Health Insurance and Preventive Behavior

by

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Abstract

This paper investigates how health insurance parameters influence preventive behavior and studies the structure of optimal health insurances. Preventive behavior is, in general, not unambiguously related to any health insurance parameter. There are several methods by which the first-best allocation with full coverage for costs of curative care can be reached if all prevention is observable by the insurer. If unobserved prevention is not negligible, consumers will usually purchase only partial coverage for curative care. Observable prevention will be encouraged by the insurer unless this does not have a strongly negative effect on prevention of the unobservable type. (JEL: I 11, I 12)
In a next step a more complicated model with two types of prevention is analyzed. While the first type of preventive activities can be observed by the insurer (e.g. regular examinations by the dentist), the second is not observable (e.g. dental hygiene, nutrition habits). It turns out that, in general, costs of curative care will not be fully covered, and the insurer will set incentives to encourage prevention of the observable type. If, however, prevention of the unobservable type reacts strongly negative to an increase in the other type of prevention, the insurer may even try to restrict prevention of the observable type. The paper concludes with a summary of the main results and indicates directions for future research.

2 The Basic Model

There is only one period in this model. The representative individual is endowed with initial resources amounting to \( w \). He is obliged to pay a health insurance contribution \( \pi \). During this period he either becomes ill (state \( i \)) with probability \( p \) or remains healthy (state \( h \)) with probability \( (1 - p) \). If he becomes ill, he will suffer from costs of curative care amounting to \( K \), with the amount \( X \) being covered by the insurance. The individual's only decision concerns the amount of preventive care undertaken before the period begins which is measured by the costs of preventive care \( e \). For simplicity, the price of prevention is set to unity. The insurance covers a fraction of \( b_v \) of the costs of preventive care. It is assumed that preventive care reduces the probability of becoming ill so that \( p \) is a function of \( e \) with \( p' < 0 \) and \( p'' > 0 \). Thus, preventive care is "self-protection" in the sense of EHRLICH and BECKER [1972]. The individual derives utility only from nonmedical consumption according to a utility function \( u(c) \) with \( u' > 0 \) and \( u'' < 0 \). He is assumed to maximize his expected utility

\[
EU = (1 - p(e))u(w - \pi - (1 - b_v)e) + p(e)u(w - \pi - (1 - b_v)e - (K - X))
\]

with respect to \( e \). The first-order condition for an interior maximum is

\[
\frac{dEU}{de} = \frac{dp}{de}[u(c^i) - u(c^h)] - (1 - b_v)[pu'(c^i) + (1 - p)u'(c^h)] = 0
\]
where

\[ c^h = w - \pi - (1 - b_v)e, \]

\[ c^i = w - \pi - (1 - b_v)e - (K - X). \]

From (2)-(4) it follows that interior solutions can only be reached if \( b_v < 1 \) and \( X < K \), i.e. if there is a partial insurance for both preventive and curative care, or \( b_v > 1 \) and \( X > K \), i.e. if there is an over-insurance for both types of care. If \( b_v < 1 \) and \( X \geq K \) or \( b_v = 1 \) and \( X > K \), then there is no demand for preventive care. If \( b_v > 1 \) and \( X \leq K \) or \( b_v = 1 \) and \( X < K \), then demand for preventive care is infinite. Last, if the insurance covers all costs, i.e. \( b_v = 1 \) and \( X = K \), consumption is independent of the chosen amount of preventive care, and therefore the demand for preventive care is indeterminate.

If \( X < K \) and \( b_v < 1 \), the first-order condition for optimal prevention can be interpreted as follows: The marginal gain in expected utility due to a lower probability of becoming ill is just offset by the marginal loss in expected utility due to a lower consumption level in both states.

The sufficient second-order condition is

\[ \frac{d^2 EU}{de^2} = \frac{d^2 p}{de^2} [u(c') - u(c^h)] \]
\[ -2(1 - b_v) \frac{dp}{de} [u'(c') - u'(c^h)] \]
\[ + (1 - b_v)^2 [pu''(c') + (1 - p)u''(c^h)] < 0. \]

In neither of the two cases that may lead to an interior solution, the second-order condition is fulfilled automatically. While in each case the third term on the right-hand side of (5) negative and the second term is positive, the first is negative if the insurance is partial, i.e. \( X < K \), and positive in case of an over-insurance. Thus, it seems more likely for a partial insurance than for an over-insurance that the second-order condition is fulfilled.

3 Comparative Statics of Prevention

In this section comparative static results are derived. The analysis is confined to the case that there is a strictly positive copayment for both preventive and
curative care. Moreover, it is assumed that for any given set of parameters a unique solution for e exists which lies in the interior and fulfills the sufficient second-order condition.

