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Economic Policy Analysis

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Our results suggest that lowering or abolishing the voluntary deductible in the Netherlands would modestly increase total healthcare expenditures and would improve risk solidarity to a small extent.

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Selection and Moral Hazard Effects in Healthcare*

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In the Netherlands, average healthcare expenditures of persons without a voluntary deductible are twice as high as average healthcare expenditures of persons with a voluntary deductible. When assessing the effects of voluntary cost-sharing in healthcare on healthcare expenditures, it is important to disentangle moral hazard from selection: are healthcare expenditures low because people pay (a bigger share of) their healthcare expenditures out-of-pocket? Or are people with higher cost-sharing levels healthier? In this study, we separate selection from moral hazard for the combined mandatory and voluntary deductible in the Netherlands. We use proprietary claims data from Dutch health insurers and exploit with a panel regression discontinuity design that we can observe healthcare expenditures before and after the deductibles kick in for 18 year olds. Our study shows that selection, not moral hazard, is the main effect explaining the difference in healthcare expenditures between persons with and without a voluntary deductible. Furthermore, we find that 18 year olds who never chose a voluntary deductible reduce their healthcare spending by 26 euros (on average) in response to a 100 euro increase in the (mandatory) deductible. However, for 18 year olds who chose a voluntary deductible (on top of the mandatory) we find that this choice does not result in a further reduction in healthcare spending. For the full population, we use a panel regression and find that for people who chose a voluntary deductible (on top of the mandatory) that a 100 euro increase in the deductible leads to an average reduction in healthcare spending of 25 euros per person. For the population as a whole these results suggest that lowering or abolishing the voluntary deductible in the Netherlands would modestly increase total healthcare expenditures and would improve risk solidarity to a small extent.

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1. Introduction

This paper separates the moral hazard and selection effects of a voluntary deductible scheme using Dutch individual claims data of all inhabitants in the Netherlands for the period 2008-2013. In the Netherlands, (basic) health insurance is mandatory and features a mandatory deductible. On top of the mandatory deductible, people can choose a voluntary deductible. Healthcare expenditure for people with a voluntary deductible is lower than for people with (only) a mandatory deductible. This could be due to two effects. First, a selection effect: low-risk individuals with low expected healthcare expenditures are more likely to opt for voluntary cost-sharing than high-risk individuals with high expected expenditures (Cutler and Zeckhauser, 2000). Second, a moral hazard effect: higher cost-sharing increases the price of healthcare, and leads to lower healthcare demand (Zweifel and Manning, 2000). With a panel regression discontinuity design we separate selection and moral hazard effects.

The motivation for our paper is the public debate in the Netherlands on whether the voluntary deductible should be abolished or not. Currently, the Dutch have a mandatory deductible of 385 euros for all individuals over 18 years old. On top of this mandatory deductible, each individual above 18 years old can opt for a voluntary deductible of either 100, 200, 300, 400 or 500 euros. In return, they receive a discount on their health insurance premium. Below 18, people face neither a mandatory nor a voluntary deductible. Three questions play a central role in the debate. First, to what extent are persons with and without a voluntary deductible different? We answer this question by disentangling moral hazard and selection effects. Second, how much will healthcare spending increase if the voluntary deductible is abolished? This boils down to the extent to which a voluntary deductible reduces healthcare expenditures. If this moral hazard effect is substantial, abolishing voluntary deductibles may lead to a large increase in healthcare expenditures. Third, if there is (adverse) selection resulting from the voluntary deductible: does it distort health insurance prices? Dutch policymakers worry that high-risk individuals, such as the chronically ill, pay a higher price for their insurance *because* of this selection effect of the voluntary deductible. The argument goes that high-risk individuals, for whom a voluntary deductible is unprofitable, partly finance the discount in premiums that low risk individuals with a voluntary deductible receive.

It is empirically challenging to disentangle selection and moral hazard effects (Bajari et al., 2014; Trottmann et al., 2012; Geruso and Layton, 2017). Randomized control experiments, such as the RAND and Oregon experiment (Newhouse, 1993; Finkelstein et al., 2012; Chiappori et al., 1998) are less suited as the idea of randomization is to remove endogenous choice, and thus selection, problems. That is, in such an experimental set-up there is no selection effect to

start with. The majority of papers analyzing non-experimental data remove selection by using econometric techniques such as instrumental variables (examples are Eichner (1998); Trottmann et al. (2012); Van Vliet (2004)) or by using a structural model (Bajari et al., 2014; Gardiol et al., 2008). These approaches often require restrictive assumptions. Bajari et al. (2014) and Einav et al. (2013) measure and visualize selection by showing the distribution of health status and expected health risks parameters across multiple health plans.

The identification strategy of our study relies on the introduction of cost-sharing in the Netherlands at age 18, which allows for a quasi-experimental regression discontinuity design. We add a panel dimension to a regression discontinuity design and include time and individual fixed effects to capture factors other than the deductible that may affect healthcare expenditure, such as policy changes or health status. We also control for other potential shocks at 18 that may affect healthcare expenditure. Einav et al. (2013) also use a quasi-experimental design, a differences-in-differences approach, with a structural model. The regression discontinuity design used in this paper, yields straightforward estimation and visualization of the selection effects and reductions in moral hazard caused by cost sharing. A regression discontinuity design is not possible for an analysis of the total population. As a result, we use a panel regression design that exploits annual variation in the size of the voluntary deductibles.

We find that average healthcare expenditures for persons who have never chosen a voluntary deductible are almost twice as high at age 18 as average healthcare expenditures of persons who have chosen a voluntary deductible at least once. This difference is mainly the result of selection, not moral hazard. Moreover, we find that persons who have never chosen a voluntary deductible reduce their healthcare spending at age 18 by 26 euros (on average) in response to a 100 euro increase in the (mandatory) deductible. However, for persons who have chosen a voluntary deductible at least once we find on average no response at age 18 to an increase in the (mandatory plus voluntary) deductible.

For the full population, we find that lowering or abolishing the voluntary deductible will not increase healthcare spending by a large amount. Second, we find some evidence of a distortion in prices in the sense that individuals without a voluntary deductible –who tend to be high risk– pay a higher price for insurance because of the existence of a voluntary deductible. When abolishing the voluntary deductible, one also needs to consider that people differ in their degree of risk aversion. People who tend to be less risk averse benefit from the option of choosing a high (voluntary) deductible. This benefit disappears when the voluntary deductible is abolished.

Our work is related to a large body of literature on moral hazard, adverse selection and demand-side cost-sharing in healthcare. For excellent overviews of the literature, we refer to Baicker and Goldman (2011); McGuire (2012); Geruso and Layton (2017) and Einav and Finkel-

stein (2018). In many adverse selection papers, such as Bajari et al. (2014); Einav et al. (2013); Cutler and Reber (1998), endogenous contracts complicate the analysis as contracts differ in a number of dimensions.[1] In our case, the endogenous contract dimensions are limited, because the coverage of the mandatory (basic) healthcare plans across the Dutch population only differs by the level of the deductible. The treatments covered by basic insurance are set by the government, not by the insurers. Insurance contracts can differ in their provider networks, but these differences are small in the period that we analyze.

There are several Dutch papers on this topic. Van Vliet (2004) studies the reduction of moral hazard due to the voluntary deductible. He estimates a price elasticity of -0.14 and uses prior pharmaceutical costs as a proxy for health status to control for adverse selection.[2] His results however only apply to privately insured individuals with a voluntary deductible in the 1990s, whereas we use data from the current healthcare system which was introduced in 2006 (see section 2). Oortwijn et al. (2012) estimates that the introduction of the mandatory deductible in the Netherlands in 2008 led to a reduction of healthcare expenditure between 2.6 and 7.3 percentage points. Klein et al. (2018) find that persons spend on average roughly 36 percent less on healthcare before they hit the mandatory deductible limit than in the months after exceeding the deductible. They omit persons with a voluntary deductible which are the focus of our analysis. Similar to our paper Croes et al. (2018) show that selection effects are present in the voluntary health insurance. Moreover they find that individuals with a voluntary deductible are overcompensated by the risk adjustment system. The paper does not disentangle moral hazard from selection effects, nor estimate moral hazard effects as we do in this paper. Remmerswaal et al. (2019, forthcoming) is related to this paper as the same data and the discontinuity at 18 is used to study the effect of different cost-sharing schemes on healthcare expenditure; a deductible vs. a rebate. The authors deal with selection effects by omitting persons who chose a voluntary deductible (at least once) entirely from the analysis. This paper builds on Remmerswaal et al. (2019, forthcoming) to address selection effects.

Section 2 describes the institutional setting of the Dutch healthcare sector. Section 3 explains our administrative data set and provides several descriptive statistics. We describe our empirical strategy in section 4 and present our results in Section 5. Section 6 extends the analyses to the full population and presents policy analyses. We conclude in Section 7.

[1] In the United States for example, selection may also occur from having "no insurance". The majority of the American body of literature was conducted before the introduction of the Patient Protection and Affordable Care Act, and thus before trying to introduce mandatory health insurance.

[2] Pharmaceutical costs were at the time covered by a separate insurance scheme, free from cost-sharing.

