Journal of Health Economics 28 (2009) 198–209

Contents lists available at ScienceDirect

Journal of Health Economics

journal homepage: www.elsevier.com/locate/econbase

# Shifted deductibles for high risks: More effective in reducing moral hazard than traditional deductibles

R.C. van Kleef*, W.P.M.M. van de Ven, R.C.J.A. van Vliet

*Institute of Health Policy and Management, Erasmus Medical Centre/Erasmus University, Rotterdam, The Netherlands*

ARTICLE INFO

*Article history:*
Received 5 April 2007
Received in revised form 1 September 2008
Accepted 25 September 2008
Available online 4 October 2008

*JEL classification:*
D84
G22
I10

*Keywords:*
Health insurance
Deductibles
Moral hazard
Health status
Risk

ABSTRACT

In health insurance, a traditional deductible (i.e. with a deductible range [0,$d$]) is in theory not effective in reducing moral hazard for individuals who know (ex-ante) that their expenditures will exceed the deductible amount $d$, e.g. those with a chronic disease. To increase the effectiveness, this paper proposes to shift the deductible range to [$s_i$,$s_i + d$], with starting point $s_i$ depending on relevant risk characteristics of individual $i$. In an empirical illustration we assume the optimal shift to be such that the variance in out-of-pocket expenditures is maximized. Results indicate that for the 10-percent highest risks in our data the optimal starting point of a €1000-deductible is to be found (far) beyond €1200, which corresponds with a deductible range of [1200,2200] or further. We conclude that, compared to traditional deductibles, shifted deductibles with a risk-adjusted starting point lower out-of-pocket expenditures and may further reduce moral hazard.


## 1. Introduction

A major goal of deductibles in health insurance is to reduce moral hazard[1]. However, a traditional deductible, i.e. with a deductible range [0,$d$], is in theory not effective in reducing moral hazard for high-risk individuals who know ex-ante that their expenditures will exceed the deductible amount $d$. These individuals are hardly price sensitive, since cost containment in the deductible range will not prevent them from having the maximum out-of-pocket expenditures at the end of the contract period (usually one calendar year). To increase the effectiveness of a deductible for high risks, we propose to shift their deductible range to [$s_i$,$s_i + d$], with $s_i$ referring to the deductible's starting point for individual $i$.[2] This reduces the probability of *exceeding* the deductible range and thereby increases the price sensitivity below $s_i + d$. At the same time, however, such a shift (also) reduces the probability of *reaching* the deductible range and thereby reduces the price sensitivity below $s_i$. It is realistic to assume that up to a certain starting point the first effect dominates the second, and that for high starting points

* Corresponding author at: Institute of Health Policy and Management (iBMG), Erasmus University, Rotterdam, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands. Tel.: +31 10 408 8950; fax: +31 10 408 9092.
*E-mail address:* vankleef@bmg.eur.nl (R.C. van Kleef).

[1] Existing literature discusses also other motives for deductibles. Schlesinger (2000), for instance, argues that, under a proportional loading fee and risk aversion, a deductible plan is preferred over full coverage. The scope of this study, however, is purely on the moral hazard reduction.

[2] Note that, in principle, a shifted deductible looks like the doughnut-hole deductible in the US Medicare part D (Rosenthal, 2004). The crucial difference, however, is that its starting point is not uniform, but adjusted to the individual's (ex-ante) risk profile. In this conceptual paper we focus on the *principles* of shifted deductibles with a risk-adjusted starting point rather than the implications for particular health care schemes.

0167-6296/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.jhealeco.2008.09.007

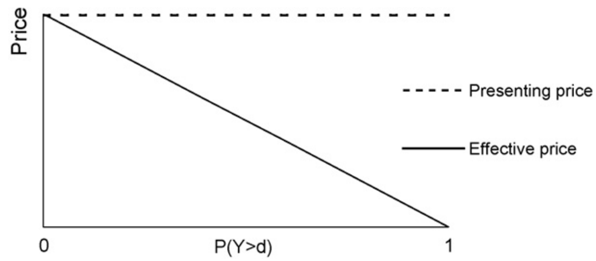


**Fig. 1.** Effective price of a unit of medical care for the consumers in relation to its presenting price and the probability of exceeding *d*.

the second effect is dominant. We assume the optimal shift to be such that the uncertainty about out-of-pocket expenditures is maximized.

In this paper, we primarily focus on the effect of deductibles on ex-post moral hazard (i.e. the positive correlation between medical expenditures and insurance coverage, once a health loss has occurred). Evidence on ex-post moral hazard in health insurance comes from natural experiments, observational comparisons and the (RAND) health insurance experiment. Zweifel and Manning (2000), who summarize the evidence, conclude that, despite variations in estimated price-elasticities among the three sources and according to different types of care, the responsiveness of the demand for medical care to net prices is beyond doubt. We will not focus on the effect of cost sharing on ex-ante moral hazard (i.e. the correlation between insurance coverage and the probability of a health loss to occur) for which the evidence is much weaker.

The goal of this paper is to illustrate the concept of shifted deductibles, both theoretically and empirically. In the theoretical part, we consider the responsiveness to deductibles (Section 2), discuss the limitations of traditional deductibles and introduce the idea of *shifted* deductibles (Section 3). In the empirical part, we illustrate the concept of shifted deductibles with data from a Dutch health insurer (Sections 4 and 5). Finally, we conclude and discuss the findings (Sections 6 and 7).

## 2. Effective prices versus presenting prices

Under a traditional deductible the consumer's price sensitivity is negatively correlated with the probability $p$ of expenditures $Y_i$ to exceed deductible amount $d$, ceteris paribus. The explanation is that the *effective* price of medical care in the deductible range decreases with the probability of having free care later in the contract period[3]. We define the effective price of a unit medical care as its presenting price minus the product of its presenting price and $p(Y > d)$, as illustrated in Fig. 1.

On a given day in contract period $t$, the probability of exceeding the deductible amount in the remainder of $t$ depends on:

1. the amount of medical care already consumed in $t$;
2. the number of days left in $t$;
3. the individual's health status.

In case of *complete* uncertainty about the need for medical care in (the remainder of) $t$, only the first and second determinants are relevant. This means that for an individual who has not yet exceeded deductible $d$, probability $p(Y > d)$ increases with a higher amount of care already consumed in $t$ and decreases with a lower number of days remaining in $t$ (Keeler et al., 1977).

In practice, however, individuals will not always find themselves in a situation of *complete* uncertainty. Some individuals have *planned* medical consumption due to the treatment of a chronic disease, for instance. The higher these planned treatment costs are, the higher will be $p(Y > d)$. If the total price of planned consumption exceeds the (remaining) deductible then $p(Y > d) = 1$.

