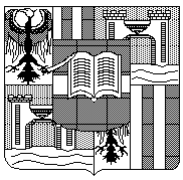

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The Effectiveness of Health Screening

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Working Paper No. 1201
January 2012

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The Effectiveness of Health Screening[1]

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January 17, 2012

Abstract

Using a matched insurant-general practitioner panel data set, we estimated the effect of a general health-screening program on individuals' health status and health care cost. To account for selection into treatment, we used regional variations in the intensity of exposure to supply-determined screening recommendations as an instrumental variable. We found that screening participation substantially increased inpatient and outpatient health care costs for up to two years after treatment. In the medium term, we found cost savings in the outpatient sector, whereas in the long run, no statistically significant effects of screening on either health care cost component could be discerned. In summary, screening participation increases health care costs. Since we did not find any statistically significant effect of screening participation on insurants' health status at any point in time, we do not recommend a general health-screening program. However, given that we found some evidence for cost-saving potentials for the sub-sample of younger insurants, we suggest more targeted screening programs.

JEL Classification: I10, I18

Keywords: Health screening, health care costs, sick leave, mortality.

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1. Introduction

Health screening was a rapidly growing and widely accepted practice in health care during the twentieth century.[2] Proponents of screening programs stress that in addition to the potential of early disease detection (secondary prevention), they also provide the opportunity for screening participants to change unhealthy lifestyles through the so-called lifestyle counseling (primary prevention). Consequently, participants' long-term health outcomes are expected to improve, and future health care costs should decrease. However, more recently, screening programs have faced heavy criticism. Opponents emphasize a list of contra-arguments. They argue that in many cases, the effectiveness of screening is limited and that screening costs will exceed associated savings. Screening may produce false positive outcomes that result in overtreatment. This may not only increase short-term but also long-term health care costs. Moreover, several screening procedures may themselves entail potential harm (e.g., due to radiation exposure) or considerable discomfort for patients (e.g., as in the case of a colonoscopy). According to the latter arguments, different health organizations have recently revised their screening guidelines.

Typically, these screening guidelines are based on two strands of medical and epidemiological literature. One branch analyzes the selection process of patients into the screening programs. Summing up this extensive body of literature, one can put forward that screening participants are positively selected on socioeconomic characteristics. Moreover, there is evidence that especially healthy people as well as those with a family history of particular illnesses participate.[3] The other strand of literature deals with the effectiveness of screening programs. Typically, randomized control trials (RCTs) are used to evaluate the effectiveness of screening programs.[4] Based on this medical and epidemiological evidence, screening guidelines and their

[2] Screening might be defined as the active search for a disease (or a pre-disease condition) in patients who are presumed and presume themselves to be healthy (Holland and Stewart 2005). In such a setting, screening is, in general, not able to reduce the likelihood of a certain disease; however, it may reduce its negative consequences. Therefore, screening is usually considered as a form of *secondary prevention*. In cases where screening programs incorporate aspects of health counseling, it also constitutes *primary prevention*.

[3] Jepson et al. (2000) provides an extensive survey on determinants of screening participation. Compare also Aas (2009), Blom et al. (2008), Fukuda et al. (2007), Lange (2011), Meissner et al. (2007), Sabates and Feinstein (2006), Selvin and Brett (2003), Sambamoorthi and McAlpine (2003), Whynes et al. (2007), or Park and Kang (2008) for more recent studies.

[4] Actual recommendations of the *U.S. Preventive Services Task Force* are, for instance, based on Andriole et al. (2009) and Schröder et al. (2009) for prostate-cancer screenings, Nyström et al. (2002) and Tabár (2000) for breast cancer screening, or Hardcastle et al. (1996) and Mandel et al. (1993) for colorectal cancer screening. Raffle and Gray (2007) presents state-of-the-art studies for RCTs (e.g., *UK Collaborative Trial of Ovarian Cancer Screening*) and other more disputed methods in the clinical realm that have been used to bring evidence of the impact of screening programs (e.g., so-called case control studies or long-term trend analysis).

changes over time leave the overall impression that, as compared to previous periods, contra-arguments have been given a higher priority more recently.[5]

In this paper, we evaluate an Austrian mass screening program launched in 1974. Every Austrian adult is invited to undergo an annual health screening offered by her/his general practitioner (GP), the financial costs of which are fully covered by statutory health insurance. The screening process comprises a general health examination and some age- and sex-specific components. Laboratory tests and the determination of behavioral risk factors (based on the insurants' medical history) should help to detect cardiovascular diseases. In addition to this form of secondary prevention, participation is expected to motivate insurants to engage in primary prevention.

Our analysis is based on a matched patient-GP panel data set comprising all private sector employees and their dependents from the state of Upper Austria covering the period from 1998 through 2007. This data set allowed us to estimate the effect of screening participation on a number of health outcomes such as outpatient health care costs, the incidence of hospitalization and sick leave, and mortality. In order to solve the problem of self-selection into treatment, we took advantage of the fact that GPs have an incentive to "sell" the screening exams to their patients. In particular, we suggest an instrumental variable (IV) estimation strategy that utilized exogenous variation in screening participation due to supply-determined screening recommendations. To quantify each insurant's exposure to supply-determined screening recommendations, we used the number of prescribed screenings per insurant by all GPs located in the insurant's zip code area. As we will argue in detail below, after controlling for insurant and GP fixed effects, this variable should affect insurants' subsequent health outcomes only through the screening participation.

For the average insurant, we observed an increase in outpatient health expenditures (by 27 percent in the year of screening participation and by 39 percent in the following year) and of inpatient health care costs (by about 40 percent). In the medium run, outpatient expenditures decreased by 20 percent in the third year after treatment, and by 40 percent in the fourth and fifth years. We neither found long-run effects on health care cost nor observed any effects on the health status variables days of sick leave and mortality. In summary, we did not observe overall cost savings or any positive effects on health for the average insurant. These patterns are quite robust across different sub-samples of the population. However, given that the short-run increase in health expenditures is comparably low for younger insurants (around sixty years of age or younger), we found some evidence for overall cost-saving potentials for this group.

[5] For instance, the *U.S. Preventive Services Task Force* has released new guidelines for breast cancer screening by 2009 (USPSTF 2009). Whereas previous recommendations for screening mammography were for screening every one to two years after the age of 40 years, the new recommendations call for participation only after the age of 50 years. Or, the *American Cancer Society* takes a clear position discouraging mass population screening and encouraging doctors to inform their patients about screening uncertainties and to involve them more in the decision-making process (Smith et al. 2008).

This paper extends the existing literature on the effectiveness of screening as follows. (i) While the literature on cost effectiveness of mass screenings takes into account direct costs of screening examinations, little information on indirect follow-up treatment costs is available. Screening participation might manifest itself in cost savings through early detection of diseases or, in turn, in an increase in costs triggered by subsequent medical treatment that would not have occurred otherwise. We observed the medical history of a patient in the records of the regional sickness fund over a period of 10 years. Therefore, we provide a more comprehensive analysis of potential financial consequences of screening participation. (ii) Compared to existing literature, for all participants and non-participants, we observed the universe of health-service utilization that allowed us to study a broad variety of outcome variables (e.g., expenses for medical attendance and drugs, hospitalization, sick leave, and mortality). This enabled a more comprehensive evaluation of health screening. (iii) The administrative panel data provided in the register of the regional sickness fund cover 73 percent of the population in the state of Upper Austria and made an evaluation of screening participation in general medical practice possible. (iv) Finally, the Austrian Bismarckian-type health care system represents a good example for countries with universal health care where anyone is eligible to participate in a health screening examination once a year. Consequently, we did not expect sample selection based on financial constraints of the patients.

The remainder of the paper is organized as follows. In Section 2, we start with a brief description of the institutional setting. Section 3 presents the data and descriptive statistics. Thereafter, we explain our estimation strategy and discuss the identifying assumptions of our empirical strategy in Section 4. Section 5 reports the main empirical results and presents several analyses of important sub-samples to check the robustness of the results. Finally, Section 6 concludes the paper.

2. Institutional setting

Austria is a particularly useful case to study the effectiveness of screening participation. It represents a Bismarckian-type (social) health insurance system and offers a nationwide health-screening program. Every resident is covered by mandatory health insurance. Depending on occupation and place of residence, individuals are insured with one of 25 regional sickness funds.[6] Most sickness funds cover all costs associated with sickness and maternity, and some of them charge a small deductible or copayment.[7] In all funds, a visit to a GP for a referral to a medical specialist is recommended; however, there is no obligation to do so, and more and more specialists are consulted directly by the patients.

[6] Due to historical reasons, the division is not only regional but also occupational.
[7] The *Upper Austrian Sickness Fund* (whose data we use below) does not charge deductibles or copayments.