2. Institutional setting

The Dutch curative healthcare sector is characterized by regulated competition, which is written down in the Health Care Act. There is competition among private health insurers and among healthcare providers (van de Ven and Schut, 2008). To safeguard solidarity and access to care, the government set up a mandatory basic benefit package for all Dutch citizens.[3]

All inhabitants of the Netherlands, except children up to the age of 18, pay for healthcare costs in three ways. The first part is an health insurance premium that individuals pay directly to their health insurer. Annual premiums are between 1,000 to 1,250 euros, see appendix A.1). A person with a low income can receive an income dependent subsidy to pay for his or her health insurance premium. The second part is an income dependent fee, which the tax collector levies on an individual basis. These income dependent fees must cover exactly 50 percent of total health expenditures in the Netherlands. The last part is cost-sharing.

In 2008, the government introduced a mandatory deductible of 150 euros.[4] Since 2008 the deductible has been increased each year; see Table 1.[5]

Table 1: Deductibles in the Netherlands for 2008-2013

year	2008	2009	2010	2011	2012	2013
mandatory (€)	150	155	165	170	220	350
voluntary (€)	100, 200, 300, 400, or 500					

In addition to the mandatory deductible, an individual can opt for a voluntary deductible of maximally 500 euros on top of the mandatory deductible. To illustrate, if a person chooses a voluntary deductible of 500 euros in 2013, he or she faces a *total* deductible of 850 euros. In return for choosing the higher deductible, individuals pay a lower premium. Insurers are free to determine the size of this premium discount, but on average the discount for a 100 euro voluntary deductible was 45 euros and for a 500 euro voluntary deductible 230 euros in 2013. In 2013, about 10% of the Dutch population chose a voluntary deductible (see Appendix A.4).

The deductible applies to nearly all health services in the basic benefit package, such as hospital care, physiotherapy and pharmaceutical care. Only primary care, maternal care, obstetric

[3]The Health Care Act has been in place since 2006. Before 2006, there was no regulated competition in Dutch curative healthcare. Insurance was only obligatory for persons with a low or middle income, but not for persons with a high income. The latter often opted for health insurance at a private insurer.

[4]Remmerswaal et al. (2019, forthcoming) compare the effect of the rebate (which was in place in 2006 and 2007) and deductible in Dutch healthcare. They show that a deductible causes a larger reduction in healthcare expenditure than a rebate of similar magnitude.

[5]The mandatory deductible was increased further in 2014 to 365 euros, 375 euros in 2015, 385 euros in 2016, and 385 euros in 2017 and 2018 as well. As we only have data for 2008-2013, Table 1 shows the deductibles for these years.

care, and GP care are exempted.[6] The basic package is determined each year by the government and its coverage is the same for all citizens.[7] There have been changes in coverage over time. Remmerswaal et al. (2019, forthcoming) provide a summary table of changes in the basic benefit package and other policy changes during the period of our study.

Individuals can choose to buy supplementary insurance to cover healthcare that is not part of the basic benefit package, for example alternative medicine, glasses, contact lenses and cosmetic surgery. Supplementary insurance is however offered independently from the basic package, which means that persons are not required to buy basic and supplementary insurance from the same insurer.[8] We focus on the basic insurance market and do not consider supplementary insurance. Re-insuring the deductible is allowed in special circumstances, for example for seasonal workers or people with a very low income. However, under 1.5 percent of the population has re-insured his or her deductible (Nederlandse Zorgautoriteit, 2014).

3. Data and descriptive statistics

3.1. Data

Proprietary healthcare claims data from Vektis are available for this study.[9] The data cover all, roughly 17 million, insured inhabitants in the Netherlands between 2006 and 2013. After cleaning and excluding the years 2006 and 2007 (when there was a rebate in place, not a deductible), we retain 97 million observations.[10]

The data do not suffer from underreporting of healthcare claims.[11] It is a common problem with claims data that people with little healthcare expenditure do not bother to claim their bill to their insurer, because they do not expect to be compensated as they have not exceed their deductible. In our data however, healthcare providers are motivated to report *all* costs directly to patients' health insurers: the providers are only reimbursed if they report the costs to their patient's health insurer. Healthcare providers send their bills to the insurer electronically, who subsequently will bill the patient (if the deductible is not exhausted).

[6] These cost categories comprise a small share of healthcare expenditure.

[7] There exist small differences in basic benefit packages –not in terms of coverage but provider networks can differ between insurers (Nederlandse Zorgautoriteit, 2014).

[8] Over 85 percent of the Dutch population bought supplementary health insurance in our data period (Nederlandse Zorgautoriteit, 2014).

[9] Vektis is a private organization that gathers and manages data for all Dutch health insurers. The data are pseudonymized and not publicly available.

[10] The data cleaning steps are described in Appendix A.2. The same data and a similar data preparation are used in Remmerswaal et al. (2019, forthcoming).

[11] Vektis also supports this claim.

The data include total annual healthcare expenditure for each individual in the Netherlands. The timing of spending within the year is unknown to us, as only annual expenditure data are available. In addition, we know the composition of total healthcare expenditure by healthcare category, such as hospital care, dental care, physiotherapy, et cetera.[12]

An individual's annual choice of a voluntary deductible is available. Based on these choices, we construct a binary variable which is 1 if an individual chose a voluntary deductible at least once, and 0 if this is not the case.[13] Note that this binary variable, unlike the voluntary deductible choice itself, can also be 1 for a person under 18 years old, if he or she has chosen a voluntary deductible (in our data set) after turning 18. Based on this binary variable, we create two groups: group 'at least once a voluntary deductible' and group 'never a voluntary deductible'. We compare healthcare expenditures of these two groups before and after they turn 18 (when the deductibles kick in).

Our data also include person characteristics such as sex, age, indicators of chronic use of care and medication, and a four digit postal code. Age is reported in years and for December 31st in every year.[14] DCG stands for diagnosis cost group ('diagnosekostengroep') and is a binary variable that indicates whether a person is chronically ill and had high healthcare costs in the previous years.[15] PCG, an abbreviation of pharmaceutical cost group ('farmaciekostengroep'), indicates whether a person uses medication chronically. Using the four digit postal code, we can link to each observation the average standardized disposable household income in a postal code area from Statistics Netherlands.[16]

All persons with mental healthcare expenditure between 2008 and 2013 are excluded, because the mental healthcare sector faced additional changes in cost-sharing in 2012 (see Remmerswaal et al. (2019, forthcoming) for a list of policy changes). Between 2008 and 2011, dental care coverage also changed in a different way for persons above and below 18. We do not delete all individuals who use dental care, because almost all inhabitants use dental care and dental costs are low. Therefore, we do not include dental expenditure in our dependent variable: healthcare expenditure under the deductible. We verify in the robustness analyses that these choices do not

[12] Appendix A.5 includes a list of all categories.

[13] To construct these groups we used additional information from 2006 and 2007 and coded an individual with '1' if he or she chose for a voluntary deductible in 2006 or 2007 but not in 2008-2013.

[14] A person who becomes 18 on December 1st in 2013 is classified as being 18 years old in 2013, even though he or she was 17 years old for 11 months that year.

[15] DCG and PCG are variables from the Dutch risk adjustment system, which aim to identify chronic disorders that will lead to high healthcare expenditures.

[16] Average standardized disposable household income is gross household income from which taxes and premiums for public insurance policies have been deducted. It has been standardized for differences in size and households compositions. In our data set, there are on average 3,130 persons per four digit postal code.

affect our results. The main dependent variable in this study is total healthcare expenditure for healthcare services for which the deductible applies, but without dental healthcare costs. From hereon, we will refer to this variable as healthcare expenditure under the deductible. See Table A.5 for details on the cost categories that are included in this variable.

In most of our analyses, we follow Remmerswaal et al. (2019, forthcoming) and select all persons aged 15 to 21, but 18 year olds are excluded. The argument for excluding 18 year olds is that the exact date of birth is not available in the data. Therefore, within a year we cannot differentiate a person who turns 18 on January 1st from a person who turns 18 on December 31st (the former person has the deductible for almost the entire year while the latter does not face a deductible at all). By removing 18 year olds from the sample, we reduce the possibility of anticipation and substitution effects.

To sum up, for our main analysis we study young adults between 15 and 21 years old (18 year olds are excluded), who did not have any mental healthcare expenditures in the period 2008-2013. We compare two groups, people who did not choose a voluntary deductible at all and people who did choose a voluntary deductible at least once, and follow them before and after they turn 18 years old.