Proposition 1 shows that the demand for prevention does not react to a change in any given insurance parameter in an unambiguous fashion.

Proposition 1

Neither \( \frac{\partial e}{\partial b_v} \) nor \( \frac{\partial e}{\partial X} \) nor \( \frac{\partial e}{\partial \pi} \) is determined in sign.

Proof: The derivatives of the demand function are given by

\[
\frac{\partial e}{\partial b_v} = -\frac{\partial^2 EU}{\partial e \partial b_v}, \quad \frac{\partial e}{\partial X} = -\frac{\partial^2 EU}{\partial e \partial X} \quad \text{and} \quad \frac{\partial e}{\partial \pi} = -\frac{\partial^2 EU}{\partial e \partial \pi}.
\]

Differentiating the first-order condition (2) with respect to the insurance parameters yields

\[
(6) \quad \frac{\partial^2 EU}{\partial e \partial b_v} = pu'(c') + (1 - p)u'(c^h) \\
+ \varepsilon \left[ \frac{dp}{de} [u'(c') - u'(c^h)] \right] \\
- (1 - b_v) [pu''(c') + (1 - p)u''(c^h)]
\]

\[
(7) \quad \frac{\partial^2 EU}{\partial e \partial X} = \frac{dp}{de} u'(c') - (1 - b_v)pu''(c'),
\]

\[
(8) \quad \frac{\partial^2 EU}{\partial e \partial \pi} = \frac{dp}{de} [u'(c^h) - u'(c')] + (1 - b_v) [pu''(c') + (1 - p)u''(c^h)].
\]

While \( \frac{\partial^2 EU}{\partial e^2} < 0 \) holds due to the second-order condition of the consumer's optimization problem, the right-hand sides of (6)-(8) are all ambiguous in sign.

A rise in \( \pi \) lowers consumption in both states by the same amount. This reduction in income raises the marginal gain from higher prevention due to a reduction in the probability of the unfortunate state, but also the loss from higher prevention due to the decrease of consumption in both states. Raising \( b_v \) not only drives the price of prevention down but at the same time increases income. While the price reduction clearly stimulates the demand for prevention, it cannot be excluded that the positive price effect is overcompensated by a negative income effect. A rise in \( X \) increases consumption.
in the ill health state. While this reduces the gain in expected utility from lowering the probability of turning ill, it also decreases the marginal costs of prevention in terms of expected utility.

Since usually the premium has to be increased if an insurance benefit is raised, investigating the partial effects of a variation in one parameter is not conclusive. Therefore, compensated variations in the benefit parameters, i.e. variations where the expected budget deficit of the insurance is kept constant, are treated in Proposition 2. It is assumed that, in absence of administrative costs, insurance is supplied at actuarially fair prices, i.e. \( \pi \) fulfills

\[
(9) \quad b_v e + p(e) X - \pi = 0.
\]

In order to conduct a meaningful comparative static analysis, it is assumed that the conditions (2) and (9) define a unique allocation \((\pi, e)\) for a given set of parameters, and that this allocation is characterized by a positive insurance premium and positive expenditures on prevention.

**Proposition 2** If (2) and (9) define a unique pair \((\pi, e) \gg 0\), then a compensated increase in the benefit rate for preventive care raises the demand for preventive care, while the reaction of the insured to a compensated increase in the benefit for curative care is ambiguous.

**Proof:** Totally differentiating (2) and (9) yields

\[
\left[ \begin{array}{c}
\frac{\partial^2 EU}{\partial e^2} & \frac{\partial^2 EU}{\partial e \partial \pi} \\
\frac{\partial^2 EU}{\partial e \partial b_v} & -1
\end{array} \right]
\left[ \begin{array}{c}
de \\
d\pi
\end{array} \right] + \left[ \begin{array}{c}
\frac{\partial^2 EU}{\partial e \partial b_v} \\
\frac{\partial^2 EU}{\partial e \partial X} + X \frac{dp}{de}
\end{array} \right] db_v + \left[ \begin{array}{c}
\frac{\partial^2 EU}{\partial e \partial X} \\
\frac{\partial^2 EU}{p}
\end{array} \right] dX = 0.
\]