Every insurant (18 years of age or older) is invited to undergo a voluntary health screening once a year. This screening examination is conducted by a GP and is fully covered by mandatory health insurance without any extra payment by patients. The screening examination includes a general health check and several age- and sex-specific diagnostic services. The general health examination consists of laboratory tests to monitor blood sugar, uric acid, triglycerides, cholesterol, gamma GT, and measurement of body mass index. Based on a short anamneses questionnaire, the insurant's own and family medical history, frequency of physical activity, alcohol consumption, and cigarette smoking is determined. This information is the basis for the GP to identify behavioral risk factors and to motivate the patient to engage in primary prevention (life-style counseling). Concerning alcohol abuse and smoking, assistance is provided in reducing alcohol intake and smoking cessation. Obese patients get nutritional counseling. The program primarily aims to prevent or detect cardiovascular disease at an early presymptomatic stage in order to reduce future health care costs and improve insurants' quality of life. Depending on age and sex, several additional examinations may be recommended by the examining GP.[8]

As Figure 1 shows, annual screening participation has steadily increased since the nineties.[9] While only about six percent of all male insurants and seven percent of all female insurants participated in the year 1990, the participation rate increased to thirteen and fourteen percent respectively in 2010. To put these numbers into perspective, it must be noted that very few insurants participate in the screening every year. For instance, in the state of Upper Austria, the majority (about 60 percent) of attendees only participated once or twice over a ten-year period. About six percent showed up every second year, and less than one percent attended every year.

The direct costs of the health-screening program are substantial. For instance, in 2010, the sickness funds spent more than 65 million Euros on screenings of about 850,000 insurants; this is equivalent to 0.27 percent of the total health care cost (or 0.024 percent of GDP). This figure only includes the cost for the general health examination and accounts for neither the additional age- and sex-specific components nor further referrals to medical specialists. In general, participation rates are higher for older insurants (see first line in Table 1).

[8] In detail, the program comprises the following: 40 years or older: counseling and education concerning breast cancer, recommendation of a supplementary mammography. 50 years and older: counseling and education concerning colorectal cancer, performing a fecal occult blood test, recommendation of a supplementary colonoscopy. 65 years and older: special examinations of hearing and vision.

[9] Females are more likely to participate in screenings; this is also confirmed by a regression analysis using the micro-level data to be explained in the next section. Detailed estimation output is available upon request.

3. Data

Our empirical analysis is based on all private sector employees and their dependents residing in the state of Upper Austria.[10] We used the database of the *Upper Austrian Sickness Fund* to compile a matched insurant-GP panel data set for all insurants who were born before 1965. Our data set covers the period from 1998 through 2007.[11] In order to assign a GP to each insurant, we used the patients' GP consultation record. For each year, we determined the GP who was most frequented by the insurant.[12] On average, an insurant had 8.8 GP consultations per year (the median is equal to 5.0), provided by 1.2 different GPs. During years in which an insurant had no GP consultation (about 18.6 percent of all observations), we assigned the GP from the preceding (or if not available, from the succeeding) year(s). The nature of the matched insurant-GP panel data implies that we had to exclude all insurants (7.7 percent) from our analysis who had never consulted a GP in Upper Austria during their insurance spell(s).[13]

Obviously, our panel is not balanced. Individuals dropped out of our sample if they were no longer insured with the *Upper Austrian Sickness Fund*, if they moved outside Upper Austria, or if they passed away. Equivalently, individuals born before 1965 entered into our panel if they joined the *Upper Austrian Sickness Fund* and resided in Upper Austria after 1998. Still, the vast majority of insurants (82.4 percent) in our sample could be observed in each year.

Our data set includes information on all covered health services (including screening participation) that had been provided to an insurant by his/her GP or any other resident medical specialist. That means that we observed each single doctor visit and each drug that had been prescribed, and with the exact date of service utilization. The data set also provides information on the incidence of hospitalization and sick leave. In order to obtain exact information on the place of residence (zip code area), labor market status, and mortality, we linked our data to the *Austrian Social Security Database* and the database from the *Austrian Federal Ministry of Finance*.

To evaluate the effectiveness of health screening, we considered the following outcomes in our estimation analysis below: outpatient health care expenditures including cost for medical

[10] Upper Austria is one of nine states in Austria and comprises about one sixth of the Austrian population and work force. From the total population (about 1,400,000) we observed 1,180,000 insured private sector employees with their dependents. Out of this group, we focused on 541.351 persons born in 1964 or earlier. From this sample, 266,170 persons (49.17 percent) had at least participated once in a screening program. The remaining 275,181 (50.83 percent) never joined the screening program.

[11] Therefore, at the beginning of our observation period, the included insurants were 34 years of age or older. For younger people, health expenditures are mainly driven by accidents or genetically disposed diseases. Both aspects are not covered by the screening program.

[12] If an insurant had consulted two (or more) GPs equally often in a given year, we picked the most recently consulted one.

[13] Since these insurants had comparably shorter insurance spells, they accounted for only 4.4 percent of the observations.

attendance and medical drugs, days of hospitalization, days of sick leave, and mortality.[14] As Table 1 shows, the average insurant generated 636.00 Euro of outpatient health expenditures per year, spent 3.36 days in the hospital, and was on sick leave (conditional on employment) for 13.48 days. As expected, in each category, the mean and the standard deviation increased with age.[15] By the end of 2007, about one percent from the youngest age group and 53 percent of the oldest age group passed away.

4. Estimation strategy

To estimate the effect of screening on subsequent health outcomes, we started with the equation

$$y_{it} = \alpha_r * s_{i,t-r} + \beta * x_{it} + \theta_i + \psi_{J(i,t)} + \delta_t + \varepsilon_{it}$$

where y_{it} denotes the health outcome of insurant *i* in period *t*. The binary variable(s) $s_{i,t-r}$ capture whether individual *i* participated in a health screening in period *t-r* with $r \subseteq \{0,1,2,3,4,5,6,7,8\}$. As covariates, we included time-varying characteristics of the insurants (denoted by x_{it}), insurants fixed effects (θ_i), GP fixed effects ($\psi_{J(i,t)}$) and time fixed effects (δ_t). The parameters of primary interest are α_r, indicating the effect of screening *r* years ago.

An obvious issue is the endogeneity of screening participation. Self-selection into treatment has to be expected. In other words, a correlation between $s_{i,t-r}$ and the error term ε_{it} is highly likely. A priori, it is hard to assess the sign of the selection bias. It is reasonable to believe that health-conscious individuals are more likely to participate. In that case, OLS would overestimate the effect of health screening. At the same time, it would be rational for individuals from high-risk groups to undergo a check-up on a regular basis. If the latter effect dominates, OLS would underestimate the effect of screening.[16]

Selection that is based on insurants' observed characteristics or unobserved time-invariant heterogeneity is controlled for by the inclusion of the vector of time-varying individual characteristics and the insurants' fixed effects. However, if screening participation is correlated with time-varying unobservables that affect health outcomes, no control strategy succeeds in

[14] The cost of screening participation has been deducted from outpatient health care expenditures Days of hospitalization were used as a proxy for inpatient health care expenditure. The analysis of sick leave was restricted to the sample of insurants with employment spells. Moreover, sick leave was only measured precisely for sickness absences that lasted longer than 3 days. It is not mandatory for employees or firms to notify the *Upper Austrian Sickness Fund* of sickness absences lasting less than 3 days.

[15] Note that this does not apply to sick leave for the two highest age groups. Since average effective retirement age in the year 2007 was 57.9 for males and 58.9 for females (Source: *OECD Database*), the remaining insurants in the sample are positively selected.

[16] There is extensive medical and epidemiological literature available that confirms this positive selection into screening (see the Introduction and footnote 3).

identifying the causal effect of screening. To account for the latter situation, we suggest an IV approach. This allows a consistent estimation of the causal effect of screening without asymptotic bias from unobserved time-varying heterogeneity.

4.1. Supply-determined screening demand

The idea of our IV strategy was to utilize exogenous variation in screening participation due to supply-determined demand. In other words, we took advantage of the fact that patients do not only self-select into screening but are also examined simply because of their GPs' recommendation. In fact, there are good reasons to believe that this market is mainly driven by the supply side. To motivate this approach, we discuss in a first step why GPs in Austria should have a strong incentive to recommend screening, and we provide evidence that patients responded to this recommendation. These are two necessary conditions for the suitability of our IV strategy.