## 3. Framework

This study focuses on the third determinant mentioned above and considers the consequences of variation in health status for the consumer's price sensitivity under a deductible plan.

[3] This can be illustrated by the following example from Newhouse (1993): "Consider a consumer with 50 percent coinsurance and a $1000 MDE (maximum dollar expenditure). In any contract period this person will have free care after spending $2000 on medical services. Suppose the person knows in advance that he/she will spend at least $2000; then any additional care he/she decides to purchase today is, in effect, free. Alternatively, suppose the person knows that he/she will not spend as much as $2000; then any additional care he/she decides to purchase today will cost 50 cents on the dollar because he/she will not anticipate free care later in the year. This example suggests a simple rule: the price a utility-maximizing consumer on an insurance plan will use to determine whether a visit (say) was worth its cost is the presenting price of the visit (say $20) minus the product of the probability of exceeding the MDE and the presenting price of the visit, thus, if there is a 25 percent chance of exceeding the MDE, the effective price (to the consumer) of a $20 office visit is $15 ($20-$5)."

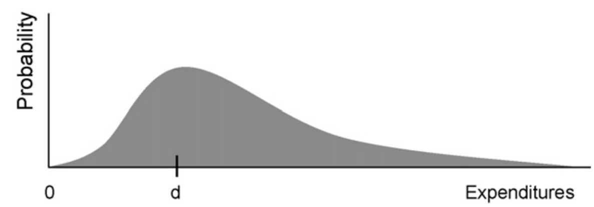


**Fig. 2.** A traditional deductible *d*.

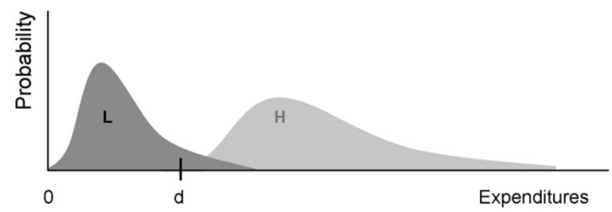


**Fig. 3.** A traditional deductible *d* for low risks L and high risks H.

### 3.1. A traditional deductible

Assume that a group of insured is confronted with a traditional deductible [0,*d*] for a contract period of 1 year. Fig. 2 represents the distribution of annual medical expenditures[4] in this group under full coverage. At group level the introduction of [0,*d*] is expected to *increase* out-of-pocket expenditures and to *decrease* total expenditures (Manning et al., 1987; Keeler et al., 1988; van Vliet, 2004). From a welfare perspective, such a deductible makes sense as long as the welfare gain due to a decrease in total expenditures outweighs the welfare loss due to an increase of uncertainty about future (out-of-pocket) expenditures (Arrow, 1963; Zeckhauser, 1970; Feldstein, 1973; Feldstein and Friedman, 1977; Buchanan et al., 1991). For reasons of simplicity, however, this paper will exclusively focus on the expenditure effects (and thus not on the welfare effects in terms of utility).

If the group is homogeneous in terms of ex-ante health status then the *expected* impact of a traditional deductible [0,*d*] on price sensitivity is equal for all individuals. In other words, they would experience the same effective price for a *certain* unit of medical care on the *first* day of the contract period (given a constant presenting price). Obviously, a moral hazard reduction results in a shift of the expenditure distribution to the left. For reasons of simplicity and given the conceptual nature of this study, we will not incorporate this complicating aspect in the illustrations.

If the group is heterogeneous in terms of ex-ante health status then the (ex-ante) probability of exceeding *d* is not the same for all individuals. Consequently, the *expected* impact of a deductible on the price sensitivity varies among individuals as well. Assume the group to consist of different risk types of which two are shown in Fig. 3, with L being (relatively) low risks and H being (relatively) high risks. Obviously, individuals of type H expect to have expenditures (far) beyond the deductible amount. Even a considerable reduction in the total expenditures, i.e. a considerable shift of the expenditure distribution to the left (relative to *d*), will hardly change that expectation.

This implies that for risk type H the probability of having maximum out-of-pocket expenditures is close to 1, as shown in Fig. 4. For these individuals the effective price of medical consumption below *d* is close to 0, which theoretically results in hardly any price sensitivity.

So, in theory, a traditional deductible is hardly effective for those whose expenditures have a high probability of exceeding the deductible amount. In practice, this is probably the case for those with a chronic disease, who are subject to an expensive treatment program for a long period of time.

### 3.2. Non-uniform cost sharing

From different perspectives Chernew et al. (2000) and Breurer (2005) have recognized the limitations of uniform cost sharing[5], such as traditional deductibles. They advocate that, given a maximum on out-of-pocket expenditures, cost sharing could lead to larger expenditure reductions if it would be *non-uniform*. Chernew et al. (2000) argue that cost sharing should vary with the elasticity of demand. If an individual must inevitably undergo some treatment and there is a choice about specific treatment, then the costs of the cheapest alternative should not be subject to cost sharing since this would not lead to an efficiency gain. Instead, cost sharing should apply to the costs at the margin. A way to do so is charging a co-payment *only*

[4] As far as covered by their insurance.

[5] With cost sharing we mean that insured pay some portion of the covered medical expenditures themselves (U.S. House of Representatives, 1976). The deductible is one form of cost sharing; other forms are coinsurance and copayments, for instance.

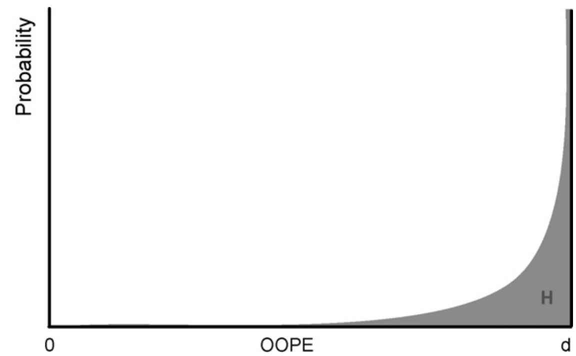


**Fig. 4.** Out-of-pocket expenditures (OOPE) for high risks H under a traditional deductible.

to those choosing a relatively expensive treatment. Simulation results indicate that, for prostate cancer, treatment-specific cost sharing results in a substantial moral hazard reduction. In their conclusion, Chernew et al. (2000) state that probably also the rate of cost sharing should vary across different diseases and treatment alternatives. This is in line with work of Breurer (2005) who argues that the rate of cost sharing should vary with the price sensitivity for each type of loss. The reason is that the possibility of an individual to either prevent the occurrence of a loss or to control its costs varies across (states of) diseases.

