{12} > 0$ can be interpreted as complementarity between health and wealth.

[6] Details are available from the authors upon request.

a common factor—like age—can increase simultaneously the two probabilities of occurrence.

To capture this effect, we investigate how an increase in k affects WTP for a reduction in p_1. Straightforward algebra yields:

$$\frac{\partial}{\partial k}\left(\frac{\mathrm{d}W}{\mathrm{d}p_1}\right) = \frac{E[U_1]\cdot(p_2\{(U(H_2)-U(H_{12}))-(U(H_0)-U(H_1))\})-Np_1p_2((U_1(H_{12})-U_1(H_2))+(U_1(H_0)-U_1(H_1)))}{(E[U_1])^2} \tag{4.1}$$

An easy case emerges: if $U_{12}=0$ all the U_1s have the same value so that $(U_1(H_{12})-U_1(H_2))$ and $(U_1(H_0)-U_1(H_1))$ are both equal to zero. Then risk aversion, which makes the first term in the numerator of (4.1) positive, is sufficient to yield the intuitive result that a patient is willing to pay more to reduce p_1 if the cormorbid condition is 'more correlated' with the index condition.

When U_{12} is positive, matters are less obvious. Since by risk aversion the first term in the numerator of (4.1) is positive, a sufficient condition for $\partial/\partial k(\mathrm{d}W/\mathrm{d}p_1)$ positive is that U_1 is both increasing and concave in H. Fig. 1 illustrates.

If U_1 is increasing and concave $(U_{12}>0$ and $U_{122}<0)$ then

$$0<U_1(H_0)-U_1(H_1)<U_1(H_2)-U_1(H_{12}). \tag{4.2}$$

Consequently, the term in parentheses that multiplies $-Np_1p_2$ is negative and $\partial/\partial k(v\mathrm{d}W/\mathrm{d}p_1)$ is positive.

While a negative value of U_{22} (aversion to health risks) and a nonnegative value of U_{12} (complementarity between health and wealth) can easily be interpreted, the sign of U_{122} is

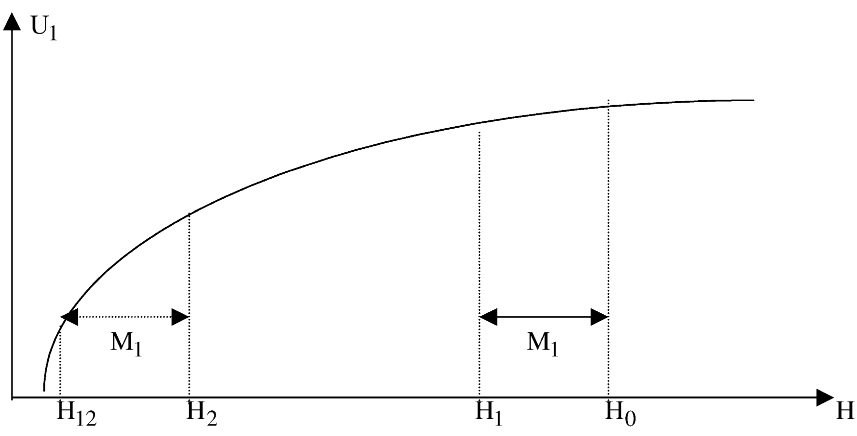

Fig. 1. The marginal utility of W as a function of H.

less intuitive. To motivate a negative U_{122} observe that the impact of changes in wealth on the aversion to health risks is given by:

$$\frac{\partial}{\partial W}\left(-\frac{U_{22}}{U_2}\right) = -\frac{U_2U_{221} - U_{22}U_{21}}{U_2^2}. \tag{4.3}$$

When $U_{21} = U_{12}$ is positive, $U_{221} = U_{122}$ negative is a necessary condition for aversion to health risk to increase with wealth. Even though no empirical evidence exists on the relationship between patients' perception of health risks and their wealth, people with higher incomes seem to engage in more healthy lifestyles, giving some a priori validity to the assumption that U_{122} is negative.[7]

To conclude this section, a case can be made that a greater statistical complementarity between the risks (increase in k) reinforces WTP. This holds definitively true when U_{12} is equal to zero. For $U_{12} > 0$, one force (aversion to health risks) increases WTP while the effect of the other force (the interrelationship between wealth and health) is less straightforward.

6. Conclusion

Existing cost benefit (CBA) and cost effectiveness (CEA) studies in health care tend to neglect the impact of comorbidities and focus only on the impact of interventions on the targeted disease.

By using a utility function for wealth and health, we showed that contrary to a widespread belief WTP for improvements in the index condition (which is the measure of benefits in CBA) is an increasing function of the severity or probability of the comorbidity condition and with some additional assumptions of the correlation between the two conditions.

Our analysis confirms—from another point of view—results recently published by Dow et al. (1999). They consider complementarity in the production function of survival and conclude that 'typically programs are evaluated solely upon the success or failure of their impact on the targeted disease... Such an exclusive evaluation may significantly underestimate the overall effect of disease-specific interventions when multiple risks act as competing forces on life'. In the present paper, we showed that complementarity either in the utility function or between the probabilities of occurrence has basically the same effect.

Because old people are also more likely to develop comorbidities, the effect of comorbidities on WTP tends to compensate for the fall in WTP associated with increased age. Thus our analysis leads to a qualification of the often made claim that CBA studies based on WTP are unfair to old people.

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[7] Note that the causation between income and health could go both ways.

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