By Cramer's rule, it follows that

\[
(10) \quad \frac{\partial e}{\partial b_v} = -\frac{\partial^2 EU}{\partial e \partial db_v} + e \frac{\partial^2 EU}{\partial e \partial \pi} \frac{\partial^2 EU}{\partial e^2} + (b_v + X \frac{dp}{de}) \frac{\partial^2 EU}{\partial e \partial X},
\]

and

\[
(11) \quad \frac{\partial e}{\partial X} = -\frac{\partial^2 EU}{\partial e \partial X} + p \frac{\partial^2 EU}{\partial e \partial \pi} \frac{\partial^2 EU}{\partial e^2} + (b_v + X \frac{dp}{de}) \frac{\partial^2 EU}{\partial e \partial X}.
\]
The denominator of the two expressions of the right-hand sides of (10) and (11) is negative if the second-order condition for a solution of the consumer's optimization problem is satisfied and if there is exactly one solution \((\pi, e) \gg 0\) for (2) and (9). This claim can be verified as follows: Condition (2) defines a function \(e(\pi)\) with the slope \(\frac{de}{d\pi} = -\frac{\partial^2 EU}{\partial e^2}\), and condition (9) defines a function \(\pi(e)\) with the slope \(\frac{d\pi}{de} = b_0 + \frac{dp}{de}X\). Due to the second-order condition for optimal prevention, \(\frac{\partial^2 EU}{\partial e^2}\) is negative. Therefore, there are two cases in which the denominator on the right-hand sides of (10) and (11) can be positive.

First, if \(\frac{\partial^2 EU}{\partial e\partial\pi} > 0\) holds, then a positive denominator requires that \(\pi' > \frac{1}{\pi} > 0\) at the common point \((\hat{e}, \hat{\pi})\). In this case, the \(\pi(e)\)-curve cuts the \(e(\pi)\)-curve in the \((e, \pi)\)-diagram at \((\hat{e}, \hat{\pi})\) from below. Since both \(e(\pi)\) and \(\pi(e)\) are continuous and \(e\) and \(\pi\) are bounded from below, this implies that another intersection point with lower values for \(\pi\) and \(e\) must exist (see Figure 1).

Second, if \(\frac{\partial^2 EU}{\partial e\partial\pi} < 0\) holds, then a positive denominator on the right-hand sides of (10) and (11) requires that \(\pi' < \frac{1}{\pi} < 0\) at the common point \((\hat{e}, \hat{\pi})\). In this case, the \(\pi(e)\)-curve cuts the \(e(\pi)\)-curve in the \((e, \pi)\)-diagram at the intersection of both curves \((\hat{e}, \hat{\pi})\) from above. Since \(e(0)\) and \(\pi(0)\) are finite, \(e(\pi)\) and \(\pi(e)\) are continuous and \((e, \pi) \geq 0\), it follows that at least two other intersection points exist, where the first is characterized by \(\pi > \tilde{\pi}\) and \(e < \hat{e}\), and the second by \(\pi < \hat{\pi}\) and \(e > \hat{e}\) (see Figure 2).
Hence, the denominator on the right-hand sides of (10) and (11) cannot be positive if (2) and (9) define a unique pair \((\pi, e) \gg 0\). Ignoring the boundary case that this expression is zero in order to avoid major technical complications, it can be concluded that the denominator in question must bear a negative sign.

It turns out that

\[
\frac{\partial e}{\partial b_v} = -\frac{p u'(c') + (1-p)u'(c^h)}{\frac{\partial^2 EU}{\partial e^2} + (b_v + X\frac{dp}{de})\frac{\partial^2 EU}{\partial c\partial e}} > 0
\]

and

\[
\text{sgn}\left[\frac{\partial e}{\partial X}\right] = \text{sgn}\left[\frac{dp}{de}[pu'(c^h) + (1-p)u'(c')] + (1-b_v)p(1-p)[u''(c^h) - u''(c')]\right].
\]

Since \([u''(c^h) - u''(c')]\) is ambiguous, \(\frac{\partial e}{\partial X}\) is not determined in sign. □

The effect of a compensated increase in the benefit rate for costs of prevention is unambiguous since compensation eliminates the income effect, i.e. \(c^h\) and \(c'\) are unaffected if prevention is kept constant. But then the price of prevention is simply lowered, which in turn leads to more preventive activities. A compensated increase in the coverage for curative care raises \(c'\) and lowers \(c^h\). While this unambiguously decreases the gain from prevention due to a lower probability of illness, the marginal costs of prevention due to a reduction in consumption may also fall.

The two results are in line with Kenkel [1994] who finds evidence for a positive correlation of insurance coverage for preventive care with demand for prevention, but cannot unambiguously determine the influence of additional coverage for curative care on preventive activities.

Now consider the case that there is a common benefit rate \(b\) for both preventive and curative care, i.e. \(b = b_v = \frac{X}{K}\). This type of compensation scheme has the advantage that it can be employed even if the insurer cannot distinguish if a certain treatment is preventive or curative in nature. The modified budget equation of the insurer is

\[
\pi = b[e + p(e)K].
\]

Equation (2) still represents the first-order condition for the consumer’s optimal choice of prevention where \(b_v = b\). The following proposition deals with
comparative statics for both partial and compensated variations of $b$. It is assumed that for any given $b > 0$ there is exactly one combination $(\pi, e) \gg 0$ which satisfies both (2) and (14).