Theoretically, cost sharing as proposed by Chernew et al. (2000) and Breurer (2005) can be more effective than uniform cost sharing, given a certain maximum on out-of-pocket expenditures. It has the important practical drawback, however, of severely complicating insurance schedules. Given that real-world insurance schedules tend to be transparent, there seems to be a trade-off between the level of transparency and the positive welfare effects due to differentiated cost sharing (Cutler and Zeckhauser, 2000).

Treatment-specific cost sharing, as proposed by Chernew et al. (2000), has two important requirements that might further complicate the implementation. In the first place, it must be possible to determine ex-ante the costs of each treatment path. In the second place, patients must be well-informed about the clinical consequences of different treatment alternatives in order to make a deliberate choice, which does not just depend on the level of cost sharing (Chernew et al., 2000). In practice, these requirements are unlikely to be met for a wide range of treatments.

### 3.3. Shifted deductibles

The previous consideration and illustrations bring us to a simple alternative to traditional deductibles, which is expected to increase the impact of a deductible on individual *i*'s price sensitivity without substantially reducing the transparency of the insurance schedule. The essence is to shift the deductible range from $[0,d]$ to $[s_i,s_i+d]$, such that the probability of exceeding the range reduces. The framework is schematically shown in Fig. 5. For an individual of risk type H, the deductible is shifted from $[0,d]$ to $[s_H,s_H+d]$, with $s_H$ the expenditure level at which full coverage turns into no-coverage and $s_H+d$ the expenditure level at which no-coverage returns into full coverage.

For risk type H, a shift of the deductible range reduces the probability of having maximum out-of-pocket expenditures, as shown in Fig. 6. This is expected to result in a higher effective price of medical consumption below $s_H+d$ and thereby in a higher impact of $d$ on the price sensitivity.

A crucial question is how far the deductible range should be shifted to maximize the impact of $d$ on price sensitivity. A shift reduces both the probability of exceeding the deductible range $p(Y>s+d)$ and the probability of reaching the deductible range $p(Y>s)$. This implies that, for risk type H, the distribution of out-of-pocket expenditures concentrates to $d$ in case of a traditional deductible (Fig. 4) and concentrates to zero in case of an extreme shift. According to the arguments in Section 2, the price sensitivity will be low in both situations, since there is hardly any uncertainty about (the final level of) out-of-pocket expenditures (in the contract period). We assume the optimal starting point, i.e. the value of $s$ where the impact of a

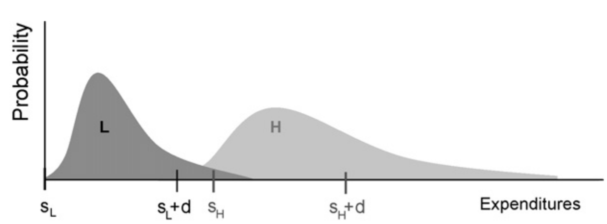


**Fig. 5.** Shifted deductible for high risks H.

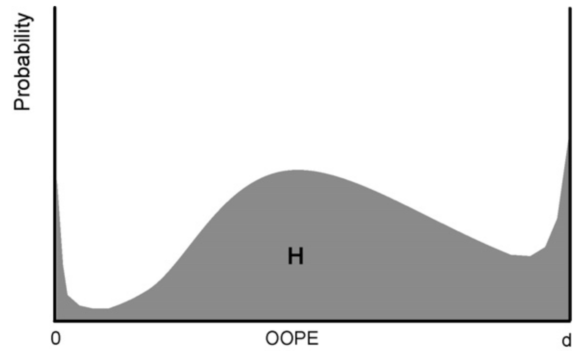


**Fig. 6.** Out-of-pocket expenditures (OOPE) for high risks H under a shifted deductible.

**Table 1**
Descriptive statistics of 1994-medical expenditures in Euros of 2006.

| | |
|---|---|
| *N* | 36408 |
| Mean | 1741 |
| S.D. | 5313 |
| Median | 449 |
| $p(Y=0)$ | 0.048 |

deductible on price sensitivity is at its largest, to be such that the *uncertainty* about the (total) out-of-pocket expenditures in the contract period is maximized.

This brings us to a reasonable criterion for finding the optimal starting point, which is the variance in out-of-pocket expenditures VAR(OOPE). If expected out-of-pocket expenditures $E$(OOPE) are close to either zero or $d$, there is hardly any uncertainty about the final level of out-of-pocket expenditures, which is reflected in a VAR(OOPE) close to zero. Obviously, the uncertainty increases if $E$(OOPE) moves away from these boundaries, which is reflected in an increase of VAR(OOPE). This is illustrated by Fig. 4 (traditional deductible for type H) and Fig. 6 (shifted deductible for type H). The variance in expenditures as a direct measure for uncertainty is not unfamiliar in existing literature. Pratt (1964), for instance, uses it for calculating risk premiums that consumers are willing to pay for insurance apart from their actuarially fair premium.

As mentioned before, a moral hazard reduction results in a shift of the expenditure distribution to the left. Ideally, this effect has to be taken into account if the variance in out-of-pocket expenditures is used to find the optimal starting point. Neglecting this effect results in a non-optimal starting point, which will be too high if the expenditure distribution (used for the estimation procedure) is based on a situation of full insurance and will be too low if the expenditure distribution is based on a situation of no insurance coverage. With respect to the goal of this study, we will, however, not incorporate this correction into our empirical illustration, since this would unnecessarily complicate the exposition.

## 4. Empirical illustration: data and methods

Hence, the concept of shifted deductibles is empirically illustrated using the variance in out-of-pocket expenditures VAR(OOPE) as the criterion for finding the optimal starting point.

### 4.1. Data

The administrative data are from a Dutch insurance company, which was operating under the mandatory sickness fund scheme. This scheme existed until the introduction of the basic health insurance in 2006. The data consist of individual level information on medical expenditures in 1991 through 1994 categorized into expenditures for inpatient care, outpatient care, pharmaceuticals, and others. Costs of medical care provided by a general practitioner are not included[6]. Table 1 shows information on 1994-expenditures (in Euros of 2006) and reveals that 95.2 percent of the insured had positive expenditures. No expenditures are missing since all bills were sent directly from the provider of care to the insurer. All insured ($N$ = 36,408) were 18 years or older.

In the relevant period, all 36,408 individuals had full coverage. As argued in Section 3, this requires that the procedure used to determine the optimal starting point includes a correction for the effect of a moral hazard reduction on the expenditure distribution. With respect to the primary goal of this study, we will, however, not incorporate such a (complicated) correction. Note that this simplification might result in a slight overestimation of the optimal starting point.

[6] This is because of the uniform annual fee that the general practitioner received for each sickness fund member in his practice regardless of medical consumption.