Table 2: Summary statistics of the baseline sample

	Never a voluntary deductible		*At least once a voluntary deductible*	
	15-17 years	19-21 years	15-17 years	19-21 years
Healthcare expenditure under deductible (€)	557 (3,719)	589 (3,294)	324 (1,315)	322 (1,672)
Of which:				
Hospital care (€)	373 (3,211)	436 (2,866)	219 (1,098)	247 (1,546)
Physiotherapy (€)	40 (156)	8 (110)	28 (115)	4 (69)
Pharmaceutical care (€)	89 (1,289)	97 (1,101)	51 (497)	49 (313)
Other care (€)	55 (679)	48 (506)	25 (245)	21 (217)
Age (years)	16 (0.82)	20 (0.82)	16 (0.79)	20 (0.81)
Male (%)	0.51 (0.50)	0.52 (0.50)	0.53 (0.50)	0.54 (0.50)
Diagnosis cost-related group (%)	0.01 (0.09)	0.02 (0.13)	0.00 (0.06)	0.01 (0.08)
Pharmaceutical cost-related group (%)	0.02 (0.15)	0.03 (0.16)	0.01 (0.10)	0.01 (0.10)
Household income quintile	3.21 (1.37)	2.92 (1.43)	3.39 (1.30)	3.00 (1.45)
Average deductible level (€)	0 (0)	201 (70)	0 (0)	398 (247)
Number of observations	2,521,889	2,369,686	319,827	700,922

Notes: Standard deviations are reported between parentheses. Healthcare services category 'other care' combines paramedical care, medical aids, transportation costs of persons lying down and for seated persons, care that is provided over the Dutch borders, geriatric revalidation and other healthcare costs which are not part of the cost categories in appendix A.5. Household income quintiles range from 1 to 5, where quintile 1 refers to the households with the lowest incomes and household quintile 5 to households with the highest incomes. The differences between all characteristics of 15-17 year olds and 19-21 year olds of group 'Never a voluntary deductible' are all significant at a 1% significance level. These extremely small p-values are a result of the large sample size: even very small differences are highly significant.

3.2. Descriptive statistics

Table 2 describes the baseline sample, divided into 15-17 year olds (who do not face a deductible) and 19-21 year olds (who do face a deductible), and persons who never chose a voluntary deductible (group *never*) and persons who chose a voluntary deductible at least once (group *at least once*). Individuals in group *never* have, as expected, higher healthcare expenditure than those in group *at least once*: healthcare expenditure of 19 to 21 year olds in the former group is on average 589 euros, whereas for the latter it is 322 euros which is 267 euros less. Looking at 15 to 17 year olds, we see that this difference in healthcare expenditure already manifests itself before the deductibles kick in: healthcare expenditure of 15 to 17 year olds in group *never* is on average 557 euros, 233 euros higher than healthcare expenditure of 15 to 17 year olds in group *at least once*. The difference of 233 euros suggests that there is a selection effect, as this difference cannot be caused by the deductibles.

Here we already see in a "crude form" the main result of the paper.[17] The 267 euros difference in expenditures for 19-21 year olds is made up of a selection and a moral hazard effect. The difference of 233 euros for 15-17 year olds is a pure selection effect. Hence, the biggest part of the difference in 19-21 year old expenditures between people without and with a voluntary deductible is due to a selection effect.

Hospital care accounts for most of healthcare expenditure, and physiotherapy for a small part. Average costs of physiotherapy are substantially lower for persons aged 19 to 21 compared to persons aged 15 to 17. This could indicate an effect of the deductible kicking in. All four groups are relatively healthy (because they are young): only between zero and two percent is a chronic user of healthcare (i.e. classified with a DCG) and between one and three percent is a chronic user of medication (i.e. classified with a PCG). Persons who chose a voluntary deductible are more often male. The average household income quintile is slightly higher for 15 to 17 year olds compared to 19 to 21 year olds, and lowest for 19 to 21 year olds who never chose a voluntary deductible.

The average deductible level for 19 to 21 year olds in group *never* between 2008 and 2013 is 201 euros and 398 euros for persons in group *at least once*.[18] Group *never* is considerably larger than group *at least once*, because only a tenth of the Dutch population has chosen a voluntary deductible. Furthermore, we have a limited time period of our data. It's possible

[17] "Crude" because we are not correcting for other effects like age.

[18] Appendix A.3 shows the voluntary deductible choice of 19 to 21 year olds in group *at least once* between 2008 and 2013. A deductible of €0 and €500 is most common, with on average 50 and 29 percent respectively. The majority of the group did not choose a voluntary deductible each year when they turn 18. However, the €500 deductible gains popularity over time. The 201 euros average mandatory deductible is close to the unweighted average (200 euros) of 150, 155, 165, 170, 220 and 350 euros.

that someone will choose a voluntary deductible for the first time in 2014. In our analysis, we would incorrectly classify this person as never having chosen a voluntary deductible. This data limitation implies an underestimation of the selection effect: some healthy individuals with low healthcare expenditure are included in group *never*.[19]

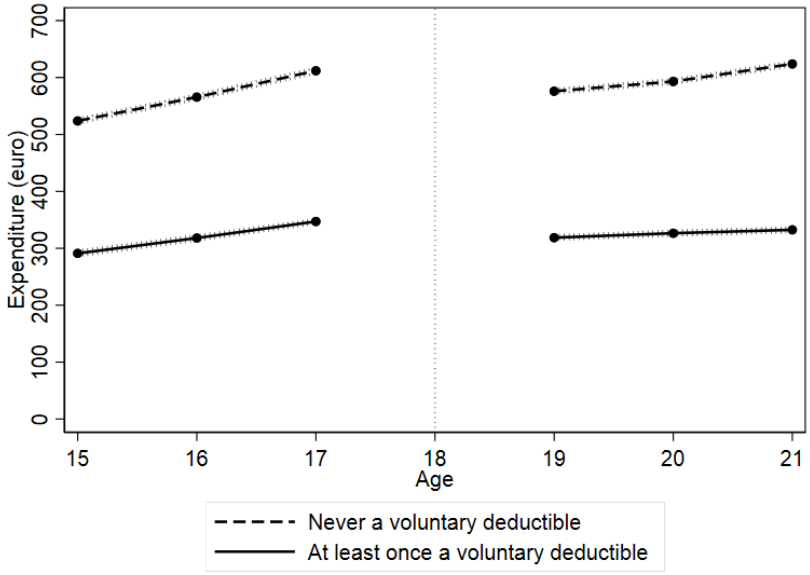

Figure 1: Mean healthcare expenditure for persons who have never chosen a voluntary deductible or have chosen a voluntary deductible at least once

Figure 1 demonstrates further descriptive evidence of selection and moral hazard effects between the two groups.[20] The line of average healthcare expenditure of persons in group *at least once* is well below the line of those in group *never*, before and after the deductibles kick in. Furthermore, we see that the increasing trend of healthcare spending with age is reduced after 18. This is evidence of the effect of the deductible kicking in at 18. In the next section, we formalize this further in our empirical approach.

In our main analyses we focus on 15 to 21 year olds. For additional (policy) analyses, we also extend the age range to the full population. Table 3 lists the descriptive statistics for the full population above age 18. Mean healthcare expenditures are higher compared to 15-21 year olds with 1,932 euros for persons in group *never* and 657 euros for persons in group *at least*

[19]We also estimate the selection effect for the more restrictive group of individuals who *always* chose voluntary deductible in our time period; see Section 5.

[20]Standard errors of the mean expenditures are shown in Figure 1, but as these standard errors are very small, they are barely visible. They differ from standard deviations of individual expenditures as reported in, for example Table 2.

Table 3: Summary statistics for the full population (>18 years old)

	Never a voluntary deductible	*At least once a voluntary deductible*
Healthcare expenditure under deductible (€)	1,932 (6,038)	657 (3,180)
Of which:		
Hospital care (€)	1,346 (5,137)	507 (2,815)
Physiotherapy (€)	32 (237)	7 (103)
Pharmaceutical care (€)	359 (1,535)	95 (634)
Other care (€)	196 (1,038)	48 (538)
Age (years)	51 (18)	41 (14)
Male (%)	0.49 (0.50)	0.59 (0.49)
Diagnosis cost-related group (%)	0.10 (0.30)	0.03 (0.16)
Pharmaceutical cost-related group (%)	0.31 (0.46)	0.09 (0.28)
Household income quintile	3.08 (1.39)	3.25 (1.39)
Average deductible level (€)	203 (71)	390 (240)
Number of observations	58,029,130	8,838,512

Notes: Standard deviations are reported between parentheses.

once. Comparing the two groups, we see that persons who chose a voluntary deductible at least once tend to be younger, male and live in an area with a high income. They also tend to be more healthy, as healthcare expenditures are low and they are less often chronically ill or chronic users of medication.

4. Empirical strategy

The tables and graph in the previous section show first descriptive evidence of selection and moral hazard effects. Here we describe our empirical strategy. Figure 2 is an adaptation of Figure 1 and explains the idea of our identification strategy to disentangle selection and moral hazard effects for 18 year olds. First, we extrapolate the healthcare expenditure trend of 15 to 17 year olds up to age 18 for persons in group *never*. This extrapolation is illustrated with a dotted line in Figure 2. This extrapolated line crosses the vertical line at age 18. This point is denoted by y_{never0}. Hence, y_{never0} shows the average healthcare expenditure for an 18 year old who will never choose a voluntary deductible *in absence of any deductible*.

Next, we extrapolate the healthcare expenditure trend of 19 to 21 year olds in group *never* to age 18. y_{never1} denotes healthcare expenditure of an 18 year old who never chose a voluntary deductible *but who faced a mandatory deductible*. Therefore, $y_{never1} - y_{never0}$ is the effect of the deductible kicking in on healthcare expenditure for persons who never chose a voluntary deductible.[21]

[21]Note that other factors may change as well at 18 which can also lead to a drop in healthcare expenditure. We will address these shortly (equations (1) and (2) below). To simplify the exposition, first we assume the only

We repeat the same steps for persons in group *at least once*. $y_{at\ least\ once0}$ denotes healthcare expenditure for an 18 year old who will choose a voluntary deductible at one point in time, but in absence of a deductible and $y_{at\ least\ once1}$ is the same but when facing a deductible. Again, $y_{at\ least\ once1} - y_{at\ least\ once0}$ is the moral hazard effect of the mandatory plus voluntary deductible.