**Proposition 3** The reaction of preventive care to an increase in the common benefit rate is ambiguous. If there is exactly one combination $(\pi, e) \gg 0$ which satisfies both (2) and (14), then the change in prevention after a compensated increase in the common benefit rate is also ambiguous.

**Proof:** The partial reaction is given by

$$\frac{\partial e}{\partial b} = -\frac{\partial^2 EU}{\partial e \partial b},$$

where the numerator is

$$\frac{\partial^2 EU}{\partial e \partial b} = \frac{dp}{de}[u'(c')|e + K] - u'(c^k)e] + pu'(c') + (1 - p)u'(c^k) - (1 - b)[pu''(c')|e + K] + (1 - p)u''(c^k)e]$$

and the denominator is given by (5), which is negative due to the second-order condition of the consumer’s optimization problem. Since (16) cannot be determined in sign, $\frac{\partial e}{\partial b}$ is also ambiguous.

Totally differentiating (2) and (14) yields

$$\begin{bmatrix}
\frac{\partial^2 EU}{\partial e \partial b} & \frac{\partial^2 EU}{\partial e \partial \pi} \\
\frac{dp}{de} & -1
\end{bmatrix}
\begin{bmatrix}
de \\
d\pi
\end{bmatrix}
+ \begin{bmatrix}
\frac{\partial^2 EU}{\partial e \partial b} & \frac{\partial^2 EU}{\partial e \partial \pi} \\
\frac{dp}{de} & e + pK
\end{bmatrix}
= 0.$$

By Cramer’s rule, it follows that

$$\frac{de}{db} = -\frac{\frac{\partial^2 EU}{\partial e \partial b} + (e + pK)\frac{\partial^2 EU}{\partial e \partial \pi}}{\frac{\partial^2 EU}{\partial e^2} + b(1 + K)}.$$

By an argument analogous to the corresponding one in the preceding proposition, the denominator of the fraction on the right-hand side of (17) is
negative. Thus, it turns out that

\[
\text{sgn} \left( \frac{de}{db} \right) = \text{sgn} \left[ pu'(c^i) + (1 - p)u'(c^h) \right]
\]

\[
+ \frac{dp}{de} K [pu'(c^h) + (1 - p)u'(c^i)]
\]

\[
+ (1 - b) Kp(1 - p) [u''(c^h) - u''(c^i)]
\].

Since the first term of the right-hand side of (18) is positive, the second is negative and the third is ambiguous in sign, \( \text{sgn} \left( \frac{de}{db} \right) \) cannot be determined.

\[\Box\]

An increase in the common benefit rate raises \( c^i \) more than \( c^h \) and lowers the price of prevention. While this unambiguously decreases marginal costs of prevention in terms of expected utility, the marginal gain from prevention due to a reduction in the probability of becoming ill is also negatively affected. If a compensated increase in \( b \) is considered, then \( c^h \) is lowered and \( c^i \) rises. While this decreases the marginal gain from prevention due to a reduction in the probability of illness, the marginal costs may also be negatively affected. It turns out that both derivatives cannot be determined in sign, which is consistent with a similar result in Phelps [1978].

### 4 Optimum Insurances

The subject of this section is whether and how an insurance can be designed which generates the first-best allocation. The first-best allocation is derived by maximizing expected utility subject to the budget equation of an insurance with no payments for preventive care,

\[
\text{\pi} = p(e)X,
\]

with respect to \( e \) and \( X \). Thus, the objective function is

\[
\text{EU} = (1 - p(e))u(w - p(e)X - e) + p(e)u(w - e - K + (1 - p(e))X),
\]

and the first-order conditions are

\[
\frac{\partial \text{EU}}{\partial X} = p(1 - p)[u'(c^i) - u'(c^h)] = 0,
\]
\[
\frac{\partial EU}{\partial e} = \frac{dp}{de} [u(c') - u(c^h)] \\
-(1 + \frac{dp}{de} X) [(1 - p)u'(c^h) + pu'(c')] = 0.
\]

From (21) it follows that \( X = K \) is optimal, i.e. the first-best allocation is characterized by full insurance for costs of curative care. Given that \( X = K \), condition (22) shows that prevention is chosen in such a way that total expected costs of care, \( \tilde{K} = e + p(e)K \), are minimized. The first-order condition for cost-minimal prevention is given by

\[
1 + \frac{dp}{de} K = 0,
\]

where the second-order condition \( \frac{d^2 p}{de^2} K > 0 \) is always fulfilled.