Next to medical expenditures, the dataset includes information on age, gender, hospital days, and health problems. The last were deduced from information on prescribed drugs, e.g. someone having at least four prescriptions for diabetes treatment (on an annual basis) was qualified as diabetic. Similarly, the following health problems and chronic diseases were distinguished: psychosis, COPD (Chronic Obstructive Pulmonary Disease), high cholesterol, heart diseases, inflammations, thyroid disorders, gastric disorders, high blood pressure, and PAD (Peripheral Arterial Disease). In the Netherlands such information is used for categorizing insured into pharmacy-based cost groups (PCG's), which are used in the risk equalization system (Lamers, 1999).

### 4.2. Method

To illustrate the concept of shifted deductibles the data set is assumed to represent a group of individuals who are exposed to deductible $d$ for a contract period of 1 year. For each individual the optimal starting point is deduced with the following four-step procedure:

1. Estimate an expenditure model where medical expenditures $Y$ depend on relevant risk factors;
2. Calculate the expected expenditures $E(Y)_i$ for each individual;
3. Calculate the expected out-of-pocket expenditures $E(\text{OOPE})_i$ and the variance in out-of-pocket expenditures $\text{VAR}(\text{OOPE})_i$ for each individual and for different values of $s$;
4. Find for each individual the optimal starting point where $\text{VAR}(\text{OOPE})_i$ is maximized.

For reasons of transparency we will not include index $i$ in the subsequent equations and description.

#### 4.2.1. Expected expenditures

To calculate the expected expenditures $E(Y)$ we estimated an expenditure model with the actual expenditures in 1994 as the dependent variable. Since $E(Y)$ was finally used to predict out-of-pocket expenditures, which mainly concentrate in the left-tail of the medical-expenditure distribution in case of a traditional deductible and around the centre in case of a shifted deductible, we searched for a statistical model that performed well in these expenditure ranges. We chose not to use a two-part model since only 4.8 percent of the insured had zero expenses. Instead we used a single-equation model taking into account both positive and zero expenses. Testing a normal-, lognormal-, Poisson- and gamma-distribution revealed that the latter fitted the log(expenditures + 1) best. Accordingly, GLM with log-link and a gamma distribution was used. An additional advantage of this model is that predictions do not have to be retransformed to monetary units (Duan et al., 1983; Manning and Mullahy, 2001). As will be shown in Section 4.2.2, this model seemed to be a robust basis for calculating the expected out-of-pocket expenditures.

Explanatory variables for the expenditure model were based on the following information: age, gender, expenditures in $t-1$ (1993) and $t-2$ (1992). 24 dummies were defined to represent age/gender groups and continuous variables were created for log(inpatient costs $t-1$), log(inpatient costs $t-2$), log(outpatient costs $t-1$), log(outpatient costs $t-2$), log(pharmaceutical costs $t-1$), and log(pharmaceutical costs $t-2$). The $R^2$ found for this model equals 0.1745. The estimation results are shown in Table 2.

#### 4.2.2. The variance and expectation of out-of-pocket expenditures under a traditional deductible

Given $E(Y)$, the next step was to calculate the expected out-of-pocket expenditures due to deductible $d$. As shown in Table 2, step 1 provided a value of scale parameter $k$ for which the following relation holds:

$$k = \frac{1}{(cv)^2} \tag{1}$$

with $cv$ the coefficient of variation (= standard deviation divided by mean). Given the estimate of $k$, the expected expenditures of an individual with expenses below a *traditional* deductible $d$ can be calculated according to Eq. (2), derived by van Kleef et al. (2006).

$$E(Y|Y < d) = E(Y) \times \frac{\Gamma(c_d, k+1)}{\Gamma(c_d, k)} \tag{2}$$

with $\Gamma(\cdot)$ the cumulative density function of the gamma distribution with parameters $c$ and $k$ with:

$$c_d = d * \lambda, \quad \text{and} \quad \lambda = \frac{k}{E(Y)} \tag{3}$$

Accordingly, the expected out-of-pocket expenditures in case of a traditional deductible [0,$d$] can be calculated by Eq. (4):

$$E(\text{OOPE})_d = E(Y) * \Gamma(c_d, k+1) + d * (1 - \Gamma(c_d, k)) \tag{4}$$

Table 3 shows that the predicted expenditures below expenditure level $d$ closely agree with the actual expenditures below $d$. Given $E(Y)$, $E(\text{OOPE})_d$, $c_d$, and $k$, the variance in out-of-pocket expenditures VAR(OOPE) with deductible $d$ can be calculated

**Table 2**
Estimation results for medical expenditures using a gamma distribution with log-link ($N = 36{,}408$, $R^2 = 0.1745$).

| | Estimate | S.E. | Chi-square | $p$ |
|---|---|---|---|---|
| Intercept | 4.9728 | 0.0912 | 2971.88 | <.0001 |
| Men 20–24 | 0.3364 | 0.1101 | 9.34 | <.0022 |
| Men 25–29 | 0.3645 | 0.0997 | 13.37 | <.0003 |
| Men 30–34 | 0.4239 | 0.0974 | 18.95 | <.0001 |
| Men 35–39 | 0.5442 | 0.0977 | 31.03 | <.0001 |
| Men 40–44 | 0.5268 | 0.0976 | 29.15 | <.0001 |
| Men 45–49 | 0.7826 | 0.0976 | 64.29 | <.0001 |
| Men 50–54 | 0.7964 | 0.0993 | 64.29 | <.0001 |
| Men 55–59 | 1.0021 | 0.0988 | 102.83 | <.0001 |
| Men 60–64 | 0.9656 | 0.0997 | 93.85 | <.0001 |
| Men 65–69 | 1.4516 | 0.1003 | 209.33 | <.0001 |
| Men ≥ 70 | 1.5482 | 0.0957 | 261.49 | <.0001 |
| Women 18–19 | 0.2531 | 0.1231 | 4.23 | <.0398 |
| Women 20–24 | 0.5441 | 0.1061 | 26.29 | <.0001 |
| Women 25–29 | 0.7563 | 0.0973 | 60.42 | <.0001 |
| Women 30–34 | 0.7544 | 0.0950 | 63.11 | <.0001 |
| Women 35–39 | 0.5614 | 0.0954 | 34.64 | <.0001 |
| Women 40–44 | 0.6469 | 0.0960 | 45.44 | <.0001 |
| Women 45–49 | 0.6704 | 0.0950 | 49.80 | <.0001 |
| Women 50–54 | 0.8170 | 0.0968 | 71.27 | <.0001 |
| Women 55–59 | 0.8723 | 0.0970 | 80.83 | <.0001 |
| Women 60–64 | 1.0485 | 0.0977 | 115.08 | <.0001 |
| Women 65–69 | 1.1682 | 0.0979 | 142.24 | <.0001 |
| Women ≥ 70 | 1.3391 | 0.0929 | 207.68 | <.0001 |
| Log(pharmacy expenditures $t-2$) | 0.0405 | 0.0037 | 117.78 | <.0001 |
| Log(pharmacy expenditures $t-1$) | 0.1127 | 0.0041 | 767.66 | <.0001 |
| Log(outpatient expenditures $t-2$) | 0.0617 | 0.0038 | 262.75 | <.0001 |
| Log(outpatient expenditures $t-1$) | 0.0952 | 0.0040 | 567.81 | <.0001 |
| Log(inpatient expenditures $t-2$) | 0.0406 | 0.0033 | 151.36 | <.0001 |
| Log(inpatient expenditures $t-1$) | 0.0710 | 0.0033 | 473.16 | <.0001 |
| Scale | 0.4346 | – | – | – |