Do GP's have an incentive to recommend screening? GPs may consider screening a sensible method of secondary prevention and advocate it to their patients in order to improve their future well-being. This type of supply-determined health demand is fully altruistic and solely guided by the *Hippocratic Oath*. Moreover, GPs may also act in their own interest, as they recommend screening that is driven by their profit-maximizing behavior (McGuire 2000). In a static setting, GPs have a clear financial incentive to sell screenings.[17] Supply-determined recommendations may be particularly strong in the case of screening, since this service can be sold to any patient, healthy or unhealthy, with a low probability of medical liability due to overtreatment. To put it bluntly, screening is the only service by which a GP can officially earn income with perfectly healthy people. At least in Austria, screening also seems to be a comparably lucrative business. Table 2 provides frequencies and fees paid from the *Upper Austrian Sickness Fund* to the GPs for different health care services. It can be seen that the reimbursement for general consultation, including extra payments from the third visit of a patient in a quarter, makes up to 53 percent of the GPs total income.[18] Screening accounts for almost 7 percent of the total amount of fees. Although we do not have detailed information on the doctors' time spent for the different service categories, Table 2 also indicates that a GP can earn relatively good money by providing screening examinations. The screening fee is more than four times higher than that for the first treatment in a quarter, and almost as high as the reimbursement for a cardiopulmonary resuscitation—one of the most expensive health services in the Austrian primary health care market. We conclude from this that GPs have a clear incentive to recommend screening to their patients whether due to altruistic or non-altruistic reasons.

[17] In a dynamic setting, it could be optimal for GPs to undersupply preventive care measures in order to reap higher profits from curative care measures in the future (Kenkel 2000).

[18] A GP can have contracts with several health insurance funds. The funds are very similar in their fee structure, and the funds' GP fees generate most of a GP's income.

Do patients respond to GPs' screening recommendations? The conjecture that screening participation is highly driven by GPs' recommendations is confirmed in the literature. For instance, Cole et al. (2002) analyzed the effectiveness of three different letter designs for colorectal cancer screening invitations. The first letter was dispatched from a central screening service, the second included a reference to the patient's GP, and the third was also signed by the GP. It turns out that the participation rate was lowest among patients who received the first letter (32 percent) and highest among the third group (41 percent). This and similar evidence[19] suggests that patients respond to GPs' screening recommendations.

In line with this evidence, we found in our data that GP fixed effects alone explain about eight percent of the variation in individual screening participation. Patient fixed effects, however, account for only 0.04 percent of the variation in screening participation. This suggests that screening participation is predominantly driven by GPs and only to a small extent by patients themselves.

4.2. Quantifying supply-determined screening recommendations

Ideally, we would like a random sample of GPs recommending screening to a random sample of all their patients, and we could observe this and their subsequent health outcomes in our data.[20] Since this type of field experiment is not feasible, we suggest using a proxy for the intensity of exposure to GP screening recommendations. In particular, we argue that the number of prescribed screenings by GPs located in a given zip code area provides (within a panel data regression framework) a good proxy for exposure to supply-determined recommendations.

We wanted to capture the simple idea that insurants are more exposed to supply-determined screening recommendations if the consulted GPs are more likely (for whatever reason) to advocate this service to their patients. If we were willing to assume that insurants had been randomly assigned to GPs, we could simply use GP fixed effects as an IV for screening participation.[21] In order to relax this assumption, and to allow for a setting where insurants may actively select a particular GP within their local neighborhood, we suggest measuring the exposure to supply-determined screening recommendations not on a GP level but on zip-code level.[22] Another advantage to this procedure is that we were able to include GP fixed effects in our

[19] See, for instance, Meissner et al. (2007), Richardson et al. (1994), Bowman et al. (1995), Cole et al. (2002), Cowen et al. (1996).

[20] This would allow us to use the randomly assigned screening recommendation as an IV for actual screening participation. Given that a reasonably large fraction of patients follow their GPs' advice (i.e., there is a "*strong first stage*"), we could estimate the causal effect (in particular, a *local average treatment effect*) of screening participation on subsequent health outcomes for those patients who comply with their GP's recommendation.

[21] In fact, the spatial distribution of GPs possessing a contract with the *Upper Austrian Sickness Fund* is likely close to random. Since such a contract is highly attractive, GPs queue for it, and have a strong financial incentive to accept available offers, even if this is from outside their initial place of residence.

[22] This resembles the typical situation in Austria, where insurants have a GP in their local neighborhood (about 72.7 percent of insurants have a GP within their zip code), whom they consult to get basic medical care or sick leave slips for their employer.

regression analysis that captured all unmeasured time-invariant GP characteristics. In particular, we calculated our IV (denoted by $S_{z(i),t-r}$) for each zip code area z and year t as the sum of all screenings prescribed by all GPs located in a given zip code area (consumed by any insurant minus the screening of individual *i*) divided by all insurants residing in this zip code area minus one.

The spatial distribution of our IV averaged over annual values from 1998 through 2007 is depicted in Figure 2. One can see that the exposure to supply-determined screening recommendations varies quite substantially across zip code areas. GPs in different zip code areas and/or at different points in time vary in selling this service with respect to both their assessment of the effectiveness of screening and their financial incentives.

4.3. IV estimation

Our suggested IV strategy translates into the following first-stage estimation:

$$s_{i,t-r} = \varsigma * S_{z(i),t-r} + \beta * x_{it} + \theta_i + \psi_{J(i,t)} + \delta_t + \upsilon_{it}$$

We will see below that this proxy for the intensity of exposure to supply-side-driven screening $S_{z(i),t-r}$ in the residential zip code area z is highly correlated with the individual screening participation, and that the parameter ς enters as a highly statistically significant determinant. The inclusion of GP fixed effects θ_i allows for the direct influence of GPs on patients' health outcomes that are potentially correlated with the extent of GPs advising screening. For instance, GPs who like to recommend screening may also tend to prescribe more (or more expensive) medical drugs.

In order to evaluate the validity of our IV, it is useful to highlight the exact sources of variation in the first stage. In our framework, patients experienced a variation in the intensity of exposure to supply-determined screening recommendation (i) if an existing GP in a zip code area is substituted (e.g., due to retirement), (ii) if an additional GP is allocated, (iii) if patients move to another zip code area, and (iv) if existing GPs change their screening recommendation behavior over time. The latter may be triggered by a re-evaluation of GPs' assessment of the effectiveness of screenings (e.g., due to training) and/or by changing financial incentives to sell screenings. Our proxy of exposure to supply-determined screening may also be altered (v) if other patients of GPs within a certain zip code area request more screenings without any GPs' intervention. While it is not possible to disentangle and quantify each of different channels of variation, we expect the fifth channel to be comparatively less important.[23] It can be shown that GP fixed effects explain 200 times more variation as compared to insurant fixed effects. In other words, this suggests that this market can be characterized by Say's law, and most demand is determined by its supply.

[23] We observed 91.80 percent of our GPs in each year over the whole sample period. At least 5.64 percent of GPs left the sample (via retirement or death), and 2.56 percent joined the sample at a later point in time. Moreover, 20.30 percent of insurants moved across zip code areas within Upper Austria at least once.

The first four (and supposedly quantitatively most important) sources of variation seem undoubtedly exogenous and should not affect insurants' later health outcomes through channels other than screening participation. What about variation due to the fifth channel? This type of variation would only be problematic if autonomously increased screening demand by other insurants $(-i)$ of GPs in the same zip code area has an independent effect on insurant's (i) later health outcomes. While it is possible that family members and other peers persuade one to follow their example to participate in screening and to change others' health behavior, we consider herding phenomena in single zip code areas that are large enough to create substantial variation in our IV to be highly unlikely. In sum, given that we control for GP and insurant fixed effects (among others) in our regression framework, we regard a correlation between our IV and the error term in the second stage as highly unlikely.

Under the validity of our IV approach, we can then identify a local average treatment effect. This means that we estimated the causal effect of screening participation on later health outcomes for insurants who participated in health screenings due to their high exposure to supply-determined screening recommendations. In other words, we can think of the compliers as those patients who get check-ups due to their GP's recommendation and not because of their own request.

5. Empirical Results

This section presents our estimation results. We begin by providing first-stage results. Subsequently, we discuss the estimated effects of screening participation on our main measures of health care cost (outpatient expenditures including costs for medical attendance and medical drugs and incidence of hospitalization) and health status (incidence of sick leave and mortality). It turns out to be useful to distinguish here between short-, medium-, and long-run effects of screening participation. Moreover, we present disaggregated estimation results for medical attendance (where we distinguish between different medical specialists) and for different categories of medical drugs to provide further insights.

Table 3 summarizes the first-stage results for the different lags in our IV estimations. Given that the outcome days of sick leave applies only to employed insurants, we used two different samples, the full sample and the sub-sample of insurants with employment spells. In both samples, we found a highly statistically significant effect of our IV (i.e., the proxy for the exposure to supply-side screening recommendations) on the likelihood of screening participation. The estimated coefficients of the instrument range between 0.51 and 0.73 for the full sample and between 0.43 and 0.48 for the restricted sample. This means that an increase in the instrument (screening rate per zip code area) by one standard deviation (0.057) increased an insurant's propensity to participate in a health screening by 2.85 percentage points if we assume a first-stage coefficient of

0.5. The F-statistic on the excluded instrument is very high for each lag, indicating that we can reject the hypothesis of a weak instrument (Stock and Yogo, 2005).