$y_{never0} - y_{at\ least\ once0}$ is the selection effect for an 18 year old, as it is the difference in healthcare expenditure between the two groups at age 18, but in absence of any deductible. $y_{never1} - y_{at\ least\ once1}$ is the selection effect minus the difference in the moral hazard effect of the deductible between the two groups.[22] Note that in most cases, one only observes $y_{never1} - y_{at\ least\ once1}$, which is a mixture of the selection and moral hazard effects. The Dutch setting however offers an opportunity to directly measure a pure selection effect: $y_{never0} - y_{at\ least\ once0}$.

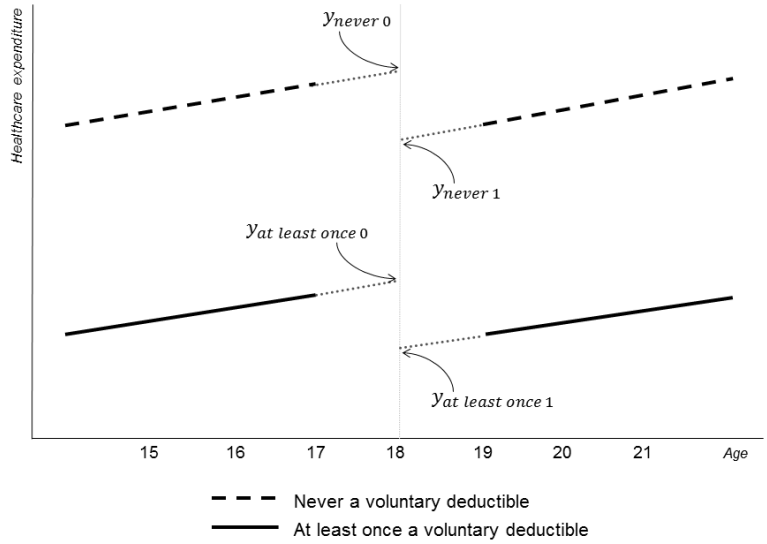

Figure 2: Graphical illustration of identification strategy

This identification strategy can be formalized in a panel regression discontinuity design (Thistlethwaite and Campbell, 1960). With this a design, we can estimate the causal effects of the deductibles on healthcare expenditure.

change at 18 is the moral hazard effect of the deductible.

[22] We label the moral hazard effect of the deductible as MH_{never} and $MH_{at\ least\ once}$, where the former is $y_{never1} - y_{never0}$ and the latter is $y_{at\ least\ once1} - y_{at\ least\ once0}$. $y_{never1} - y_{at\ least\ once1}$ can be rewritten as $(y_{never0} - MH_{never}) - (y_{at\ least\ once0} - MH_{at\ least\ once})$. The selection effect is $y_{never0} - y_{at\ least\ once0}$, so $y_{never1} - y_{at\ least\ once1}$ equals $selection - (MH_{never} - MH_{at\ least\ once})$. Note that the selection effect can be larger than the observed difference in healthcare expenditure between the two groups if $MH_{never} > MH_{at\ least\ once}$.

Regression discontinuity designs exploit discontinuities in assignment variables. In this case, age is the running variable: when a person's age is known, then it is also known whether he or she received the treatment:

$$T = \begin{cases} 1 & \text{if } age \geq 18 \\ 0 & \text{if } age < 18 \end{cases}$$

where T is a binary variable which indicates whether an individual receives the treatment or not.

A necessary assumption for the regression discontinuity design is that persons cannot influence the running variable (Lee and Lemieux, 2010). As persons cannot manipulate their age in administrative data, this assumption holds. Furthermore, all factors that potentially affect healthcare expenditure must evolve smoothly with age, i.e. the only shock that may occur at 18 is the introduction of the deductible. This assumption will not hold: at 18, many students in the Netherlands graduate from high school, go to university and move out of their parental house. This is likely to affect healthcare spending at 18, and is therefore a threat to the validity of our design. Remmerswaal et al. (2019, forthcoming) show that the share of young adults moving and going to university indeed increases at 18. However, they also show that the sizes of these shocks (and several others) are constant over time. Table 1 shows that the deductible levels are not constant over the years. Hence, by exploiting this variation over time, we take out the constant changes at 18. As a result, we can estimate the effect of an *increase* in the deductible, but not the mere effect of the deductible kicking in at 18.[23]

Equation (1) formulates the panel regression discontinuity approach for group *never*:

$$y_{it} = \alpha_t + \alpha_i + \beta_1 a\tilde{g}e_{it} + \beta_2 T_{it} a\tilde{g}e_{it} + \tau T_{it} + \nu n_t T_{it} + \epsilon_{it} \tag{1}$$

We include individuals i in periods $t \in \{2008, 2009, 2010, 2011, 2012, 2013\}$ where $age_{it} \in \{15, 16, 17, 19, 20, 21\}$. y_{it} denotes healthcare expenditure under the deductible of individual i in period t. α_t and α_i are year and individual fixed effects respectively. Age is centered to 18 and denoted as $a\tilde{g}e_{it} = age_{it} - 18$. It captures the linear trend between age and healthcare expenditure (see Figure 1).[24] $T_{it} = 1$ if $age_{it} \in \{19, 20, 21\}$, and zero otherwise. Hence, β_2 allows this linear trend to be different for persons before and after they turn 18.

We assume a linear relationship between the moral hazard effect and the size of the deductible: τ is the effect of becoming 18 on healthcare spending. n_t denotes the size of the mandatory deductible in period t for persons who never chose a voluntary deductible. ν is

[23] Figure 2 suggests that we can measure the moral hazard effect after abolishing the deductible. However, this is not the case as we can only measure marginal effects of changes in the deductible.

[24] Remmerswaal et al. (2019, forthcoming) show that the relationship between healthcare spending and age is indeed linear for this age range and for persons who never chose a voluntary deductible.

one of the main parameters of interest as it captures the effect of a marginal increase in the mandatory deductible for persons who never chose voluntary deductible. ϵ_{it} is the error term.

Equation (2) is almost identical to equation (1), but applies to persons in group *at least once*:

$$y_{it} = \alpha_t + \alpha_i + \gamma_1 a\tilde{g}e_{it} + \gamma_2 T_{it} a\tilde{g}e_{it} + \theta T_{it} + \lambda a_{it} T_{it} + \epsilon_{it} \tag{2}$$

Parameters γ_1 and γ_2 capture the linear trend for age and θ is the effect of becoming 18. a_{it} denotes the level of the (mandatory plus voluntary) deductible for an agent i in period t who chose a voluntary deductible at least once (in our data period). It's the total deductible size, so the mandatory plus the voluntary deductible (if a person chose one in a given year). Note that it varies across both person i and year t, as persons can choose and change their voluntary deductible size.[25] λ captures the effect of a marginal increase in the total deductible size for persons who chose a voluntary deductible at least once.

The panel structure of the data allows us to include individual fixed effects (α_i) and time fixed effects (α_t) in models (1) and (2). Individual fixed effects control for differences in health status or personality traits (e.g. risk aversion or gratification) which might be related to both choosing a voluntary deductible and healthcare expenditures. Time fixed effects control for changes over time that affect persons above and below 18, for example changes in basic benefit package coverage. The standard errors are clustered at the individual level in all models to correct for correlation (Lee and Lemieux, 2010). Clustering the standard errors differently, for example by age or age times year, does not change our results; it leads to (even) smaller standard errors for group *never* and similar standard errors for group *at least once* (see Appendix A.7).

Parameters ν and λ from models (1) and (2) provide the marginal effects of the deductibles on moral hazard. From the models we can also derive the selection effects. The approach is based on Figure 2 and delivers yearly selection effects at age 18. Basically, from the estimated parameters of models (1) and (2) we predict for each year the points y_{never0} and $y_{at\ least\ once0}$ at age 18 and subtract these from each other. As we do this at age 18 with $T = 0$, we have $y_{never0} = \bar{\alpha}_t + \bar{\alpha}_i + \bar{\varepsilon}_{it}$ in equation (1), and a similar expression for $y_{at\ least\ once0}$ from equation (2).

5. Results

The results of models (1) and (2) are presented in Table 4. For persons who never chose a voluntary deductible, we find a ν coefficient of -0.26 which is statistically significant at a 1

[25] This in contrast to the mandatory deductible which –for people above 18– does not vary across individuals in a given year.

percent significance level. To illustrate the economic significance of this estimate, a coefficient of -0.26 means that for 18 year olds who have never chosen a voluntary deductible, a 100 euro increase in the mandatory deductible reduces healthcare expenditure on average by 26 euros per person. This corresponds to a deductible elasticity of -0.09.[26]

The size of the deductible elasticity is roughly two times smaller than the price elasticity from the RAND experiment (Newhouse, 1993). This may be a result of institutional differences between the United States and the Netherlands. The level of the deductible is also much lower in the Netherlands compared to the United States. Finally, we find this deductible elasticity for a very specific age category: young adults around 18 years old.