by Eq. (5) (van Kleef et al., 2006):

$$VAR(\text{OOPE})_d = E(Y)^2 * \left(1 + \frac{1}{k}\right) * \Gamma(c_d, k+2) + d^2 * (1 - \Gamma(c_d, k)) - E(\text{OOPE})_d \quad (5)$$

Table 3 shows that the standard deviation of the predicted expenditures in range [0,$d$] estimated with Eq. (5) is in line with the standard deviation of the actual expenditures in range [0,$d$].

#### 4.2.3. *The variance and expectation of out-of-pocket expenditures under a shifted deductible*

In case of a shifted deductible [$s$,$s + d$] the calculation of $E$(OOPE) and VAR(OOPE) is more complicated. Compared to a traditional deductible [0,$d$], a new expenditures range [0,$s$] occurs. Thus, $E(\text{OOPE})_{s,d}$ should be calculated as the expected expenditures in expenditure range [0,$s + d$] minus the expected expenditures in range [0,$s$]. Translating this into Eq. (4) results in Eq. (6):

$$E(\text{OOPE})_{s,d} = E(Y) * (\Gamma(c_{s+d}, k+1) - \Gamma(c_s, k+1)) - s * (\Gamma(c_{s+d}, k) - \Gamma(c_s, k)) + d * (1 - \Gamma(c_{s+d}, k)) \quad (6)$$

with

$$c_s = s * \lambda, \quad \text{and} \quad c_{s+d} = (s + d) * \lambda \quad (7)$$

**Table 3**
Mean of actual and predicted out-of-pocket expenditures (OOPE) and mean of predicted standard deviation (S.D.) with *traditional* deductible $d$.

| $d$ | Actual OOPE (S.D.) | Predicted OOPE | Predicted S.D. |
|---|---|---|---|
| 200 | 170 (60) | 154 | 72 |
| 500 | 360 (182) | 332 | 196 |
| 1000 | 594 (393) | 563 | 397 |
| 2000 | 902 (769) | 891 | 751 |
| 3000 | 1102 (1086) | 1122 | 1044 |

**Table 4**
Mean of actual and predicted out-of-pocket expenditures (OOPE) and mean of predicted standard deviation (S.D.) with a shifted deductible of €1000 and starting point *s*.

| *s* | Actual OOPE (S.D.) | Predicted OOPE | Predicted S.D. |
|---|---|---|---|
| 0 | 594 (393) | 563 | 398 |
| 200 | 499 (436) | 486 | 424 |
| 500 | 406 (447) | 411 | 428 |
| 1000 | 307 (433) | 328 | 414 |
| 2000 | 200 (385) | 230 | 375 |
| 3000 | 148 (346) | 173 | 339 |

Accordingly, $\mathrm{VAR}(\mathrm{OOPE})_{s,d}$ can be calculated by Eq. (8):

$$VAR(\mathrm{OOPE})_{s,d} = E(Y)^2 * \left(1+\frac{1}{k}\right) * (\Gamma(c_{s+d}, k+2) - \Gamma(c_s, k+2)) - 2*s*d*(\Gamma(c_{s+d}, k+1) - \Gamma(c_s, k+1)) + s^2 * (\Gamma(c_{s+d}, k) - \Gamma(c_s, k)) + d^2 * (1 - (\Gamma(c_{s+d}, k)) - E(\mathrm{OOPE})^2_{s,d} \quad (8)$$

Table 4 shows the mean of actual and predicted expenditures in expenditure range $[s,s+d]$ for different values of $s$. Similar to the results in Table 3, the estimated standard deviation of expected expenditures in $[s,s+d]$ is close to the standard deviation of actual expenditures in this range.

Now, the question is how to find the value of $s$ for which $\mathrm{VAR}(\mathrm{OOPE})_{s,d}$ is maximized, given $E(Y)$, $k$, and $d$. As argued above, this value would maximize the uncertainty about the out-of-pocket expenditures and thereby the price sensitivity. From Eq. (8) it is clear that no analytical solution exists for this maximization problem. Therefore, we resorted to a numerical method. This boiled down to an iterative procedure in which $E$(OOPE) and VAR(OOPE) were calculated for a range of values of $s$ until the maximum was found.

### *4.2.4. Determining s for risk group j*

The procedure described above produces a different value of optimal starting point for individuals who differ in terms of the explanatory variables. For reasons of transparency it might be preferred to differentiate the deductible's starting point at group level instead of the individual level. The pros and cons of this alternative are illustrated in Section 5.2 using the following criteria to distinguish among risk groups: the optimal starting point (at individual level) itself, age, and health problems. Obviously, many other risk factors can be used. The optimal starting point for a certain group is simply calculated as the average optimal starting point of all individuals in that group.

## 5. Empirical results

In sum, the first part of the empirical analyses was aimed at finding the optimal starting point for each individual and the second part was aimed at categorizing individuals into risk groups in order to differentiate the starting point at group level. In this section, the results are presented separately.

### *5.1. The optimal starting point at individual level*

For each individual the optimal starting point was calculated for five values of $d$, i.e. €200, €500, €1000, €2000 and €3000. The mean optimal starting point (and standard deviation) equals 939 (1102), 879 (1101), 801 (1094), 675 (1068) and 579 (1033), respectively. The distribution of the optimal starting point per deductible is shown in Table 5. The results reveal three important findings.

For all individuals the deductible range should be shifted to have maximum variance in out-of-pocket expenditures. So, for all individuals the ex-ante uncertainty about out-of-pocket expenditures is higher with a shifted deductible than with a traditional deductible, also for low risks.