The second-stage results of our IV estimations for our main outcome variables are summarized in Table 4, along with the respective OLS estimates for comparison. The coefficients give the estimated effect of screening on the respective outcome variable *r* years after treatment. Each entry in Table 4 represents a separate estimation for the respective lag.[24] The IV and the OLS estimates are, in many cases qualitatively and in most cases quantitatively, very different from each other. This suggests that selection into screening is an important issue that must be taken into account in an evaluation. In other words, the OLS estimates seem to be heavily biased and should not be interpreted causally. The findings suggest that, in particular, healthy or health-conscious people participate in screening. Healthy screeners cause a moderate increase in expenses for doctor visits, spend less on medical drugs, and spend fewer days in the hospital; moreover, the increasing number of sickness days may indicate that they do not go to work if they are sick.

Short-run effects: Based on the IV estimation, we found a highly statistically significant increase in short-term outpatient expenditures up to two years after the screening participation: plus €279 in the year of treatment and plus €195 in the year thereafter. This is equivalent to an increase of 38 percent and 27 percent, respectively. The sharp increase in outpatient expenditures is predominantly due to a rise in expenses for medical drugs, and to a smaller extent due to cost increases of medical attendance. Expenses for medical drugs rose by €211 and €154, while expenses for medical attendance increased only by €67 and €41.[25] In the short run, screening participation also substantially increased the incidence of hospitalization. We found an increase of one and a half days in the hospital (or about plus 40 percent) in the year of the treatment and in the year thereafter. At the same time, we did not find any statistically significant impact of screening participation on the incidence of sick leave.

These results suggest that screening leads to further inpatient and outpatient medical treatment following the screening exam. The more disaggregated results (summarized in Table 5 and Table 6) help to explain the mechanism behind this short-run health care cost increase. The estimation results for particular groups of medical drugs in Table 5 show that drug expenditures for the cardiovascular system and for the nervous system increased significantly in the short run. On average, drug expenditures for antidepressants and other drugs for the nervous system doubled in the first three periods after screening participation. The increase of expenses for medication for the cardiovascular system meets expectations given the fact that one of the primary purposes of the

[24] We also estimated a specification including the complete set of lagged screening participation simultaneously. Due to the inclusion of lag 8, this specification can only be applied to the reduced sample of observations from the years 2006 and 2007 (16 percent of the whole sample). Based on this specification, we did not find a sufficiently strong first stage.

[25] Direct costs for the screening programs of the examining GP are not included in our measures for outpatient expenditures.

Austrian screening program is the detection and prevention of cardiovascular diseases. It is important to note, however, that the cost-increasing effect on cardiovascular drugs is mainly driven by medication treating high cholesterol. If we exclude these medical drugs from the superordinate cardiovascular group, the previous significantly positive effect vanishes. We presume that the GPs prescribe anti-cholesterol drugs if the blood tests reveal cholesterol values beyond predetermined thresholds. The rise of medications for neural and mental diseases is surprising, however, since these illnesses are not even mentioned in the objectives of the screening program. This result provides support for the conclusion that patients mention their mental unease in the course of a comprehensive anamnesis and, as a subsequent consequence, the GPs prescribe antipsychotics on a large scale. Further cost-increasing effects of screening participation can be found for genito-urinary and musculo-skeletal drugs and for drugs that cannot be attributed to ATC codes ("Missing").

The disaggregated findings for medical attendance in Table 6 show a strong short-term increase in expenditures for diagnostic medical services. Both the expenditures for medical attendance by radiologists and for laboratory services increase substantially up to four years after treatment. There is every reason to believe that GPs, who carry out the general health screening, subsequently refer patients to specialists for further and/or more detailed diagnostic services. Notably, the positive effect on medical attendance cost (in particular, for radiologists and laboratory services) is highest in the year of the screening, and decreases thereafter.

The decomposition also reveals a decrease of expenditures for urologists, gynecologists, and dermatologists in the short run. Since the visits at these medical specialists often have a preventive character (e.g., screening for prostate, breast, or skin cancer), these consultations can be expected to represent substitutes to the general screening program conducted by the GPs. The negative impacts of screening participation on these expenses are not in contradiction to this argument in the least. There is another striking and surprising result. The continuous and quantitatively highly relevant decrease of expenditures for physiotherapy over the period zero to five years after screening is remarkable since these medical services typically have a rehabilitation character without a direct connection to screening. We presume some kind of substitutional relationship between screening and physiotherapy; however, we lack a convincing medical explanation for this result. While the expenses for the residual category "Other services" decreased in the short run, we found an increase in costs for pulmonologist visits.

Medium-run effects: In the medium run, outpatient expenditures decreased due to screening participation (see Table 4). The decline in outpatient expenditures three, four, and five years after treatment was €145, €293, and €289, respectively. This is equivalent to a decrease of 20 and 40 percent, respectively. As in the short run, the effect of screening on outpatient expenditures can be predominantly attributed to an effect via the consumption of medical drugs, and to a smaller

extent due to changing medical attendance. We did not find any statistically significant effect on incidence of hospitalization.

The medium-run decrease in expenditures for medical drugs can be partly explained by the group of pharmaceuticals for the alimentary tract and metabolism (Table 5). There is weaker evidence for a reduced consumption of medical drugs targeting the cardiovascular system. The decomposition of drug expenditures further shows that the expenses for pharmaceuticals for blood and blood-forming organs, for the genito-urinary system including sex hormones, for the musculo-skeletal system, for the respiratory system, dermatologicals, anti-infectives, and for the residual category are reduced in response to screening participation in the time span of three to six years after treatment.

The medium-run cost-decreasing effects for medical attendance are mainly driven by visits at GPs and internists (see Table 6). Depending on the year, we found cost reductions between 17 and 35 percent for GPs and between 50 and 73 percent for internists. Comparable cost can be observed for visits at all other specialists (see category "Other"), with a decline of expenditures in an order of magnitude between 23 and 66 percent two to seven years after treatment. Only the special medical fields radiology and laboratory diagnostics showed increasing service utilization even in the medium run; however, the quantitative effects were much smaller as compared to the short run. This result might be an indication of regular checkups after a medical problem has been found in the screening examination.[26]

Long-term effects: In the long run (i.e., six years or more after treatment), we did not find any statistically significant effects of screening on outpatient expenditures or on the incidence of hospitalization (see Table 4). However, the point estimates for outpatient expenditures were quite big in absolute terms. For the disaggregated expenditure components (summarized in Tables 5 and 6), we saw sporadic statistically significant negative coefficients. Here, one has to keep in mind that we had far less observations available to estimate these long-run coefficients. This increases the standard errors substantially, which may increase the likelihood of a type II error. In sum, however, we interpret the estimation results as evidence for a fading out of the effect of screening over time. This interpretation is also substantiated by the results of our last outcome of consideration, namely, mortality.

Heterogenous effects for sub-populations: In order to explore whether screening participation has different effects across sub-populations, we re-ran our analysis for important sub-samples along the dimensions sex, age and, employment. In each case we had a strong first-stage and very comparable patterns in the second-stage. That means, for each sub-population, we observed an increase in short-run cost, a decrease in medium-run cost, no significant effects on

[26] In addition, we split the sample into an older cohort (birth year 1942 and older) and a younger cohort (birth year 1943 and younger). For the older cohort, we observed higher short-run expenditures and higher medium-run savings. Qualitatively, however, we did not find a systematic difference between these two subsamples. A similar procedure was applied for a split sample of women and men. In this case, we observed stronger effects for men.

long-run cost, and no impact on the incidence of sick leave. However, the size of the estimated coefficients (and also their statistical significance) varied across sub-populations. The most important distinction to make is between the effects for younger versus older insurants. Table 7 summarizes these results where we distinguished between younger insurants (born 1943 or later) and older insurants (born before 1943). For younger insurants, the increase in short-run cost was less pronounced; in particular, we did not find a significant increase in the incidence of hospitalization. It seems that younger patients got less (or less complicated) follow-up medical treatments after a general health screening. However, the cost-savings in the medium were are also less pronounced for the younger cohorts.

Mortality: The primary objective of screening is to maintain or improve insurants' health. Therefore, we looked at the ultimate health outcome given by mortality. Since humans die at a certain point in time, we could not use a panel estimation with insurant fixed effects and had to adapt our estimation strategy accordingly. The dependent variable in this analysis now becomes a binary indicator for whether the insurant was still alive in the year 2009.[27] Given that mortality crucially depends on age, we ran separate regressions for three birth cohort groups (born before 1933, between 1934 and 1943, and between 1944 and 1953). Following Angrist (2001), we estimated a linear probability model of mortality for each birth cohort group in which we used all insurants who were permanently insured between 1998 and 2003. As the variable of primary interest, we included the number of screenings carried out in this time span, which varied between zero and six. As before, we used our proxy for the exposure to supply-side screening recommendations to instrument for actual screening participation. In contrast to the panel data framework above, we used the average exposure over a treatment period defined as 1998 to 2003. The F-statistics on the excluded instrument (from the first stage) support again the strength of our instrument, as can be seen in the lower panel of Table 8. As further control variables, we included information on the insurant's age, sex, nationality, education, GP in the year 1998, and the exemption of the prescription charge, which served as a proxy for income.