It can easily be shown that an insurance with a fixed copayment rate for preventive care never generates the first-best allocation should this require a positive level of prevention.

**Proposition 4** There is no insurance with a fixed coinsurance rate for preventive expenditures that leads to the first-best allocation if this requires \( e > 0 \).

**Proof:** Reaching the first-best allocation requires that \( X = K \). If thus a full insurance for costs of curative care is chosen, then \( b_v < 1 \) leads to \( e = 0 \). The insured will choose an infinite amount of preventive care if \( b_v > 1 \), while his decision cannot be determined if \( b_v = 1 \).

It is not surprising that, as Spence and Zeckhauser [1971] already claimed, if the insurer can observe prevention, a payoff scheme that leads the insured to choose the level of prevention which minimizes expected costs can always be found. The insurer may simply dictate that benefits for curative care are only paid if the insured purchases the cost-minimizing level of prevention. If, however, compensation for curative care has to be independent of preventive care and a continuous benefit scheme for costs of preventive care has to be employed, a non-linear schedule will also do the trick. Suppose that the insurance pays \( f(e) \) if the consumer chooses prevention that leads to costs amounting to \( e \). The function \( f \) is assumed to be differentiable.
Proposition 5 The first-best allocation will be reached if the insurance has
the features that $X = K$ and $f'(e)$
\[
\begin{cases}
> 1 & \text{if } e < \epsilon_{\text{min}}, \\
1 & \text{if } e = \epsilon_{\text{min}}, \\
< 1 & \text{if } e > \epsilon_{\text{min}},
\end{cases}
\]
where $\epsilon_{\text{min}}$ denotes the level of preventive expenditures which minimizes expected costs of care.

Proof: It is obvious that the first-best allocation requires $X = K$. The first-order condition for an optimal $e$ is
\[
(24) \quad \frac{dp}{de}[u(c^i) - u(c^h)] + [f'(e) - 1][1 - (1 - p)u'(c^h) + pu'(c^i)] = 0.
\]
Since $X = K$ implies that $c^i = c^h$, it follows that $\frac{\partial EU}{\partial c^i} > 0$ for $e < \epsilon_{\text{min}}$
because of $f'(e) > 1$, and $\frac{\partial EU}{\partial c^i} < 0$ for $e > \epsilon_{\text{min}}$ because of $f'(e) < 1$. Thus, the insured will choose $e = \epsilon_{\text{min}}$, and the first-best allocation is reached. □

A consumer with risk aversion does best if he receives full coverage for costs of illness. However, this destroys his incentives to demand preventive care. In order to restore the correct incentives for prevention, a compensation schedule is used where the insured maximizes the difference between compensation and costs of preventive care by choosing the amount of preventive care which minimizes expected costs of care. It has to be noted that if $f(0) \geq 0$ is required, the compensation for prevention costs has to exceed these costs at the optimum, i.e. $f(\epsilon_{\text{min}}) > \epsilon_{\text{min}}$.

The result bears some similarity to the solution in EHRICLICH and BECKER [1972] where there are no benefits for preventive activities. In their paper, the insurance premium can be chosen contingent on the amount of prevention. The first-best allocation is then reached if the insurance premium is always actuarially fair, which implies that the sum of preventive expenditures and insurance premium is minimized at $e = \epsilon_{\text{min}}$.

Proposition 6, which generalizes a result of KAMEN and SCHWARTZ [1973], shows that an allocation close to the first-best allocation can be reached if a very small common copayment rate for both preventive and curative care is employed.

Proposition 6 If there is a common benefit rate $b \in (0,1)$ for both preventive and curative care, i.e. $b = b_v = \frac{X}{K}$, then the level of prevention converges to the cost-minimizing level if $b \to 1$.
Proof: If \( b \in (0,1) \) and \( b \to 1 \), the first-order condition for an optimal \( c \) is

\[
\frac{dp}{de} = \frac{(1 - b)[pu'(c^i) + (1 - p)u'(c^h)]}{u(c^i) - u(c^h)}
\]

reduces to

\[
\frac{dp}{de} = -\frac{1}{K},
\]

since for \( b \to 1 \) it follows that \( u'(c^i) \approx u'(c^h) \approx \frac{u(c^h) - u(c^i)}{c^h - c^i} \). Since (26) is equivalent to (23), the consumer indeed chooses prevention close to the cost-minimizing level if \( b \to 1 \).