**Table 5**
Distribution of the (individual) optimal starting point per deductible *d*.

| Percentile | *d* = 200 | *d* = 500 | *d* = 1000 | *d* = 2000 | *d* = 3000 |
|---|---|---|---|---|---|
| 1 | 73 | 41 | 12 | 2 | 1 |
| 5 | 122 | 81 | 41 | 11 | 2 |
| 10 | 162 | 116 | 64 | 21 | 5 |
| 25 | 271 | 221 | 151 | 71 | 31 |
| 50 | 461 | 411 | 331 | 211 | 125 |
| 75 | 791 | 732 | 645 | 494 | 372 |
| 90 | 1,441 | 1,382 | 1,292 | 1,121 | 971 |
| 95 | 2,081 | 2,031 | 1,936 | 1,761 | 1,591 |
| 99 | 4,294 | 4,241 | 4,151 | 3,971 | 3,791 |
| 100 | 15,921 | 15,864 | 15,773 | 15,592 | 15,411 |

**Table 6**
Mean (S.D.) of out-of-pocket expenditures (OOPE) under a traditional and under a shifted deductible of €1000.

| Optimal starting point at individual level | *N* (%) | Starting point at group level | OOPE traditional | OOPE shifted |
|---|---|---|---|---|
| 0–499 | 66.4 | 0 | 393 (381) | 393 (381) |
| 500–999 | 19.0 | 500 | 721 (302) | 494 (393) |
| 1000–1499 | 6.9 | 1000 | 835 (229) | 513 (378) |
| 1500–1999 | 3.2 | 1500 | 894 (184) | 558 (351) |
| 2000–2499 | 1.6 | 2000 | 917 (155) | 547 (347) |
| 2500–2999 | 1.0 | 2500 | 947 (126) | 514 (357) |
| 3000–3499 | 0.6 | 3000 | 951 (123) | 494 (342) |
| 3500–3999 | 0.4 | 3500 | 958 (112) | 486 (338) |
| 4000–4499 | 0.3 | 4000 | 982 (69) | 515 (329) |
| 4500–15,773 | 0.8 | 4500 | 974 (80) | 571 (314) |

For the relatively high risks the deductible range should be shifted *substantially* in order to achieve maximum variance in out-of-pocket expenditures. For more than 10 percent of the insured, the optimal starting point for a deductible of €1000 (about 57 percent of the overall mean expenditures in the data) is higher than €1200.

An increase of $d$ results in (just) a slight decrease of the optimal starting point. The reason is that medical expenditures in general – and also in our data – are positively skewed. The skewer the distribution, the smaller will be the decrease of the optimal starting point relative to an increase of $d$.

### 5.2. *The optimal starting point at group level*

Alternatively, the deductible's starting point can be differentiated at group level instead of the individual level. This is illustrated below, using the following three factors to distinguish among risk groups: the optimal starting point (at the individual level) itself, age, and health.

Table 6 presents the results for a deductible of €1000 per category of the optimal starting point. Individuals with an optimal starting point between €0 and €500 are given a deductible range of [€0, €1000], those with an optimal starting point between €500 and €1000 are given a deductible range [€500, €1500], and so on. Accordingly, about 66 percent is given a range of [€0, €1000], which is, in fact, a traditional deductible. About 19 percent is given a range of [€500 to €1500], about 7 percent is given [€1000, €2000] and for the remaining 8 percent the range is shifted even further. Table 6 also shows the mean out-of-pocket expenditures for both a traditional and a shifted deductible. These out-of-pocket expenditures are calculated as the actual expenditures in range $[0,d]$ (traditional deductible) and $[s,s+d]$ (shifted deductible) in the original data. Note that these means would probably be lower in case of a moral hazard reduction, due a shift of the expenditure distribution to the left. Nevertheless, these results reveal two important issues.

First, it is evident that a shifted deductible indeed results in an (substantial) increase of variance in out-of-pocket expenditures. So, in theory, the uncertainty about out-of-pocket expenditures is (substantially) higher with a shifted deductible than with a traditional deductible.

In the second place, these results show that the mean out-of-pocket expenditures under shifted deductible concentrate around €500. So, a shift of the deductible range is not just expected to increase the impact on price sensitivity, but also leads to lower out-of-pocket expenditures.

Table 7 presents the average optimal starting point per age group. Differentiating the deductible's starting point according to this criterion has the advantage of being practical and understandable to consumers. From the age of 35 onwards the optimal starting point increases, which is not surprising since the probability of (changing into) a worse health status increases with age.

**Table 7**
Mean (S.D.) of optimal starting point and out-of-pocket expenditures (OOPE) under a traditional and under a shifted deductible of €1000.

| Age group | *N* (%) | Optimal starting point | OOPE traditional | OOPE shifted |
|---|---|---|---|---|
| 18–19 | 3.3 | 135 (189) | 379 (459) | 281 (487) |
| 20–24 | 8.6 | 231 (362) | 418 (540) | 278 (586) |
| 25–29 | 13.2 | 328 (406) | 445 (473) | 277 (508) |
| 30–34 | 12.0 | 367 (377) | 483 (396) | 308 (432) |
| 35–39 | 9.6 | 324 (305) | 476 (360) | 309 (387) |
| 40–44 | 8.8 | 343 (324) | 490 (359) | 322 (386) |
| 45–49 | 9.3 | 431 (412) | 522 (361) | 332 (389) |
| 50–54 | 6.7 | 540 (497) | 565 (353) | 362 (383) |
| 55–59 | 6.4 | 638 (546) | 569 (348) | 339 (374) |
| 60–64 | 5.7 | 753 (720) | 592 (347) | 357 (376) |
| 65–69 | 5.3 | 1225 (1017) | 670 (325) | 351 (370) |
| ≥70 | 11.1 | 1576 (1156) | 727 (288) | 360 (359) |

**Table 8**
Mean (S.D.) of predicted expenditures $E(Y)$, optimal $s_i$, actual expenditures $Y$, and out-of-pocket expenditures (OOPE) under a traditional and under a shifted deductible of €1000.

| Disorder | $N$ (%) | $E(Y)$ | Optimal starting point | $Y$ | OOPE traditional | OOPE shifted |
|---|---|---|---|---|---|---|
| Other | 83.9 | 1415 (1295) | 405 (503) | 1238 (3911) | 459 (383) | 275 (402) |
| Psychosis | 0.5 | 2877 (2085) | 970 (826) | 3131 (4789) | 810 (246) | 507 (370) |
| COPD | 2.1 | 3125 (2340) | 1069 (926) | 3010 (4336) | 885 (205) | 534 (398) |
| High cholesterol | 0.6 | 3757 (2370) | 1316 (940) | 5060 (10373) | 940 (155) | 618 (343) |
| Heart disease | 5.0 | 3851 (2464) | 1355 (976) | 3361 (6260) | 833 (213) | 384 (366) |
| Diabetes | 1.6 | 3870 (2347) | 1362 (931) | 3833 (5606) | 913 (167) | 529 (372) |
| Inflammations | 2.8 | 3954 (2942) | 1397 (1166) | 4258 (6888) | 852 (225) | 483 (385) |
| Thyroid disorders | 0.7 | 4107 (2692) | 1456 (1068) | 4945 (9113) | 841 (208) | 448 (366) |
| Gastric disorders | 1.8 | 4463 (3055) | 1598 (1212) | 5106 (8438) | 930 (162) | 607 (359) |
| High blood pressure | 3.3 | 4516 (2903) | 1618 (1151) | 4469 (7927) | 912 (153) | 466 (365) |
| PAD | 0.8 | 5715 (2980) | 2093 (1183) | 5543 (7921) | 903 (157) | 442 (330) |