The upper panel of Table 8 summarizes the estimation results of the second stage and reports corresponding OLS estimates for comparison. Interestingly, the OLS estimates suggest a life-prolonging effect of screening. Depending on the birth cohort group, an additional screening participation is associated with an increased likelihood of being alive in 2009 between one and four percentage points. In contrast, the IV estimates do not show any statistically significant effect of screening on mortality. These results suggest that healthy insurants self-select themselves into treatment, while screening itself exerts no significant effect on mortality.

Interpretation of results: We found a clear increase in short-run health care costs (inpatient and outpatient) that is followed by medium-run decreases in the outpatient sector. In the long run,

[27] The year 2009 is the latest year for which mortality data are available.

we did not find any statistically significant cost effects. In order to evaluate the overall cost effectiveness of the screening program, we had to add all the point estimates for the lags zero to eight (as presented in Table 4). This gives an aggregate effect of about €-957 for outpatient health care costs and of about 6 days in inpatient care. For the screening participation to be cost-neutral, a day in the hospital must cost less than €132. While we cannot monetize the cost of a hospital day caused by screening, we know that a day in the hospital costs on average between €700 and €800. This means that according to our estimates, screening participation clearly increases health costs. The same qualitative result arises if we consider only statistically significant point estimates; in this case, the threshold for cost-neutrality is even lower (hospital cost per day of €61). In any case, it is comforting to know that it has no impact on the overall evaluation of the cost-effectiveness of screening whether we consider the face value of insignificant coefficients, or we assume them to be zero. In addition to the cost increase, we do not find any statistically significant effects on health as measured by the incidence of sick leave or mortality. The only sub-population, for which the cost savings in the medium-run could overcompensate the increase in short-run costs, is the one of younger insurants. Here, the threshold for cost-neutrality is €452 of hospital costs per day, if we consider all coefficients.[28] Several explanations exist for our empirical pattern:

(i) Doctors' strong risk aversion may lead to substantial overtreatment (especially of older patients). This could explain the short-run increase in expenditures without improvement of patients' health. However, this reason cannot explain the decreasing mid-term effects on expenditures.

(ii) Alternatively, the immediate increase in outpatient health expenditures may be supply-induced or at least supply-determined. Health screening offers doctors the opportunity to further increase the amount of care. If we assume that more detailed diagnostic services do not harm generally healthy patients, the observed increase of this cost category may reflect a good possibility for resident doctors to raise their income. Furthermore, GPs prescribe additional drugs, in particular for the treatment of high cholesterol, mental illness, and medications for the genito-urinary and musculo-skeletal systems. Whether the lion's share of this increase is medically justified, or if many of these prescriptions are supply-determined, cannot be clearly answered by our data. Whereas the supply-determined argument can at least partly explain our empirical pattern, there are also counter arguments. According to column 1 in Table 6, GPs do not increase their own income by screening-induced medical treatment in the immediate and the subsequent year. Generally, we do not observe a remarkable increase of short-run therapeutic services by medical specialists ("Other") in the year of screening. Moreover, supply-side effects alone cannot explain the decrease of mid-term expenditures either.

[28] Since we did not find any significant coefficient for hospital days for this sub-population (see Table 7), we cannot compute a cost-neutrality threshold of hospital costs. However, screening participation would reduce outpatient expenditures by €195 for younger insurants.

(iii) Patients' behavior may explain the screening-driven patterns in health expenditures. Suppose a person has joined the screening program in the recent past and no medical troubles have been found. After the screening, the patient is confronted with health problems that are not necessarily serious. Given that the good health of the same person has been attested through screening in the recent past, the patient may forego medical consultation in this case. Consequently, individuals' expenditures for drugs and medical attendance may decrease in a certain period after screening. We call this phenomenon the "reassurance effect" of screening participation. The relevance of this effect may be indicated by our result that the services of GPs and internists decrease significantly in the medium run. These two categories of resident doctors are typically the first place of contact for health problems in the Austrian health system. A reduction of precisely these "gatekeeping services" suggests that the confirmation of good health in recent health checks may reduce a patient's frequency of doctor visits in the near future.

(iv) The pattern of short-term increases and medium-term decreases in health expenditures may also display the intended screening effects. Even if one has to accept an increase in short-term cost (i.e., diseases are detected and treated at an early stage), the expenses in the medium run would decrease if more expensive treatments at a later stage of a disease can be prevented. Similarly, a change in lifestyle induced by the screening examination could explain our empirical results. A sustainable change in lifestyle accompanied by preventive health investments such as smoking cessation, less alcohol consumption, a more healthy diet, and more intensive sports activities would improve health and, consequently, can be expected to decrease health expenditures. In either case, we would expect improvements in the health status of treated individuals. If we interpret the number of sick days, mortality, and hospitalization as acceptable indicators for individual health, the hypothesis that significant health improvements are due to screening participation cannot be supported in the empirical analysis. The short-run impact of screening on hospitalization is even positive, and the effect on absenteeism remains insignificant for all periods. Hence, we do not observe the expected changes in health-status variables. However, our measures of individual health may indicate severe health problems. Hospital days, days of sick leave, and obviously mortality represent variables that capture serious health troubles only. Therefore, the screening program may be successful insofar as it triggers minor health improvements of patients that we cannot measure by our health status variables.

6. Conclusions

Based on comprehensive administrative data that included the history of patients' health service utilization recorded by a mandatory regional sickness fund over a 10-year period, we estimated the effects of a general health-screening program in Austria on individuals' subsequent health care costs and health status. The empirical identification is based on a panel IV estimation that exploited

exogenous variation in local exposure to supply-side screening recommendations. The broad variety of outcome variables (expenses for medical attendance and drugs, hospitalization, sick leave, and mortality) allowed a comprehensive evaluation.

We found that screening participation of an average insurant substantially increased health care costs up to two years after treatment. Inpatient and outpatient medical care increased temporarily up to 40 percent. This short-run increase in health care cost was not compensated by the medium-run cost savings in the outpatient sector. In the long run (eight years after treatment or longer), no statistically significant effects of screening participation on either health care cost component can be discerned. At no point in time did we find a statistically significant impact of screening participation on insurants' health status.

A more disaggregated analysis of cost components enabled a quite clear interpretation of the short-run rise in health care costs. The general screening examination led to substantial increases in intake of medical drugs and further medical examinations. In contrast, the medium-run decline in outpatient health care costs may have at least two different sources. The empirical evidence is consistent with successful secondary and/or primary prevention, as well as with a demand-side driven "reassurance effect." The first explanation would be an argument in favor of screening. The second explanation would suggest that screening mainly affects the timing of health care costs and has only a small impact on insurants' health status.

Given that we did not find any significant effects of screening on our measures of health status, we consider the reassurance effect as the more likely explanation for the decrease in medium-run health care costs. This interpretation is also supported by the fact that the decline in medium-run health care costs comes from the outpatient and not the inpatient sector, where the former is more amenable to demand-driven consumption. However, we have to acknowledge that our health status measurements mainly target more serious health conditions, and minor improvements in health may remain undisclosed.

In summary, screening increases health care costs on average and does not improve health. This empirical evidence corroborates the most recent screening literature that, in contrast to earlier studies, is more skeptical about the overall cost effectiveness of health screening. To Austrian health policy-makers we would recommend to abolish the program in its current form or to revise it. In particular, we suggest to focus on younger insurants (about sixty years of age or younger), since we found comparably small short-run cost increases for this group that can be overcompensated by cost-savings in the medium run.

The following proposals for improvement should be considered in implementing (general) health screening programs: (i) Given the increase of short-run outpatient expenditures, the efficiency of a program can be improved by a reduction of false positive diagnoses and subsequent overtreatment. A more precise program differentiation according to patients' age and gender-specific risk factors would allow more target-based medical examinations. Moreover, based on

these specific risk factors, binding diagnostic guidelines could be established. (ii) A well-designed program should focus on health-promoting achievements. In light of recent epidemiological developments (e.g., obesity[29]), more effective lifestyle-counseling measures could be discussed. Screening guidelines that include realistic and achievable lifestyle objectives, in combination with financial incentives for patients, should be stipulated. (iii) Finally, programs should be flexible and react to the divergence between the original intentions of the program and its real-life practice. This implies, of course, a constant and careful evaluation. Targeted guidelines for further medical treatment are necessary, especially with regard to diseases that are given a high priority in the program's objectives. For instance, disorders of the heart and circulatory system are at the core of the Austrian general health-screening program. However, with the exception of cholesterol drugs, we hardly find significant changes in cardio and circulatory medicines after the screening examination. However, the highly statistically significant causal increase in the prescription of antidepressants and other drugs is a clear example of a highly relevant health issue in practice. Given that the program does not even mention this area in its guidelines, it should be extended to react to this need.