Table 4: Deductible and selection effects for 18 year olds

	Never a voluntary voluntary deductible	*At least once a voluntary deductible*
Marginal effect of €1 increase in total deductible size (ν,λ)	-0.26*** (0.07)	0.00 (0.02)
Deductible elasticity	-0.09	0.00
Selection effect (€)	-	340
Observations	5,055,617	954,880

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. Coefficients ν and λ are estimated with models (1) and (2). The full results of the estimations are presented in Table A.6.

The estimated coefficient λ for 18 year olds who have chosen a voluntary deductible at least once is 0.00 and not statistically significant at a 10 percent significance level. After controlling for selection effects, a marginal increase in the level of the deductible does not reduce healthcare of this group significantly. This makes sense: healthcare expenditure of this group is on average well below their deductible level. As a result, they are not marginally affected by an increase in the total deductible size. The group seems to have chosen their deductible based on their expected healthcare needs. Zero deductible elasticity may also suggest that the healthcare they *do* consume is both necessary and valuable, such as an appendectomy, as they accept these treatments regardless of their deductible size. Note that the coefficient of zero does not imply that persons who chose a voluntary deductible at least once do not respond to the deductible at all. In fact, in Figure 1, we observe a drop in healthcare expenditure at 18. This reduction in

[26] We calculate the elasticity as follows:

$$\varepsilon_n^y = \frac{\partial y}{\partial n}\frac{\bar{n}}{\bar{y}_{never}} = -0.26\frac{201}{589} = -0.09 \tag{3}$$

where $\bar{y}_{never}$ is the average healthcare expenditure of 19 to 21 year olds who never chose a voluntary deductible, $\bar{n}$ is the average (mandatory) deductible size. Note that this elasticity is not a price elasticity. Price in "price elasticities" in health insurance tends to refer to co-payments or co-insurance rates. To avoid confusion, we use the term deductible elasticity.

healthcare expenditure can be the effect of the deductible kicking in, as well as other changes at 18. From Table 4 we conclude that the size of this drop at 18, does not vary over time with the size of the (mandatory and voluntary) deductible. If we estimate model (2) without individual fixed effects (i.e. ordinary least squares) then we get a value for λ equal to -0.21 (see Table A.6 in the appendix). This negative coefficient is due to selection.

The average selection effect is 340 euros. This is more than the observed 267 euros difference in healthcare expenditure between people without and with a voluntary deductible (reported in Table 2). Therefore, it must be the reduction in healthcare spending due to the mandatory deductible that makes the difference in healthcare spending between the two groups smaller. That is, persons in group *never* (with higher expected expenditures) reduce their expenditure more in response to the deductible than persons in group *at least once*.

Table 5: Other comparison groups

	Always a voluntary deductible	*Always a voluntary deductible of €500*
Marginal effect of €1 increase in total deductible size (λ)	0.01 (0.08)	0.31 (0.65)
Selection effect (€)	463	534
Observations	209,249	140,569

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. Coefficients λ are estimated with model (2). The selection effect is determined compared to individuals who never chose a voluntary deductible. The full results of the estimations are available upon request.

The main analysis compares individuals who never chose a voluntary deductible to persons who chose one *at least once*. If we narrow the latter group to individuals who *always*, i.e. each year, chose a voluntary deductible we find a similar coefficient of ν: an increase in the total deductible size does not affect healthcare spending significantly (see Table 5). The selection effect has become larger with 463 euros.[27] When selecting only persons who always chose a voluntary deductible of €500, the selection effect becomes even larger: 534 euros. The estimated ν coefficient, is relatively large, but insignificant.

We interpret these findings as follows. When moving from the group who chose a voluntary deductible at least once to the group who always chose a voluntary deductible and finally the group who always chose the highest voluntary deductible, we move to people who are (expected to be) progressively more healthy. Hence, one would expect the selection effect to increase moving from the first group to the last. Indeed, this monotone increase is what we find in the data.

We also compare effects across sex and income categories by estimating models (1) and (2)

[27] Compared to persons who never chose a voluntary deductible.

Table 6: Heterogeneity across sex and income

	Never a voluntary deductible		*At least once a voluntary deductible*		*Selection effect (€)*
	Effect of €1 increase in the deductible size (ν,λ)	Deductible elasticity	Effect of €1 increase in the deductible size (ν,λ)	Deductible elasticity	
Women	-0.38*** (0.10)	-0.11	0.01 (0.03)	0.01	358
Men	-0.15 (0.11)	-0.06	0.00 (0.03)	0.00	310
Income quintile 1	-0.41** (0.18)	-0.15	-0.01 (0.03)	-0.01	474
Income quintile 5	-0.28* (0.15)	-0.09	0.01 (0.05)	0.01	443

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. Coefficients ν and λ are marginal effects and estimated with models (1) and (2). ν_{women} is statistically different from ν_{men} for persons who never chose a voluntary deductible. The p-value of the F-test is 0.000. This is not the case when comparing household income quintile 1 with quintile 5, or for any of the estimated coefficients for persons who chose a voluntary deductible at least once. Deductible size refers to the total deductible size, i.e. the sum of the mandatory and voluntary deductible (if the latter was chosen). The full results of the estimations are available upon request.

separately for men and women, and individuals living in areas with different average household income quintiles (see Table 6). The marginal effect of the deductible differs significantly, at a 1% significance level, for men and women who never chose a voluntary deductible. Women respond more strongly to an increase of the deductible: we estimate a coefficient ν of -0.38 for women and -0.15 for men. We find no significant difference in the results for men and women who chose a voluntary deductible at least once. When we compare individuals living in postal code area with a different income, we find that ν is higher for persons living in a low income area (quintile 1) than for persons living in a high income area (quintile 5). We estimate deductible elasticities of -0.15 and -0.09 for quintile 1 and quintile 5 respectively. These differences are however not statistically different. For individuals in group *at least once*, we observe no difference among household income quintiles.

In group *never*, women appear to be more cost-conscious than men in the sense that they reduce their expenditure more strongly to an increase in the mandatory deductible. Also women appear to be more reluctant to choose a voluntary deductible requiring lower expected healthcare costs before accepting a voluntary deductible. This translates into a bigger selection effect for women compared to men.

The estimated coefficients ν and λ of -0.26 and 0.00 respectively represent the marginal effect of the deductible for all healthcare costs under the deductible. Table 7 presents the results of estimating models (1) and (2) for three different categories of healthcare expenditure separately: hospital care, physiotherapy, and pharmaceutical care.[28] The results for hospital care are similar

[28]In Appendix A.8 we also report the results for GP care. GP care is excluded from the main analyses because its costs do not apply to the deductible. However, we can still consider the results of GP care with respect to the deductible for two reasons. First, Esch et al. (2015) show that a quarter of the Dutch population (incorrectly) believes that GP care does fall under the deductible. Second, people may refrain from visiting their GP because

Table 7: Heterogeneity across healthcare categories

	Never a voluntary deductible		*At least once a voluntary deductible*		*Selection effect (€)*
	Effect of €1 increase in the deductible size (ν,λ)	Deductible elasticity	Effect of a €1 increase in the deductible size (ν,λ)	Deductible elasticity	
Hospital care	-0.26*** (0.07)	-0.12	0.01 (0.02)	0.02	251
Physiotherapy	-0.03*** (0.00)	-0.75	-0.01*** (0.00)	-1.00	3
Pharmaceutical care	0.02 (0.02)	0.04	0.00 (0.00)	0.00	54

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. Coefficients ν and λ are marginal effects and estimated with models (1) and (2). Deductible size refers to the total deductible size, i.e. the sum of the mandatory and voluntary deductible (if the latter was chosen). The full results of the estimations are available upon request.

to the main results: the estimated coefficients ν and λ equal -0.26 and 0.01 respectively. This is not surprising as most of the expenditures are hospital expenditures. Furthermore, we find that individuals are more price sensitive to physiotherapy: the estimated coefficient ν is -0.03 and λ is -0.01, both statistically significant at a 1 percent significance level. As mean physiotherapy expenditure is only 8 and 4 euros for persons above 18, these imply, in fact, large elasticities. The coefficient for pharmaceutical care is small and insignificant. This means that a reduction in pharmaceutical expenditures at 18 does not change with the total deductible size. This in contrast to other studies that find a negative elasticity for pharmaceutical care. Explanations for this include the following. As shown in Table 2, for our age categories mean pharmaceutical expenditures are relatively low; below 100 euros and clearly below the mandatory deductible. Hence, they are not marginally affected by a change in the deductible. Second, in the Netherlands pharmaceuticals have to be prescribed by a physician and hence tend to be used when they are actually effective. Finally, there could be an offset effect: as the deductible increases, people substitute towards drugs which tend to be cheaper than other treatments. Table 9 below shows that pharmaceutical expenditure is elastic when considering the population as a whole. This suggests that the first explanation is the more convincing one.

5.1. Robustness analyses

To test whether our results are driven by our specification choices, we have performed several additional analyses. The results are presented in the appendix. Here we only describe the main findings. First we show that the age bandwidth choice of three years before and after the threshold does not affect the results. In Appendix A.9 we show that for a two- or four-year age

they expect they will be referred to a hospital, for which they do have to pay out-of-pocket. However, as shown in Table A.8, the coefficients ν and λ for GP care are zero at a 1 percent significance level. Thus we do not find evidence that people refrain from visiting their GP due to a higher deductible.

bandwidth, we find very similar results to a three-year age bandwidth.