Proposition 6 can be interpreted as follows: While approaching the first-best allocation requires a reduction of the copayment for curative care close to zero, a full insurance will destroy the incentives to demand prevention. If a common coinsurance rate is employed, the price ratio of the two kinds of care is kept constant, which, in principle, retains the incentives for prevention. Since the income risk becomes negligible if the common coinsurance rate approaches zero, the consumer's decision on prevention resembles the corresponding decision of a risk neutral individual. It can easily be shown that a risk neutral individual who faces a common coinsurance rate will always choose the cost-minimizing level of prevention because this behavior will maximize his expected income (see also KAMIEN and SCHWARTZ [1973]).

5 Two Kinds of Prevention

In the following a model with two kinds of prevention is considered. The first type of prevention, denoted by \( e_1 \), is observed by the insurer, the second, denoted by \( e_2 \), is not. The insurance premium \( \pi \) can be made contingent on the coverage for cost of curative care \( X \) and on \( e_1 \). In contrast to the basic model, the insurer does not explicitly pay for prevention, but only in case of illness which occurs with probability \( p(e_1,e_2) \). It is assumed that \( p_1, p_2 < 0 \) and \( p_{11}, p_{22} > 0 \). For simplicity, it is assumed that the costs of prevention of both types can be measured in monetary terms.

Expected utility is given by

\[
EU = (1 - p(e_1,e_2))u(w - \pi(e_1,X) - e_1 - e_2) \\
+ p(e_1,e_2)u(w - \pi(e_1,X) - e_1 - e_2 - K + X),
\]
where $K$ denotes the costs of illness. After the insurer has set the premium function $\pi(e_1, X)$, the consumer chooses the coverage $X$ and the levels of prevention $e_1$ and $e_2$.

In order to keep the analysis transparent, the consumer's optimization problem is presented as a multi-stage procedure. At the lower level, $X$, $\pi$ and $e_1$ are given, and the individual maximizes expected utility with respect to $e_2$. At the middle level, the optimal insurance $(X, \pi(X))$ is determined where $e_1$ is treated as being fixed. At the upper level, expected utility is maximized with respect to $e_1$. The main idea behind this approach is that, as it has been shown in the previous section, the insurer can always set incentives by which the level of observable prevention can be fixed. Moreover, as long as $e_1$ is fixed, the model is virtually identical to one of the most prominent models of moral hazard, namely the one discussed in Pauly [1974] and Shavell [1979]. Therefore, the results on the optimal coverage from these papers can, in principle, be applied to the current model.

Before analyzing the multi-stage optimization problem, some remarks on first-best allocations are in order. Total expected costs of illness and prevention are $e_1 + e_2 + p(e_1, e_2)K$. Minimizing these costs leads to the first-order conditions

\begin{align}
1 + p_1 K &= 0, \\
1 + p_2 K &= 0,
\end{align}

from which it follows that $p_1 = p_2$ has to hold at the optimum. The sufficient second-order conditions are

\begin{align}
p_{11} K &> 0, \\
p_{22} K &> 0, \\
K[p_{11}p_{22} - p_{12}p_{21}] &> 0.
\end{align}

While (30) and (31) are always fulfilled, condition (32) requires that the cross derivative is relatively small in absolute terms. The second-order conditions are always fulfilled if $p_{12} = p_{21} = 0$. If $p_{12} > (\prec)0$, the two types of prevention are substitutes (complements). If $p_{12} > \max\{p_{11}, p_{22}\}$ everywhere, then a cost-minimizing prevention implies that only one type is employed. In the boundary case of an additive prevention function, i.e. $p(e_1, e_2) = p(e_1 + e_2)$, a first-best allocation can be reached by means of an insurance with a non-linear premium schedule with respect to $e_1$ which guarantees full coverage.
if the individual selects the cost-minimizing level of $e_1$. If the second-order condition (32) is not fulfilled in case of complements, increasing both types of prevention can lead to lower expected costs. Since a full insurance for costs of curative care will always lead to $e_2 = 0$, a first-best allocation cannot be reached if minimizing total expected costs of care requires a positive level of prevention of the unobservable type.

Given the insurance contract and $e_1$, the first-order condition for maximizing expected utility with respect to $e_2$ is

$$(33) \quad p_2[u(c') - u(c^h)] - [(1 - p)u'(c^h) + pu'(c')] = 0.$$  

The next proposition deals with comparative statics of the unobserved type of prevention. As in the basic model, only partial insurances are considered, i.e. $X < K$. It is assumed that for any given set of insurance parameters and $e_1$ there exists a unique $e_2 > 0$ which maximizes expected utility.

**Proposition 7** Neither $\frac{\partial e_2}{\partial \pi}$ nor $\frac{\partial e_2}{\partial X}$ nor $\frac{\partial e_2}{\partial e_1}$ is determined in sign.