[29] For literature on obesity, see for instance Baum and Ruhm (2009), Bhattacharya and Bundorf (2009), Bhattacharya and Sood (2011).

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8. Tables and Figures

Figure 1: Screening participation rate in Austria by sex, 1990-2010

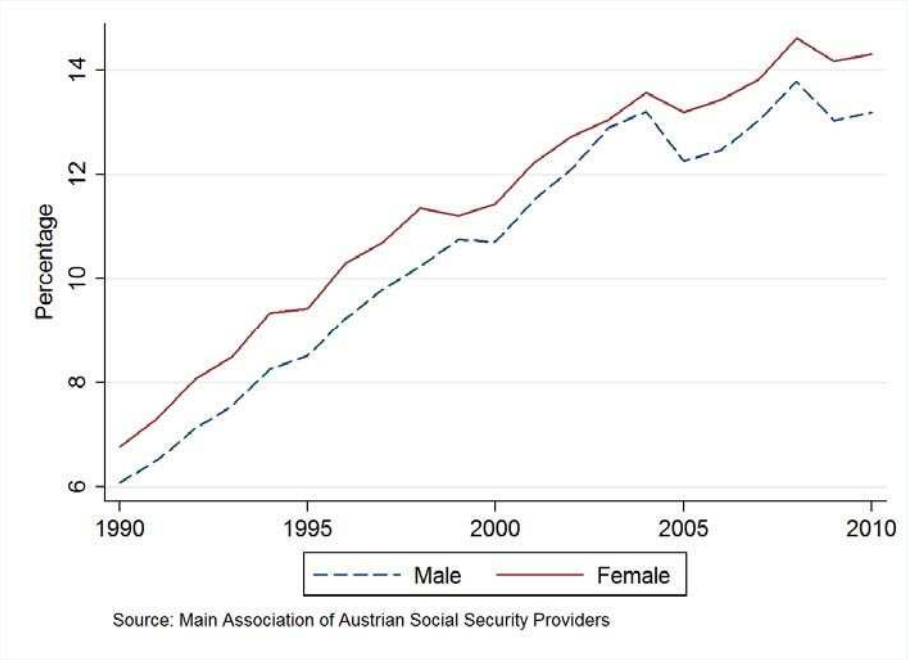


Table 1: Mean and standard deviation of screening participation and health outcomes (by age group)[a]

	Overall	Age groups				
		34-43	44-53	54-63	64-73	74+
Participation rate[b]	14.26	11.19	13.84	17.43	17.51	10.89
Outpatient Expenditures	636.00 (1059.12)	305.52 (728.22)	463.22 (970.92)	666.69 (1108.85)	855.74 (1166.86)	1097.31 (1156.46)
Medical Attendance	298.68 (364.00)	186.56 (239.89)	259.26 (324.20)	320.34 (376.75)	365.75 (416.03)	412.20 (429.24)
Medical Drugs	337.31 (915.28)	118.96 (651.67)	203.95 (866.31)	346.35 (977.47)	489.99 (1006.23)	685.11 (966.08)
Days of Hospitalization	3.36 (10.86)	1.32 (6.60)	1.98 (8.37)	2.92 (9.94)	4.50 (12.42)	7.91 (16.09)
Days of sick leave	13.48 (26.35)	11.15 (21.70)	13.90 (26.69)	17.91 (33.47)	3.29 (16.17)	3.89 (20.06)
Mortality	0.12	0.01	0.04	0.09	0.21	0.53
Number of individuals	586,915	172,465	123,199	106,343	77,917	61,427

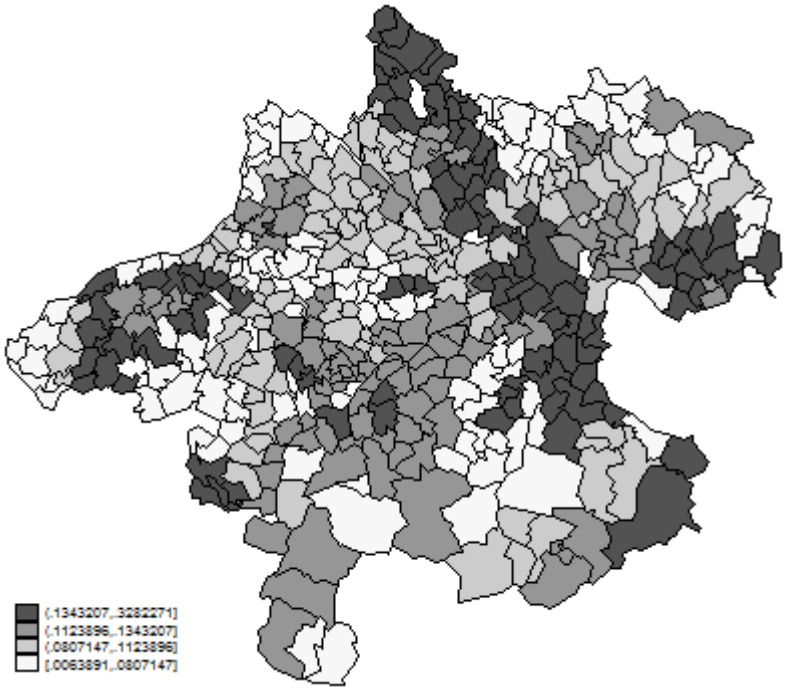
[a] This table provides the annual mean and the standard deviation (in brackets) for the health outcomes under consideration based on an unbalanced panel data set covering the period from 1998 through 2007. The first column gives the numbers for all insurants (34 years of age or older). Columns three to seven give the figures by age group. Monetary values are adjusted for inflation and expressed in 2007 Euros. Note: insurants contribute up to ten observations, and may be represented in up to two age groups. This does not apply to the outcome mortality, which gives the relative share of insurants of each age group that had passed away by the end of 2007.
[b] in 2007

Table 2: GPs' fees for different types of services[a]

Type of service	Fee	Percent
First and second consultation in a quarter	17.98	46.74
Consultation from third visit in a quarter onwards	2.33	6.09
Therapeutic counsel	10.86	3.45
Sonography	2.54	0.80
Home visit	22.35	8.04
…		
Cardiopulmonary resuscitation at the location of the accident	82.53	0.01
…		
Screening	75.00	6.88

[a] This table provides fees paid by the *Upper Austrian Sickness Fund* for different types of services by GPs, and the respective percentage of GP's total income.

Figure 2: Spatial distribution of exposure to supply-determined screening recommendations[a]



[a] This map of Upper Austria depicts the exposure to supply-determined screening recommendations across zip code areas, where a darker color represent a higher exposure. The exposure is calculated as the annual sum of all screenings prescribed by all GPs located in a given zip code area (consumed by any insurant) divided by all insurants residing in this zip code area minus one. This map shows the average of these annual values from the years 1998 through 2007.

Table 3: Firsts stage results[a]

Lag r	0	1	2	3	4	5	6	7	8
Total sample									
Coefficient of IV	0.51	0.59	0.63	0.67	0.71	0.69	0.68	0.68	0.73
Cragg-Donald Wald F statistic	2620.42	2707.12	2340.62	1936.88	1523.34	902.40	544.76	263.74	91.78
Number of obervations	4,758,720	4,195,366	3,661,284	3,148,473	2,651,756	2,171,145	1,704,049	1,251,107	824,999
Number of individuals	586,915	531,339	519,172	505,611	489,836	477,398	463,878	435,740	422,173
Average no. of obs. per indiv.	8.11	7.90	7.05	6.23	5.41	4.55	3.67	2.87	1.95
Sub-sample of insurants with employment spells									
Coefficient of IV	0.43	0.48	0.51	0.52	0.54	0.53	0.52	0.52	0.48
Cragg-Donald Wald F statistic	824.84	815.67	673.92	528.08	403.61	249.64	143.52	69.06	17.14
Number of obervations	2,093,144	1,838,268	1,594,087	1,362,607	1,140,447	928,466	725,208	531,013	346,362
Number of individuals	291,833	278,165	263,682	250,873	238,248	226,665	214,237	200,868	187,002
Average no. of obs. per indiv.	7.17	6.61	6.05	5.43	4.79	4.10	3.39	2.64	1.85

[a] The dependent variable is a binary variable equal to one if the insurant participated in the general health screening in the quarter t-r. In addition to the instrumental variable (IV), each estimation controls also for the insurant's age as well as insurants' and GPs' fixed effects. The IV is a proxy for the exposure to supply-side screening recommendations and is defined as the sum of all screenings prescribed by all GPs located in a given zip code area consumed by any insurant, minus the potential screening of individual i, divided by all insurants residing in this zip code area minus one.