Next we check the effects of a group of chronically ill persons with annual high healthcare expenditures, who are unlikely respond to an increase of the deductible, because they will exceed the deductible anyway. Excluding the chronically ill is therefore expected to increase the average moral hazard effect. We therefore exclude persons with, before turning 18, healthcare expenditures in the highest decile.[29] As shown in Table A.10, we find a much larger coefficient ν of -0.70 for persons in group *never*. That translates into a deductible elasticity of -0.26. We find a coefficient λ of -0.02, insignificant at a 10 percent significance level, for persons in group *at least once*. Furthermore, we find that excluding the persons with high healthcare expenditures does not strongly affect the selection effect.

A potential problem for our estimation is an anticipation effect for 17 year olds: they consume more care at age 17, while it is still 'free' because the deductible will kick in when they turn 18. Such anticipation effects can result in a bigger drop of healthcare expenditure at 18, and thus inflate our results. Therefore, we omit 17 year olds from the analysis. This does not affect our findings: we find a ν coefficient of -0.23 for group *never* and a λ coefficient of -0.00 for group *at least once*. The selection effect is 341 euros.

Lastly, we test how sensitive our results are to excluding persons who at one point in time use mental healthcare. When we include them (while not including their mental healthcare expenditure), we again get similar results. Hence, our choice to exclude people with mental care expenditures does not affect our results.

In each of these robustness analyses we find that there is a significant reduction in expenditures in response to an increase in the mandatory deductible (for people who never chose a voluntary deductible). For people with a voluntary deductible, there is no significant response in healthcare expenditure to changes in the total (mandatory plus voluntary) deductible. We find a selection effect that varies between 260 and 400 euros.

6. Policy analyses

There is a public debate in the Netherlands about the voluntary deductible. Benefits of voluntary deductibles mentioned in this debate are the following. First, people differ in their degree of risk aversion. For people who tend to be more risk neutral, it is beneficial (from a welfare point of view) to offer more choice in cost-sharing. Second, a higher deductible may help to reduce total

[29] We only construct deciles based on healthcare expenditure below 18, to make sure we do not select on the deductible effect. The deciles are calculated per year and age category and we only exclude individuals each year in the highest decile (before they turn 18).

healthcare expenditure thereby contributing to the sustainability of the system. Third, if due to more cost-sharing, people spend less on healthcare, it is seen as fair that they also pay a lower premium. However, in the latter case, the premium discount should not exceed the cost savings as that is seen as a cross subsidy from high risk agents (with only a mandatory deductible) to low risk agents (who are more likely to choose a voluntary deductible).

In the context of our paper, this leads to three issues. First, how much do healthcare expenditures differ for people with and without a voluntary deductible. Second, how much will healthcare spending increase if the voluntary deductible is abolished? Third, do high-risk individuals, for whom a voluntary deductible would be unprofitable, partly finance the discount in premiums that individuals who choose a voluntary deductible receive? This would be the case if the premium discount offered to persons with a voluntary deductible exceeds savings in medical spending, i.e. the additional reduction in moral hazard effects, and extra out-of-pocket payment due to the voluntary deductible. If the premium discount exceeds these cost savings for the insurer, pooling everyone into the same contract (by abolishing voluntary deductibles) would reduce the premium for high risk individuals. This would then contribute to the solidarity of the system.

The results in the previous sections show that 18 year olds who have chosen a voluntary deductible at least once do not reduce their healthcare spending in response to an increase in the total deductible size. This suggests that an abolishment of the voluntary deductible would not affect healthcare spending for this age group. This result may be different however at the full population level. To provide an answer to the aforementioned questions at the population level, we extend our analysis to persons of all ages in the Dutch population.

6.1. Extending the age range

For the panel regression we extend the age bandwidth of our analyses from 15-21 year olds to 13-99 year olds. This age bandwidth was chosen because for persons below age 13 we cannot determine at all whether they have chosen voluntary deductible or not and because there are few persons aged 100 or more. Figure 3 shows the annual average healthcare expenditures for this population.[30] We estimate model (4) below, which is identical to model (2) but now we include age dummies (α_{it}^{age}) which may capture age specific effects. We estimate:

$$y_{it} = \alpha_t + \alpha_i + \alpha_{it}^{age} + \lambda a_{it} T_{it} + \epsilon_{it} \tag{4}$$

where y_{it} is identical to y_{it} in model (2).

[30]Note that there are relatively few people above 75 who chose a voluntary deductible at least once in the period under consideration. This explains why the curve is not smooth for people over 75.

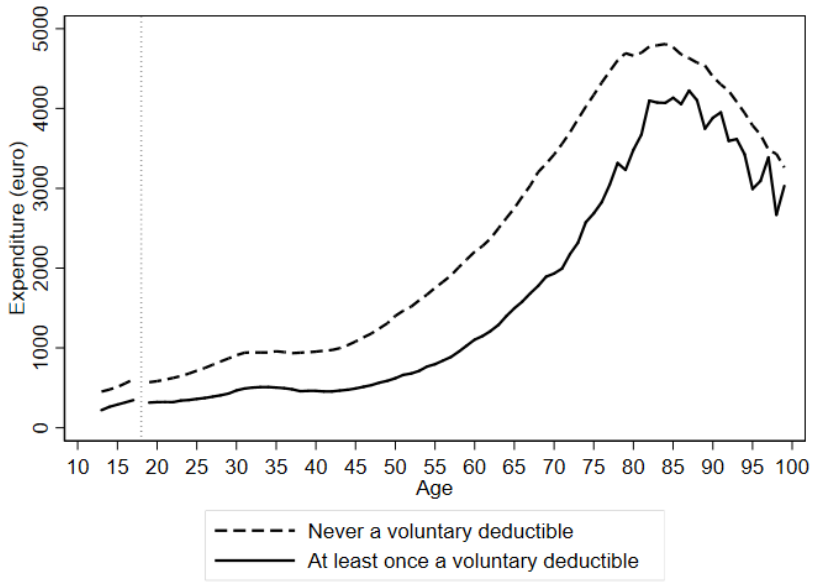

Figure 3: Mean healthcare expenditure for 13 to 99 year olds who never chose a voluntary deductible and for those who chose a voluntary deductible at least once.

For the full population, we cannot estimate a regression discontinuity design. Therefore, we measure with model (4) an average effect over all age categories from 19-99 with a panel regression design. Also we only estimate (4) for group *at least once* and thus exclude persons in group *never*. That is, we do not estimate equation (1) for the whole population as for people who never chose a voluntary deductible we have no variation in the deductible within a year.

The reason is the following. In our empirical strategy in section 4 we assume that time fixed effects α_t control for the changes over time that affect *all* ages in the bandwidth. Think of the government making changes to the set of treatments covered by the mandatory insurance. This assumption is less plausible for wide age bandwidths. For example, if new treatments are added to the basic benefit package which are only relevant to persons over 50, the time fixed effects will no longer adequately control for this as these are identified on people younger than 18. With apologies for the stereotype, adding a walker or Viagra to the basic package may not be picked up correctly by the time fixed effects.

Intuitively, for the age window 15-21 in the years 2008-2013, we have observations moving from non-treatment to treatment groups. This does not happen for, say, people over 50 in these years. For the over 50's who never chose a voluntary deductible, we do not have variation in the deductible within a year to identify deductible, age and year effects. Therefore we do not estimate (1) for this group. We can, however, estimate (2) –in the form of equation (4)– because for the group who chooses a voluntary deductible at least once, we have variation in deductible

within a year.

The results for equation (4) are presented in Table 8. The estimated λ coefficients are no longer (around) zero: a marginal increase in the total deductible size leads to a reduction of healthcare expenditure. λ is -0.25 for persons who chose a voluntary deductible at least once and -0.12 for persons who always chose a voluntary deductible. These coefficients translate into deductible elasticities of -0.15 and -0.11 respectively. Compared to 15-21 year olds, persons with a voluntary deductible here are in fact marginally affected by a change in the total deductible size. Mean healthcare expenditure for persons in group *at least once* is 657 euros (see Table 3) and 598 euros for persons in group *always*, whereas the average deductible levels for the two groups are 390 and 547 euros respectively.

Table 8: Deductible effects for full population

	At least once a voluntary deductible	*Always a voluntary deductible*
Marginal effect of €1 increase in the total deductible size (λ)	-0.25*** (0.01)	-0.12* (0.07)
Deductible elasticity	-0.15	-0.11
Observations	8,331,900	1,774,991

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. Coefficient λ is estimated with model (4). The full results of the estimations are available upon request.

As we exclude persons who never chose a voluntary deductible from our analyses, we can no longer estimate selection effects the same way as in section 4. To answer the policy questions above, we proceed by assuming that the elasticity estimated for 18 year olds who never have a voluntary deductible also applies to the full population. Appendix A.11 further explains how selection effects are computed for the full population. We get a selection effect of 1,351 euros. Again, the difference in healthcare expenditure $1,932-657 = 1,275$ euros (see Table 3) is mostly selection, not moral hazard.