**Proof:** Totally differentiating (33) yields

$$(34) \quad \left[ p_{22}[u(c') - u(c^h)] + 2p_2[u'(c^h) - u'(c')] ight]$$

$$+[(1 - p)u''(c^h) + pu''(c')]de_2$$

$$-[p_2[u'(c') - u'(c^h)] - [(1 - p)u''(c^h) + pu''(c')]]d\pi$$

$$+[p_2u'(c') - pu''(c')]dX$$

$$+[p_2[u(c') - u(c^h)] + [p_1 + p_2][u'(c') - u'(c^h)]]$$

$$+(1 - p)u''(c^h) + pu''(c')]de_1 = 0.$$  

From (34) it follows that

$$\frac{\partial e_2}{\partial \pi} = \frac{p_2[u'(c') - u'(c^h)] - [(1 - p)u''(c^h) + pu''(c')]}{N_{e_2}},$$

$$\frac{\partial e_2}{\partial X} = \frac{p_2u'(c') - pu''(c')}{N_{e_2}},$$

$$\frac{\partial e_2}{\partial e_1} = \frac{Z_{e_1}}{N_{e_2}},$$
with

\[ Z_{e1} = p_{21}[u(c^i) - u(c^h)] + [p_1 + p_2][u'(c^h) - u'(c^i)] 
+ (1 - p)u''(c^h) + pu''(c^i), \]

\[ N_{e2} = p_{22}[u(c^i) - u(c^h)] + 2p_2[u'(c^h) - u'(c^i)] 
+ (1 - p)u''(c^h) + pu''(c^i). \]

While \( N_{e2} \) is negative due to the second-order condition for an optimal choice of \( e_2 \), neither of the three numerators of the fractions on the right-hand sides of (35) - (37) can be determined in sign.

The reasons for the ambiguity of \( \frac{\partial e_2}{\partial \pi} \) and \( \frac{\partial e_2}{\partial X} \) have already been discussed in connection with Proposition 1. An increase in \( e_1 \) has three different effects on the demand for the unobserved type of prevention. First, the efficacy of unobservable preventive care is affected, which influences the marginal gain from an increase in \( e_2 \). If \( e_1 \) is increased and the two types of prevention are substitutes (complements), the efficacy of unobservable prevention falls (rises), which has a negative (positive) influence on the demand for this type of prevention. Second, consumption is reduced in both states, which increases both the gain from a reduction in the probability of turning ill and the loss from a reduction in income. The change in demand for prevention of the unobserved type is ambiguous. Third, the direct reduction of the probability of becoming ill reduces the loss in expected utility from a reduction in income, which stimulates unobserved prevention.

Next, the decision on the insurance coverage and the insurance premium in case of a given level of \( e_1 \) is analyzed.

It is well known that if a linear premium schedule has to be employed, i.e. \( \pi(X) = \sigma X \) with constant \( \sigma \), then a full insurance is chosen, and there will be no demand for prevention of the unobserved type (PAULY [1974]; BREYER [1984]; BREYER and ZWEIFEL [1992]). In this case the insurer will set incentives so that the consumer chooses the level of \( e_1 \) which minimizes expected costs of care subject to \( e_2 = 0 \).

If general fair premium schedules are possible, the insurer's budget equation for a given value of \( e_1 \) can be written as

\[ \pi(X) = p(e_2(X))X, \]

where \( e_2(X) \) is an abbreviation for \( e_2(X, \pi(X)) \). It is assumed that for any \( X \) there is a unique \( \pi(X) \) so that the insurer breaks even. Given the optimal
decision on $e_2$ at the lower level of the optimization problem, being defined by (33), expected utility can be written as

\[ EU(X; e_1) = [1 - p(e_1, e_2(X(e_1), e_1))]u(c^h) + p(e_1, e_2(X(e_1), e_1))u(c') \]

with

\[ c^h = w - \pi(X(e_1), e_1) - e_1 - e_2(X(e_1), e_1) \]

and

\[ c' = w - \pi(X(e_1), e_1) - e_1 - e_2(X(e_1), e_1) + X(e_1) - K. \]

Maximization of (41) with respect to $X$ leads to the optimality condition

\[ pu'(c') - [pu'(c') + (1 - p)u'(c^h)]\frac{\partial \pi}{\partial X} = 0 \]

where

\[ \frac{\partial \pi}{\partial X} = p + Xp_2e_21 \]

and

\[ e_21 = e_2X + e_{2\pi} \frac{\partial \pi}{\partial X}. \]

The next proposition, which is basically due to PAULY [1974] and SHAVELL [1979], shows that moral hazard leads to the result that a full insurance will not be chosen, while the incentive to insure does not vanish completely.

**Proposition 8** If $e_1$ is given, $e_2$ reacts negatively to a compensated increase in the coverage and general fair premiums can be employed, then a partial insurance will be chosen.