Table 4: Effect of screening participation (r years ago) on different health outcomes[a]

Lag r	Outpatient expenditures		Medical attendance		Medical drugs		Days of hospitalization		Days of sick leave	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
0	53.78***	278.68***	70.65***	67.32***	-16.87***	211.36***	-0.93***	1.43**	0.12**	-1.27
	(1.08)	(63.71)	(0.52)	(22.01)	(0.90)	(56.98)	(0.01)	(0.69)	(0.06)	(2.58)
1	-2.39**	195.39***	1.10**	41.31**	-20.75	154.08***	0.07***	1.47**	0.75***	0.69
	(1.20)	(62.54)	(0.56)	(21.09)	(25.60)	(56.39)	(0.02)	(0.68)	(0.06)	(2.60)
2	2.46*	38.47	3.96***	-28.86	-1.51	67.32	0.09***	1.06	0.23***	1.88
	(1.31)	(64.11)	(0.61)	(0.18)	(1.12)	(57.85)	(0.02)	(0.70)	(0.07)	(2.79)
3	-1.95	-144.56**	-0.14	-33.20	-1.81	-111.36*	0.09***	1.06	0.18**	-0.31
	(1.52)	(67.99)	(0.70)	(23.96)	(1.30)	(61.05)	(0.02)	(0.74)	(0.08)	(3.13)
4	-2.05	-292.84***	-2.01**	-78.14***	-0.04	-214.70***	0.04*	-1.10	-0.05	-3.77
	(1.72)	(76.99)	(0.78)	(27.24)	(1.48)	(69.31)	(0.02)	(0.84)	(0.09)	(3.72)
5	2.35	-289.44***	0.13	-114.90***	2.22	-174.54*	-0.01	0.15	-0.09	-1.91
	(2.01)	(101.21)	(0.92)	(35.30)	(1.72)	(92.20)	(0.03)	(1.07)	(0.10)	(4.83)
6	1.56	-162.52	-1.24	-97.51**	2.80	-65.01	-0.03	0.81	-0.15	5.50
	(2.57)	(115.23)	(1.14)	(44.98)	(2.24)	(102.47)	(0.03)	(1.36)	(0.13)	(6.53)
7	-3.87	-207.96	-0.31	-93.16	-3.56	-114.80	-0.03	1.07	0.01	5.18
	(3.14)	(136.52)	(1.49)	(62.36)	(2.67)	(117.01)	(0.04)	(1.83)	(0.17)	(8.92)
8	-2.80	-297.53	-0.37	-130.61	-2.43	-166.92	-0.02	0.17	0.18	-22.75
	(5.12)	(219.48)	(2.50)	(105.62)	(4.32)	(188.79)	(0.07)	(2.97)	(0.27)	(16.98)
Mean	726.14		343.04		383.10		3.59		13.32	

[a] This table summarizes estimation results on the effect of screening participation (r years ago) on five different health outcomes based on two methods of estimation: ordinary least squares (OLS) and two-stage least squares (IV). Each entry reflects a separate estimation. The outcome variables outpatient expenditures and the two sub-components expenditures for medical attendance and medical drugs are measured in 2007 Euros. The outcome variables hospitalization and sick leave are measured in days per year. In the IV estimations, screening participation is instrumented by a proxy for the exposure to supply-side screening recommendations that varies over zip code areas and time (see Figure 2). A summary of the first-stage results is provided in Table 3. Standard errors are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, **, and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level. Each estimation controls also for insurant fixed effects, GP fixed effects, year fixed effects, and the insurant's age.

Table 5: Effect of screening participation (r years ago) on expenditures for medical drugs by category[a]

Lag	Cardio (ATC C)	Cancer (ATC L)	Nervous (ATC N)	Metabolism (ATC A)	Blood (ATC B)	Dermatological (ATC D)	Genito-urinary (ATC G)
0	32.57**	-22.78	76.33***	8.16	-0.20	1.38	18.46***
	(13.73)	(31.50)	(18.17)	(7.98)	(15.25)	(1.35)	(3.09)
1	26.96*	-6.34	66.96***	9.27	-7.16	-0.08	12.13***
	(14.97)	(30.91)	(16.93)	(7.41)	(16.42)	(1.28)	(2.90)
2	24.045	3.49	55.12***	9.27	-28.36	-1.66	3.94
	(16.91)	(32.90)	(16.63)	(7.46)	(17.35)	(1.32)	(3.01)
3	4.214	-17.83	27.03	-11.83	-39.64*	-3.89***	14.14
	(17.93)	(35.48)	(16.68)	(7.80)	(21.81)	(1.40)	(16.09)
4	-11.489	-50.07	33.94	-26.60***	-35.73	-3.47**	-10.74***
	(18.71)	(41.57)	(21.64)	(8.55)	(23.84)	(1.52)	(3.36)
5	-36.07*	-12.49	27.13	-32.41***	-39.21	-1.17	-12.18***
	(20.11)	(56.31)	(35.27)	(10.15)	(35.31)	(1.87)	(3.99)
6	-24.371	-35.65	46.95	-27.19**	-7.75	3.01	-6.69
	(22.90)	(60.20)	(49.46)	(10.94)	(30.68)	(2.52)	(4.35)
7	-46.064	-49.08	2.11	-18.38	-15.41	-0.45	0.31
	(30.14)	(78.85)	(28.49)	(13.51)	(31.21)	(2.68)	(5.09)
8	-71.82*	32.71	-7.27	-20.54	-9.19	5.27	-8.20
	(42.14)	(131.46)	(39.01)	(19.87)	(44.53)	(3.28)	(7.48)
Mean	90.58	40.41	64.90	51.46	17.26	3.32	10.61

to be continued

Table 5 continued: Effect of screening participation (r years ago) on expenditures for medical drugs by category[a]

Lag	Hormonal (ATC H)	Anti-infectives (ATC J)	Musculo-skeletal (ATC M)	Antiparasitic (ATC P)	Respiratory (ATC R)	Sensory (ATC S)	Various (ATC V)	Missing[b]
0	18.73	10.22	35.86***	0.21	11.415*	-2.93	1.62	117.08***
	(13.17)	(16.02)	(5.92)	(0.40)	(0.05)	(1.83)	(1.76)	(35.21)
1	18.84	6.80	21.99***	0.14	2.59	-2.60	1.01	57.23
	(14.64)	(14.42)	(5.52)	(0.35)	(0.65)	(1.66)	(1.86)	(34.98)
2	15.11	12.22	-1.83	0.09	-6.54	-1.73	1.75	-24.59
	(18.13)	(13.36)	(5.92)	(0.18)	(0.25)	(1.65)	(1.88)	(34.64)
3	10.16	0.21	-30.62	-0.27	-11.833**	-2.27	2.61	-112.94***
	(18.15)	(14.11)	(6.52)	(0.30)	(0.04)	(1.77)	(3.11)	(36.67)
4	5.05	-26.37	-36.88	-0.52	-6.16	-1.78	0.51	-160.48***
	(14.90)	(17.81)	(7.01)	(0.43)	(0.36)	(1.89)	(3.38)	(39.54)
5	-3.50	-35.36*	-28.51***	-0.27	8.14	-1.19	6.21	-118.94***
	(9.91)	(21.18)	(8.10)	(0.44)	(0.28)	(2.21)	(7.58)	(52.01)
6	-7.46	19.01	-24.70***	1.38**	7.24	-1.57	-1.46	-24.75
	(11.42)	(24.42)	(9.35)	(0.58)	(0.41)	(2.43)	(2.77)	(51.99)
7	-2.85	-2.41	-4.74	0.58	7.44	3.29	-5.20	-3.39
	(13.87)	(29.57)	(11.34)	(0.55)	(0.48)	(2.79)	(3.80)	(59.31)
8	-12.71	-89.48*	-22.30	0.83	11.66	-0.23	-1.60	-100.00
	(19.13)	(54.05)	(14.81)	(0.91)	(0.39)	(3.57)	(8.54)	(94.69)
Mean	5.72	16.33	21.57	0.12	16.69	3.69	0.38	135.74

[a] This table summarizes estimation results on the effect of screening participation (r years ago) on expenditures for medical drugs of selected categories (measured in 2007 Euros) based on two-stage least squares (IV) estimation. Each entry reflects a separate estimation. In the IV estimations, screening participation is instrumented by a proxy for the exposure to supply-side screening recommendations that varies over zip code areas and time (see Figure 2). A summary of the first-stage results is provided in Table 3. Standard errors are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, **, and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level. Each estimation controls also for insurant fixed effects, GP fixed effects, year fixed effects, and the insurant's age. ATC stands for Anatomical Therapeutic Chemical (ATC) Classification System. [b] For drugs in the "missing" category, ATC-Codes are not available.