Table 9 presents the deductible effects for women and men. Again, we observe that women are significantly more responsive to a marginal increase in the deductible than men. The response for household income quintile 1 and 5 is also significantly different. λ is -0.25 for persons in quintile 1 and -0.27 for persons in quintile 5. These coefficients translate into deductible elasticities of -0.17 and -0.15 respectively.[31] Similar to what we found for 18 year olds, physiotherapy is the most elastic healthcare category. Furthermore, whereas 18 year olds did not reduce their pharmaceutical spending in response to the deductible, we do find an effect for the full

[31]Note that the deductible elasticity for quintile 1 is higher than the deductible elasticity for quintile 5. This is because mean healthcare expenditure and the mean deductible of individuals in quintile 5 are different from individuals in quintile 1.

population: λ is -0.04, which implies a deductible elasticity of -0.16.

Table 9: Heterogeneity across sex, income and healthcare categories

	At least once a voluntary deductible	
	Effect of a €1 increase in the total deductible size (λ)	Deductible elasticity
Women	-0.35*** (0.01)	-0.17
Men	-0.16*** (0.01)	-0.11
Income quintile 1	-0.25*** (0.02)	-0.17
Income quintile 5	-0.27*** (0.02)	-0.15
Hospital care	-0.17*** (0.01)	-0.13
Physiotherapy	-0.01*** (0.01)	-0.54
Pharmaceutical care	-0.04*** (0.00)	-0.16

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. λ is statistically different for men and women. The p-value of the F-test is 0.000. λ is also statistically different for quintile 1 and quintile 5. The p-value of the F-test is 0.030. Coefficient λ is a marginal effect and estimated with model (4). Deductible size refers to the total deductible size, i.e. the sum of the mandatory and voluntary deductible (if the latter was chosen). The full results of the estimations are available upon request.

6.2. Policy analyses

Here we use the estimated λ coefficients from Table 8 to calculate the average moral hazard effect as a result of the voluntary deductible. We use the estimated λ coefficient for persons in group *at least once*.[32] In addition, we compute the average premium discount and the average out-of-pocket payment due to the voluntary deductible for all individuals, including mental and dental healthcare expenditure and persons who use mental healthcare services. Although including these expenditures and people is "less clean" from an econometric perspective, they are relevant for the policy analysis. We proceed by assuming that the estimated coefficient λ from model (4) also applies to these cost categories and individuals.

Table 10 presents the results for 18 year olds and the full population with a voluntary deductible. Note that 18 year olds have a higher premium discount and larger OOP payments than the full population because they chose higher voluntary deductible levels. For 18 year olds, we find a substantial effect of the voluntary deductible on risk solidarity: 94 euros per person with a voluntary deductible. The average out-of-pocket payment due to the voluntary deductible and the average moral hazard effect do not add up to the average premium discount.

[32] Appendix A.12 shows that using the estimated λ coefficient for persons in group *always*, leads to very similar results.

In other words, in this age bracket there is a cross subsidy from high risk people (who never choose a voluntary deductible) to low risk people (who tend to choose a voluntary deductible at least once). Abolishing the voluntary deductible and pooling everyone into one contract (with one mandatory deductible) would lower the premium for high-risk individuals.

Table 10: Impact on risk solidarity

	18 year olds	Full population
Mean premium discount (€)	171	147
Mean OOP payment w.r.t. voluntary deductible (€)	76	68
Mean moral hazard effect w.r.t. voluntary deductible (€)	0	-45***
Mean reduction solidarity (€)	94	35
Total moral hazard effect w.r.t. voluntary deductible (x €1,000)	0	-40,772***
Total reduction risk solidarity (x €1,000)	1,124	31,367
Mean premium increase for persons without a voluntary deductible (€)	6	3

Notes: The mean premium discounts for a voluntary deductible are computed as a weighted average of premium discounts of the five voluntary deductible levels (see Appendix A.1 and A.3). The moral hazard effects are based on Tables 4, 5 and 8. We multiply coefficient λ by the average voluntary deductible level. Mean solidarity effect equals the premium discount minus the OOP payment w.r.t. the voluntary deductible plus the moral hazard effect w.r.t. the voluntary deductible. The total effects are calculated by multiplying the mean effects by the number of persons with a voluntary deductible in the age range. Furthermore, the mean premium increase for persons without a voluntary deductible is computed by dividing the total reduction of risk solidarity by the number of persons without a voluntary deductible in the age range.

For the full population, we find slightly smaller effects because there is a moral hazard effect. The reduction in risk solidarity due to the voluntary deductible is 35 euros. However, it is not a large reduction: for the full population maximally 35 euros per person with a voluntary deductible. Abolishing the voluntary deductible would increase healthcare spending as the moral hazard effects listed in Table 10 (in total almost 41 million euros) would disappear. If we assume "keeping all else equal" after the abolishment of the voluntary insurance categories then the annual premiums for people without a voluntary deductible would decrease with 6 euros.[33] Thus, risk solidarity would only decrease modestly, which is due to the fact that a large majority of the population does not opt for a voluntary deductible. Ceteris paribus, if the share of individuals choosing a voluntary deductible would become much larger, the reduction of risk solidarity would likewise increase.

Summarizing, we find that abolishing the voluntary deductible in the Netherlands will lead to a modest increase in healthcare spending. Although there is a substantial difference between the mean expenditure of people with and without a voluntary deductible, most of this difference is due to selection and only a small part is due to moral hazard. For 15-21 year olds we are

[33]However it is not clear whether the "keeping all else equal" statement is fully correct. For example, after the abolishment people with and without a voluntary deductible are pooled together which may affect the average premium elasticity in the insurance market.

best able to identify the moral hazard and selection effects and for this group we find that an increase in the (mandatory and voluntary) deductible has no effect on healthcare expenditure. Second, abolishing the voluntary deductible leads to a (modest) improvement in risk solidarity.

If both these effects are interpreted as being in favour of abolishing the voluntary deductible, these need to be weighed against the benefits of keeping a voluntary deductible. The main benefit is to offer choice for people who differ in their degree of risk aversion. Ex-ante moral hazard effects may also play a role: they may be less inclined to behave healthy.

7. Concluding remarks

This paper is motivated by the policy discussion in the Netherlands on whether voluntary deductibles in the mandatory (basic) health insurance should be abolished. To advise policy makers on the effects of dropping voluntary deductibles, we need to identify the selection and moral hazard effects of voluntary deductibles.

People who choose a voluntary deductible have substantially lower costs than people who face only the mandatory deductible. Selection effects partly explain this difference: healthy people are more likely to opt for a voluntary deductible. Moral hazard effects explain the other part of the difference in healthcare expenditure: with a higher deductible, healthcare becomes more expensive and healthcare use is reduced.

Using a panel regression discontinuity approach we argue that most of the cost difference between people without and with a voluntary deductible is due to selection. We find evidence of moral hazard heterogeneity: persons who have never chosen a voluntary deductible reduced their healthcare spending at age 18 by 26 euros on average, when faced with a 100 euro increase in the deductible. However, persons who have chosen a voluntary deductible at least once, did not respond to an increase of the deductible at the same age. For the full population, we use a panel regression and find that a 100 euro increase in the deductible leads to an average reduction in healthcare spending of 25 euros per person for persons who chose a voluntary deductible. For the population as a whole these translate into modest moral hazard effects: abolishing the voluntary deductible would increase healthcare expenditure for the Netherlands but not by as much as the difference in average expenditures between the groups would suggest.

People who choose a voluntary deductible understand their (low) health risk, and subsequently choose a high deductible. In return, they get a premium discount as a reward for being healthy. We show that the voluntary deductible leads to a small reduction of risk solidarity as the out-of-pocket payment and reduction of moral hazard due to the voluntary deductible is somewhat lower than the premium discount that they receive.

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A. Appendix

A.1. Nominal premium and premium discounts

	2008	2009	2010	2011	2012	2013
Average nominal premium (€)	1,050	1,059	1,095	1,199	1,226	1,213
Premium discount voluntary deductible level (€):						
€100	41	42	44	44	45	45
€200	84	84	86	86	87	88
€300	121	121	126	127	129	131
€400	163	162	166	168	174	175
€500	202	205	210	219	229	230

Notes: The Table presents the average annual nominal premium for the basic benefit package and the average annual discounts for the five voluntary deductible categories. The numbers in the table are obtained from the Dutch Healthcare Authority (Nederlandse Zorgautoriteit, 2011, 2013).

The first row in the above table presents the average nominal premium individuals have to pay for the basic insurance. Note that this premium is not the full amount that individuals have to pay for basic health insurance. Another major part is collected through income dependent contributions via the tax office (see Section 2). The other rows show the average discount that individuals receive on the nominal premium when choosing one of the five voluntary deductibles. The discount is higher for higher voluntary deductibles.

A.2. Data cleaning procedure

To clean the data, we exclude persons without a (pseudonymized) social security number, an invalid postal code, and/or a missing or invalid health insurance registration period. The registration period is usually one year, because health insurance is mandatory and an individual can only change health insurer in January of a given year. In some cases, an observation can have a shorter registration period if the enrollee emigrates or dies. We exclude persons with a registration period of more than one year. We exclude observations with other administrative errors: individuals with negative healthcare expenditures and individuals with errors in their age pattern over time. In total, we remove 2,834,720 observations from our data which corresponds to 2 percent of the total number of observations.

A.3. Evolution of voluntary deductible choice over time for 19-21 year olds who chose a voluntary deductible at least once

	2008	2009	2010	2011	2012	2013	Average
Share of sample per voluntary deductible level (%):							
€0	69	69	60	42	28	33	50
€100	6	4	4	4	5	6	5
€200	4	3	3	3	4	6	4
€300	3	8	13	18	21	4	11
€400	1	0	0	1	1	1	1
€500	17	15	20	32	42	50	29

Notes: The Table presents voluntary deductible choice for for 19 to 21 year olds who chose a voluntary deductible at least once.