**Table 9**
Mean (standard deviation) of out-of-pocket expenditures (OOPE) under both a traditional and shifted deductible of €1000 for 10-percent highest risks.

| Starting point differentiated among | OOPE traditional deductible | OOPE shifted deductible |
|---|---|---|
| Individuals | 913 (161) | 491 (352) |
| Categories of optimal $s$ | 913 (161) | 544 (347) |
| Age groups | 913 (161) | 660 (323) |
| Health problems | 913 (161) | 692 (310) |

In a similar way we differentiated the starting point according to health problems. Table 8 shows the average optimal starting point for psychosis, COPD (Chronic Obstructive Pulmonary Disease), high cholesterol, heart diseases, diabetes, inflammations, thyroid disorders, gastric disorders, high blood pressure, PAD (Peripheral Arterial Disease), and those without any of these health problems[7]. Individuals were identified as suffering from a certain health problem if they had at least four drug prescriptions for treatment of that problem in $t-1$. Three relevant issues can be observed in Table 8.

In the first place, the mean estimated expenditures are not precisely in line with the mean actual expenditures for these groups. This might lead to a biased value of the optimal starting point since the optimal starting point strongly depends on the expected expenditures, as follows from Eqs. (1), (3) and (7) and is evident in Table 8. A simple solution could be to include dummies for these health problems in the expenditure model. Given the number of individuals in our data, we chose not to follow this procedure.

In the second place, these results show a substantial variation in optimal starting points within groups. Thus, a categorization according to health problems seems to be less effective (in terms of uncertainty about out-of-pocket expenditures) than a categorization according to the optimal starting point itself (Table 6). However, for each group a substantial difference in standard deviation can be observed between a traditional and a shifted deductible indicating that uncertainty about out-of-pocket expenditures is substantially higher with a shifted than with a traditional deductible.

In the third place, the optimal starting point for those without any of these health problems is quite high as well, i.e. €405. Apparently, these health-problem categories do not capture all high-risk individuals, which is also evident in the standard deviation of the optimal starting point in the category "other". For two reasons it might be better to have a traditional deductible for this group. First, most individuals in this group will be relatively low risks. Only a few (extremely) high risks have a substantial positive impact on the average optimal starting point. Second, the difference in standard deviation between a traditional and a shifted deductible is only marginal.

Tables 6–8 do not directly indicate the loss of variance in out-of-pocket expenditures when going from a differentiation at individual level to a differentiation at group level. Table 9 shows the mean and standard deviation of out-of-pocket expenditures for the 10-percent highest risks. The classification of high risks was purely based on the expected expenditures. With differentiation at individual level, a shifted deductible results in a drop of the mean out-of-pocket expenditures by €422 and an increase of the variance by a factor 4.8. For a categorization according to the optimal starting point these figures equal €369 and factor 4.6. Using age they are €253 and factor 4.0, and using health problems they are €221 and factor 3.7. So, with the age classification, for instance, one would retain 60 percent of the optimal drop in out-of-pocket expenditures and 85 percent of the optimal increase in variance.

[7] Category "Other" includes individuals without any of the health problems mentioned in the text and also without one of the following health problems: IBD (Inflammatory Bowel Disease), epilepsy, glaucoma, gout, cancer, mood disorders, Parkinson's disease, rheumatism. The latter health problems were not included in the result section since the data did not contain sufficient numbers of individuals suffering from these health problems. Note that the sum of $N$ can exceed 100 percent due to co-morbidity.

## 6. Conclusion

A traditional deductible is in theory not effective in reducing moral hazard for high-risk individuals who know (ex-ante) that their expenditures will exceed the deductible amount *d*. These individuals have no incentive for cost-containment, since their probability of having the maximum out-of-pocket expenditures is (nearly) 1. To increase the effectiveness of a deductible, this paper proposes to shift the deductible range from [0,*d*] to $[s_i, s_i + d]$ with starting point $s_i$ depending on relevant risk characteristics of individual *i*. We conclude that such a shift reduces out-of-pocket expenditures and may lower total health care expenditures (because of reduced moral hazard).

Although the optimal starting point in our empirical illustration might be (slightly) overestimated, five important conclusions can be drawn from our empirical illustration. First, the deductible range for high risks should be shifted substantially in order to have maximum uncertainty about expected out-of-pocket expenditures. For the 10-percent highest risks in our data the optimal starting point of a €1000-deductible is to be found (far) beyond €1200, which corresponds with a deductible range of [1200,2200] or further. Second, the optimal starting point is higher than zero for all individuals, including the low risks. The reason is that the distribution of medical expenditures is positively skewed. However, for low risks the optimal starting point for (relatively) high deductibles is close to zero. Third, the optimal starting point is only slightly affected by a change in deductible amount. Again, the explanation is found in the positive skewness of the medical expenditure distribution: the skewer the distribution the smaller the decrease of the optimal starting point relative to the increase of *d*. Fourth, the optimal starting point heavily depends on the expected expenditures. This implies that the calculation of the optimal starting point will be biased in case of a poor expenditure model. A final conclusion is that differentiation of the starting point at individual level is better, with respect to the variance in out-of-pocket expenditures, than a differentiation at group level. On the other hand, a differentiation at group level might be preferred for reasons of transparency. The total number of risk groups represents a trade-off between the effectiveness of the deductible and transparency. A differentiation according to age groups, however, is rather transparent and is expected to have a substantially higher impact on price sensitivity than a traditional deductible.

## 7. Discussion

This paper shows that shifted deductibles make more sense, from a theoretical point of view, than pure traditional deductibles. A number of other aspects, however, deserve further elaboration. The main issues are: the criterion used to determine the optimal starting point, the correction for moral hazard reduction, the effects of shifted deductibles on ex-ante moral hazard, and equity aspects.