**Proof:** From (45) it follows that if prevention of type 2 is reduced due to a higher coverage, then the increase in the premium will exceed $p$ times the increase in the coverage. Then the left-hand side of (44) is differentiable
in $X$ for $X \in (0, K)$, positive for $X \to 0$ and negative for $X \to K$. Thus, a positive coverage will always be chosen, but the coverage will fall short of the costs of illness if additional coverage discourages prevention of the unobserved type.

This result is easy to understand: Should prevention be negatively affected by a higher coverage, an insurance with a nonlinear premium where the consumer chooses a partial insurance has to be employed in order to retain the incentives for prevention.

Now turning to the decision at the upper level of the optimization problem, it is assumed that unique interior solutions at both the lower and the middle level exist, being characterized by (33) and (44). Maximizing expected utility with respect to $e_1$ then leads to the first-order condition

\[ p_1[u'(c^l) - u'(c^h)] - [pu'(c^l) + (1 - p)u'(c^h)](1 + \frac{\partial \pi}{\partial e_1}) = 0 \]  

with

\[ \frac{\partial \pi}{\partial e_1} = [p_1 + p_2 \frac{\partial e_2}{\partial e_1}]X. \]

**Proposition 9** The insurer will promote prevention of the observable type if $\frac{\partial e_2}{\partial e_1} \geq 0$. In contrast, if $\frac{\partial e_2}{\partial e_1} < 0$ holds, the insurer may set incentives in order to restrict prevention of the observable type.

**Proof:** Condition (47) together with the second-order condition for an optimal $e_1$ imply that the insurer will promote (restrict) prevention of the observable type if $\frac{\partial \pi}{\partial e_1} < (>) 0$ holds. From (48), it follows that $\frac{\partial \pi}{\partial e_1} < 0$ holds if $\frac{\partial e_2}{\partial e_1} \geq 0$, while it may turn out that $\frac{\partial \pi}{\partial e_1} > 0$ if $\frac{\partial e_2}{\partial e_1} < 0$.  

If an increase in the observable type of prevention leads to a decrease in the insurance premium, the insurer will set incentives in such a way that the individual chooses a higher level of observable prevention. An increase in $e_1$ influences the insurance premium in two ways: While it directly reduces the probability of becoming ill, which leads to a reduction in the premium, it also influences the choice of the unobservable prevention. This second effect can be negative, particularly if the two types of prevention are substitutes. It cannot be excluded that it even overcompensates the direct effect. In that case the insurer sets incentives in such a way as to guarantee that observable prevention is less than the amount that would be chosen without control.
6 Conclusion

It has been shown that preventive behavior is usually not unambiguously affected by changes in the insurance parameters. It could solely be demonstrated that the demand for prevention rises if an increase in the benefit rate for costs of prevention is accompanied by a corresponding increase in the insurance premium.

If preventive behavior can be observed by the insurer, a first-best allocation can be realized by means of a full insurance for costs of curative care and a non-linear compensation scheme for costs of preventive care. Moreover, an allocation close to the first-best allocation can be reached if a very small common coinsurance rate for both preventive and curative care is employed.

These conclusions do no longer hold if there are non-negligible preventive activities which cannot be observed by the insurer. In that case the insurer will usually supply an insurance with a strictly positive copayment for costs of curative care. Observable prevention type will be encouraged by appropriate incentives if this does not affect the demand for the other type of prevention negatively. If, however, the opposite holds, it may even be the case that the insurer tries to restrict prevention of the observable type.

An interesting extension would be to incorporate the influence of the physician on the demand for prevention of the observable type. Since the profit of the physician is usually positively correlated with his patients' costs of care, the interests of the two parties will in general not coincide. If the physician aims only at maximizing his expected profit, it is not clear whether he tends to recommend a lower or a higher level of prevention than the patient would choose without his advice. Since it is probable that the physician is also interested in the good health of his patients, it is more likely that his advice biases the decision on prevention towards a higher level. This does not necessarily imply that it is a good strategy for the insurer to set incentives towards a lower level of prevention. In such a situation, the physician may support his patient's wish or even recommend a lower demand for prevention in order to increase his expected profit. Thus, it is not obvious how the incentive structure is to be adjusted if the physician's influence is of importance.
References


Gesetz zur Entlastung der Beiträge in der gesetzlichen Krankenversicherung (Beitragsentlastungsgesetz – BeitrEntlG) [1996], Bundesgesetzblatt, Teil I, 1631 – 1633.


Figure 1: Multiple solutions if $\frac{\partial^2 EU}{\partial e \partial \pi} > 0$
Figure 2: Multiple solutions if $\frac{\partial^2 EU}{\partial e \partial \pi} < 0$