Table 6: Effect of screening participation (r years ago) on expenditures for medical attendance by field[a]

Lag	GP	Radiologist	Laboratory	Internist	Urologist	Gynecologist	Dermatologist
0	1.03	61.51***	21.68***	0.50	-4.61***	-12.32***	-0.439
	(8.72)	(2.97)	(1.56)	(3.00)	(1.04)	(2.43)	(1.65)
1	-3.89	57.18***	22.80***	0.31	-5.40***	-11.66***	-4.36***
	(8.36)	(3.00)	(1.54)	(2.83)	(0.97)	(2.27)	(1.60)
2	-4.70	35.12***	18.88***	-5.92**	-5.06***	-10.30***	-7.73***
	(8.31)	(3.30)	(1.57)	(3.00)	(0.97)	(2.31)	(1.70)
3	-20.38**	31.90***	14.26***	-4.70	-2.92***	-7.63	-7.89***
	(8.53)	(3.69)	(1.64)	(3.14)	(1.03)	(2.41)	(1.73)
4	-43.63***	8.03*	4.17**	-8.15**	0.12	-4.15	-5.37***
	(9.29)	(4.34)	(1.83)	(3.53)	(1.17)	(2.58)	(2.01)
5	-19.00*	-12.42**	-8.97***	-11.80*	2.42	-2.64	-2.718
	(11.37)	(5.54)	(2.47)	(4.58)	(1.54)	(3.50)	(2.61)
6	-33.84**	26.15***	-2.87	-10.30*	-1.46	2.85	-1.159
	(13.86)	(7.75)	(3.16)	(5.82)	(1.87)	(4.13)	(3.26)
7	-11.06	15.23	0.27	11.71	-4.04*	8.07	12.77***
	(17.19)	(11.30)	(4.39)	(8.28)	(2.41)	(5.72)	(4.33)
8	-3.25	30.97	-4.87	-4.08	1.38	1.02	3.220
	(26.46)	(19.56)	(6.99)	(13.37)	(3.88)	(9.59)	(6.63)
Mean	122.93	26.09	11.54	16.18	4.14	19.54	6.75

to be continued

Table 6 continued: Effect of screening participation (r years ago) on expenditures for medical attendance by field[a]

Lag	Pulmonologist	Neurologist	ENT	Orthopedist	Oculist	Physiotheraphy	Other
0	7.92***	5.68**	-0.15	4.32	-1.89	-20.78***	-16.93
	(1.44)	(2.90)	(1.39)	(3.05)	(1.50)	(5.20)	(18.32)
1	4.98***	5.27*	0.64	3.43	-2.03	-24.82***	-35.34**
	(1.41)	(2.79)	(1.36)	(3.06)	(1.45)	(5.36)	(17.64)
2	2.31	1.022	-3.10**	-1.16	2.70 *	-19.28***	-72.62***
	(1.48)	(2.82)	(1.43)	(3.22)	(1.52)	(5.67)	(18.15)
3	1.29	0.291	0.89	3.55	3.22 *	-27.61***	-54.49***
	(1.58)	(3.15)	(1.49)	(3.42)	(1.66)	(6.10)	(20.46)
4	-0.99	-3.755	1.93	3.94	-0.09	-29.55***	-38.63*
	(1.76)	(3.54)	(1.68)	(3.52)	(1.87)	(6.92)	(23.46)
5	1.50	-13.78***	5.88***	2.68	-2.51	-14.34*	-62.61**
	(2.31)	(4.71)	(2.15)	(4.81)	(2.42)	(8.62)	(30.82)
6	0.18	-8.282	2.31	2.17	-3.75	-10.64	-76.72*
	(2.94)	(6.44)	(2.79)	(5.95)	(3.09)	(10.48)	(39.30)
7	0.72	-17.36*	10.78***	-2.23	-7.47 *	-16.25	-109.53**
	(3.97)	(8.94)	(3.84)	(8.02)	(4.50)	(13.07)	(55.14)
8	12.50*	9.201	-2.60	-18.14	-27.10***	-16.15	-149.05
	(6.46)	(14.42)	(6.41)	(12.68)	(7.11)	(19.78)	(94.89)
Mean	5.19	6.19	5.96	10.04	14.54	8.10	166.33

[a] This table summarizes estimation results on the effect of screening participation (r years ago) on expenditures for medical attendance of selected specialists (measured in 2007 Euros) based on two-stage least squares (IV) estimation. Each entry reflects a separate estimation. In the IV estimations, screening participation is instrumented by a proxy for the exposure to supply-side screening recommendations that varies over zip code areas and time (see Figure 2). A summary of the first-stage results is provided in Table 3. Standard errors are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, **, and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level. Each estimation controls also for insurant fixed effects, GP fixed effects, year fixed effects, and the insurant's age.

Table 7: Effect of screening participation (r years ago) on different health outcomes (younger and older subsamples)[a]

Lag r	Outpatient expenditures		Medical attendance		Medical drugs		Days of hospitalization		Days of sick leave
	Younger	Older	Younger	Older	Younger	Older	Younger	Older	Younger
0	137.51	446.58***	37.60	105.10***	99.90	341.48***	1.25	1.89	-1.33
	(86.39)	(94.39)	(27.32)	(36.73)	(79.07)	(81.05)	(0.81)	(1.23)	-2.61
1	82.92	321.90***	8.04	82.77**	74.88	239.12***	0.91	2.34**	0.89
	(87.24)	(88.73)	(27.17)	(33.29)	(80.14)	(77.47)	(0.83)	(1.14)	-2.63
2	16.18	63.97	-57.78**	19.00	73.96	44.97	0.46	1.82	2.04
	(89.10)	(90.89)	(28.77)	(32.82)	(81.36)	(80.46)	(0.85)	(1.16)	-2.82
3	-75.71	-220.90**	-52.63	-1.76	-23.08	-219.13***	0.39	1.98	-0.2
	(95.37)	(95.12)	(32.88)	(34.86)	(86.29)	(84.25)	(0.91)	(1.21)	-3.17
4	-270.83**	-318.43***	-74.03**	-84.15**	-196.79**	-234.27**	-0.76	-1.48	-3.83
	(107.65)	(107.15)	(37.58)	(39.34)	(97.17)	(95.68)	(1.02)	(1.39)	-3.75
5	-170.06	-406.90***	-78.26	-158.45***	-91.80	-248.45*	1.31	-1.37	-2.08
	(141.53)	(141.09)	(50.60)	(47.79)	(128.99)	(128.28)	(1.36)	(1.68)	-4.88
6	-73.98	-230.60	-83.85	-106.75*	9.87	-123.84	1.34	-0.03	5.42
	(152.60)	(174.36)	(64.37)	(61.26)	(133.44)	(157.95)	(1.77)	(2.10)	-6.59
7	-223.65	-165.79	-49.62	-153.25*	-174.03	-12.53	0.51	1.89	4.77
	(186.90)	(195.97)	(85.86)	(88.40)	(162.09)	(165.03)	(2.24)	(3.02)	-8.98
8	-261.07	-320.60	-183.50	-72.94	-77.57	-247.66	-3.72	4.87	-22.27
	(332.63)	(275.15)	(153.71)	(143.75)	(289.47)	(230.42)	(3.84)	(4.68)	-17.12
Mean	464.80	901.79	254.45	367.35	210.34	534.44	1.98	5.50	13.82

[a] This table summarizes estimation results on the effect of screening participation (r years ago) on five different health outcomes based on two-stage least squares (IV) estimation. Each entry reflects a separate estimation. The outcome variables outpatient expenditures and the two sub-components expenditures for medical attendance and medical drugs are measured in 2007 Euros. The outcome variables hospitalization and sick leave are measured in days per year. In the IV estimations, screening participation is instrumented by a proxy for the exposure to supply-side screening recommendations that varies over zip code areas and time (see Figure 2). A summary of the first-stage results is provided in Table 3. Standard errors are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, **, and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level. Each estimation controls also for insurant fixed effects, GP fixed effects, year fixed effects, and the insurant's age. Note that incidence of sick leave is not available for the older sub-sample.

Table 8: Mortality estimation

	Birth cohorts					
	1944–1953		1934–1943		1933 or before	
	OLS	IV	OLS	IV	OLS	IV
Coeff. of screening	0.01***	-0.03	0.02***	-0.02	0.04***	-0.07
	(0.00)	(0.03)	(0.00)	(0.04)	(0.00)	(0.12)
			First Stage Regression			
Coeff. of instrument		1.05***		1.01***		1.12***
Cragg-Donald Wald F statistic		44.36		26.32		34.46
Observations	99,008	99,008	85,723	85,723	92,745	92,745

[a] Estimation method: linear probability model. Data structure: cross section. Standard errors are robust but not clustered. Other controls: doctor, age, and zip code area dummies; dummies for foreign nationality, academic degree, sex, and exemption of prescription charge.