In this study the criterion for finding the optimal starting point reflects the uncertainty about out-of-pocket expenditures. This requires an expenditure model that accurately predicts the expenditures and correctly reflects how the variance is related to the mean. More practical criteria to determine the starting point could be the median or mean of expenditures (in a certain risk group, e.g. age group or health group). From a theoretical point of view, however, such criteria make less sense than the criterion used in this study.

The estimation procedure in the empirical illustration is based on an expenditure distribution under full insurance coverage. Ideally, this procedure requires a correction for the effect of moral hazard on the expenditure distribution. For reasons of simplicity (and given the conceptual nature of this study) we chose not to incorporate such a correction. This simplification presumably results in a slight overestimation of the optimal starting point. In order to apply an appropriate correction, one needs an accurate picture of how deductibles affect the expenditure distribution. While existing literature offers some evidence on this issue for traditional deductibles, further research is needed to examine the change in the expenditure distribution under shifted deductibles.

This paper primarily focuses on the effect of deductibles on ex-post moral hazard. Compared to full coverage, a deductible increases the price of medical consumption experienced by the consumer, which is expected to result in a reduction of medical expenditures. We argued that, at least for high-risk individuals, the effective price of medical consumption is higher under a shifted deductible than under a traditional deductible. Accordingly, it is to be expected that a shifted deductible is more effective in reducing ex-post moral hazard than a traditional deductible. Theoretically, this might also be true for ex-ante moral hazard (as far as this form is relevant in health insurance): for a chronically ill with annual treatment costs of about €2000 a shifted deductible [2000,3000] may imply a stronger financial incentive to avoid future losses than a traditional deductible [0,1000]. In this respect, a shifted deductible with a risk-adjusted starting point might in practice serve as a substitute for the traditional "first-dollar deductible followed by coinsurance", which is in theory the optimal *uniform* co-payment scheme to reduce both ex-ante and ex-post moral hazard (Winter, 2000).

Our final remark concerns equity. Ceteris paribus, a deductible with a shifted starting point related to health risk factors reduces the difference in out-of-pocket expenditures between low-risk and high-risk individuals. This implies that, under a community-rated insurance premium, the implicit cross-subsidies between these groups are higher with a shifted deductible than with a traditional deductible. This aspect might be of particular interest for social health insurance schemes, since the loss of implicit cross-subsidies is often used as an argument against (higher) mandatory traditional deductibles.

## Acknowledgements

The authors gratefully acknowledge the valuable comments from peer review and the comments of Roger Feldman at the ASHE-conference in Durham 2008. Remaining errors are ours.

## References

Arrow, K.J., 1963. Uncertainty and the welfare economics of medical care. American Economic Review 53, 941–973.
Breurer, M., 2005. Multiple losses, ex ante moral hazard, and the implications for umbrella policies. The Journal of Risk and Insurance 72, 525–538.
Buchanan, J.L., Keeler, E.B., Rolph, J.E., Holmer, M.R., 1991. Simulating health expenditures under alternative insurance plans. Management Science 37, 1067–1090.
Chernew, M.E., Encinosa, W.E., Hirth, R.A., 2000. Optimal health insurance: the case of observable, severe illness. Journal of Health Economics 19, 585–609.
Cutler, D.M., Zeckhauser, R.J., 2000. The anatomy of health insurance. In: Culyer, A.J., Newhouse, J.P. (Eds.), Handbook of Health Economics. Elsevier North Holland, Amsterdam, pp. 564–629 (chapter 11).
Duan, N., Manning, W.G., Morris, C.N., Newhouse, J.P., 1983. A Comparison of alternative models for the demand for medical care. Journal of Business and Economic Statistics 1, 115–126.
Feldstein, M.S., 1973. The welfare loss of excess health insurance. Journal of Political Economy 81, 251–280.
Feldstein, M.S., Friedman, B., 1977. Tax subsidies, the rational demand for health insurance, and the health care crisis. Journal of Public Economics 7, 155–178.
Keeler, E.B., Newhouse, J.P., Phelps, C.E., 1977. Deductibles and the demand for medical care services: the theory of a consumer facing a variable price schedule under uncertainty. Econometrica 45, 641–656.
Keeler, E.B., Buchanon, J.A., Rolph, J.E., Hanley, J.M., Reboussin, D.M., 1988. The demand for episodes of medical treatment in the Health Insurance Experiment, RAND Report R-3454-HHS, CA, Santa Monica.
Lamers, L.M., 1999. Pharmacy cost groups: a risk-adjuster for capitation payments based on the use of prescribed drugs. Medical Care 37, 824–830.
Manning, W.G., Mullahy, J., 2001. Estimating log models: to transform or not to transform? Journal of Health Economics 20, 461–494.
Manning, W.G., Newhouse, J.P., Duan, N., Keeler, E.B., Leibowitz, A., Marquis, M.S., 1987. Health insurance and the demand for medical care: evidence from a randomized experiment. The American Economic Review 77, 251–277.
Newhouse, J.P., 1993. Free for all? Lessons from the RAND Health Insurance Experiment. Harvard University Press, Cambridge, Massachusetts.
Pratt, J.W., 1964. Risk aversion in the small and the large. Econometrica 32, 122–136.
Rosenthal, M.B., 2004. Doughnut-Hole economics. Health Affairs 23 (6), 129–135.
Schlesinger, H., 2000. The theory of insurance demand. In: Dionne, G. (Ed.), Handbook of Insurance. Kluwer Academic Publishers, Boston, pp. 131–151 (chapter 5).
U.S. House of Representatives, 1976. A discursive dictionary of health care. Prepared by the staff for the use of the subcommittee on 'health and the environment' of the committee on 'interstate and foreign commerce'.
van Kleef, R.C., van de Ven, W.P.M.M., van Vliet, R.C.J.A., 2006. A voluntary deductible in social health insurance with risk equalization: "Community-rated or risk-rated premium rebate?". The Journal of Risk and Insurance 73, 529–550.
van Vliet, R.C.J.A., 2004. Deductibles and health care expenditures: empirical estimates of price sensitivity based on administrative data. International Journal of Health Care Finance and Economics 4, 283–305.
Winter, R.A., 2000. Optimal Insurance under Moral Hazard. In: Dionne, G. (Ed.), Handbook of Insurance,. Kluwer Academic Publishers, Boston, pp. 155–186 (chapter 6).
Zeckhauser, R.J., 1970. Medical insurance: a case study of the trade-off between risk spreading and appropriate incentives. Journal of Economic Theory 2, 10–26.
Zweifel, P., Manning, W.G., 2000. Moral hazard and consumer incentives in health care. In: Culyer, A.J., Newhouse, J.P. (Eds.), Handbook of Health Economics. Elsevier North Holland, Amsterdam, pp. 409–459 (chapter 8).