A.4. Evolution of voluntary deductible choice over time for all 19-99 year olds

	2008	2009	2010	2011	2012	2013	Average
Share of sample per voluntary deductible level (%):							
€0	95	95	95	94	93	90	93
€100	2	2	2	1	1	1	1
€200	1	1	1	1	1	1	1
€300	1	1	1	1	1	1	1
€400	0	0	0	0	0	0	0
€500	2	2	2	3	4	6	3

Notes: The Table presents the percentage 19-99 year olds that chose no voluntary deductible or for one of the five voluntary deductible categories. Due to rounding the sum in the columns may not add up to 100%.

A.5. List of healthcare expenditure categories

Type of costs	Apply to the deductible	Included in y_{it}
GP registration		
GP visits		
Other costs of GP care		
Pharmaceutical care	X	X
Dental care	X	
Obstetrical care		
Hospital care	X	X
Physiotherapy	X	X
Paramedical care	X	X
Medical aids	X	X
Transportation for persons lying down	X	X
Transportation for seated persons	X	X
Maternity care		
Care that is delivered over the Dutch borders	X	X
Primary healthcare support		
Primary mental healthcare support		
Mental healthcare with (overnight) stay	X	
Mental healthcare without (overnight) stay:		
- at institutions	X	
- by self-employed providers	X	
Other mental healthcare costs	X	
Geriatric revalidation	X	X
Other costs	X	X

Notes: Cost categories marked with X in the second column apply to the deductible. The other cost categories are exempted from the deductible. y_{it} in the third column refers to the dependent variable in our baseline specification. See equation (1) in Section 4. The cost categories marked with an 'X' in the third column are included in y_{it}. This table is duplicated from Remmerswaal et al. (2019, forthcoming).

A.6. Regression results of the baseline specification

	Never a voluntary deductible		*At least once a voluntary deductible*	
	(1)	(2)	(3)	(4)
Deductible size (ν, λ)	-0.24***	-0.26***	-0.21***	0.00
	(0.06)	(0.07)	(0.01)	(0.02)
Treatment dummy (τ, θ)	-56.10***	-53.63***	9.10	-58.81***
	(13.54)	(16.33)	(7.69)	(10.56)
Year dummies	Yes	Yes	Yes	Yes
Age centered	Yes	Yes	Yes	Yes
Age centered * treatment	Yes	Yes	Yes	Yes
Individual fixed effects	No	Yes	No	Yes
Observations	5,055,617	5,055,617	654,880	654,880
R-squared	0.000	0.707	0.001	0.501

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. Columns (1) and (3) are estimated with ordinary least squares estimation, (2) and (4) include individual fixed effects (models in equations (1) and (2) respectively). The first two columns apply to persons who never chose a voluntary deductible and the last two columns apply to persons who chose, at least once, a voluntary deductible. Other coefficients are available upon request.

A.7. Different clustering of standard errors

	Never a voluntary deductible ν	*At least once a voluntary deductible* λ
Clustered by individuals	0.07	0.02
Clustered by age	0.02	0.03
Clustered by age cohort	0.05	0.04
Clustered by individuals * age	0.06	0.02

Notes: The Table reports standard errors of coefficient ν, estimated with models (1) and (2). The analyses that were conducted for this Table are the same as in Table A.6, but differ in the way standard errors were clustered.

A.8. Analysis for GP care

	Never a voluntary deductible		*At least once a voluntary deductible*	
	Estimated ν	Mean expenditure	Estimated λ	Mean expenditure
GP care	0.00***	51	0.00***	39
	(0.00)		(0.00)	

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. The results are estimated with models (1) and (2). Mean expenditure is based on individuals of 19 to 21 years old. Other coefficients are available upon request.

A.9. Multiple age bandwidths

	Never a voluntary deductible			*At least once a voluntary deductible*			*Selection effect (€)*
	Estimated ν	Mean expen-diture (€)	Obser-vations	Estimated λ	Mean expen-diture (€)	Obser-vations	
2 year age bandwidth	-0.22*	577	3,203,989	0.03	319	650,704	259
	(0.13)			(0.03)			
3 year age bandwidth	-0.26***	598	5,055,617	0.00	326	954,880	340
	(0.07)			(0.02)			
4 year age bandwidth	-0.20***	596	6,567,519	0.00	320	1,182,701	358
	(0.06)			(0.03)			

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. The results are estimated with models (1) and (2) and include individual fixed effects. Mean expenditure is based on individuals of 19 to 21 years old. Other coefficients are available upon request.

A.10. Analyses for different sample selections

	Never a voluntary deductible			*At least once a voluntary deductible*			*Selection effect (€)*
	Estimated ν	Mean expen-diture (€)	Obser-vations	Estimated λ	Mean expen-diture (€)	Obser-vations	
Without top decile of healthcare expenditures	-0.70***	538	4,896,518	-0.02	307	894,500	400
	(0.06)			(0.02)			
Without 17 year olds	-0.23**	598	4,229,028	-0.00	326	813,871	341
	(0.11)			(0.02)			
With persons who at one point in time use mental healthcare	-0.31***	670	5,997,676	0.03	355	1,071,415	378
	(0.08)			(0.02)			

Notes: Standard errors are reported between parentheses and clustered at the individual level. *, **, and *** indicate significance based on a two sided test at the .10, .05, and .01 levels, respectively. The results are estimated with models (1) and (2) and include individual fixed effects. Mean expenditure is based on individuals of 19 to 21 years old. Other coefficients are available upon request.

A.11. Computation selection effect for full population

Let $\bar{y}_{never}$ denote the average healthcare expenditures for persons who never chose a voluntary deductible and $\bar{y}_{at\ least\ once}$ for those who chose a voluntary deductible at least once.[34]

$$\bar{y}_{never} = \bar{\alpha}_{never} + \nu\bar{n} \tag{A.1}$$

$$\bar{y}_{at\ least\ once} = \bar{\alpha}_{at\ least\ once} + \lambda\bar{a} \tag{A.2}$$

Next, we decompose $\bar{y}_{never}$ into two components: $\nu\bar{n}$ and $\bar{\alpha}_{never}$ or the average reduction in moral hazard due to the deductible and the rest; see equation (A.1). $\bar{n}$ denotes the average deductible of group *never*. $\bar{\alpha}_{never}$ is the sum of the average individual fixed effect ($\bar{\alpha}_i$), the average year fixed effect ($\bar{\alpha}_t$) and the average age fixed effect ($\bar{\alpha}_{it}^{age}$) for persons who never chose a voluntary deductible.[35] We apply the same steps for persons who chose a voluntary deductible at least once (group *at least once*) and define $\bar{\alpha}_{at\ least\ once}$ and $\lambda\bar{a}$ (see equation (A.2)). Taking the difference, we find

$$\bar{y}_{never} - \bar{y}_{at\ least\ once} = \underbrace{\bar{\alpha}_{never} - \bar{\alpha}_{at\ least\ once}}_{\text{SE}} + \underbrace{\nu\bar{n} - \lambda\bar{a}}_{\text{RMH}} \tag{A.3}$$

where SE denotes the selection effect and RMH the difference in the reduction of moral hazard effect between the two groups. SE in equation (A.3) is the average selection effect over time.[36] Next we approximate ν by $-0.09\frac{\bar{y}}{\bar{n}}$ as the elasticity is defined as $-0.09 = \nu\bar{n}/\bar{y}$; see footnote 26. As a result, we get a selection effect of 1,351 euros. Again, the difference in healthcare expenditure $1,932 - 657 = 1,275$ (Table 3) is mostly selection, not moral hazard.

[34] To illustrate, from Table 3 we know that $\bar{y}_{never}$ is 1,932 euros and $\bar{y}_{at\ least\ once}$ is 657 euros.

[35] We use that the error term is on average zero.

[36] Note that we assume that $\tau = \theta$, as we cannot estimate these terms with model (4). However, this assumption seems not unreasonable, as the difference is only 5 euros for 18 year olds in Table A.6.

A.12. Impact on risk solidarity using moral hazard effect from persons who always chose a voluntary deductible

	18 year olds	Full population
Mean premium discount (€)	171	147
Mean OOP payment w.r.t. voluntary deductible (€)	76	68
Mean moral hazard effect w.r.t. voluntary deductible (€)	4	-40*
Mean reduction solidarity (€)	98	40
Total moral hazard effect w.r.t. voluntary deductible (x €1,000)	48	-36,242*
Total reduction solidarity (x €1,000)	1,172	35,897
Mean premium increase for persons without a voluntary deductible (€)	6	3

Notes: See Appendix A.1 for the computation of the premium discounts. The moral hazard effects are based on Tables 4, 5 and 8. Mean reduction risk solidarity equals the premium discount minus the OOP payment w.r.t. the voluntary deductible plus the moral hazard effect w.r.t. the voluntary deductible. The total effects are calculated by multiplying the mean effects by the number of persons with a voluntary deductible in the age range. Furthermore, the mean premium increase for persons without a voluntary deductible is computed by dividing the total reduction risk solidarity by the number of persons without a voluntary deductible in the age range.