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What makes a new doctor better?
Effects of new primary care physicians on healthcare provision

PÉTER ELEK – BALÁZS MAYER – BALÁZS VÁRADI

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ABSTRACT
Using individual-level administrative panel data of all diabetic patients in Hungary for years 2010-2017, we analyze the effects of primary care characteristics on healthcare provision in rural areas by exploiting the change of the person of the general practitioner (GP), be it a temporary substitution or a permanent new doctor. We estimate event study models and focus on three mechanisms: (1) discontinuity of care itself, (2) changes in physician's practice style and (3) changes in local healthcare supply conditions.
We find that discontinuity of primary care has a significant positive effect on treatment (as measured by the quarterly probability of outpatient care use, glycated hemoglobin testing and statin use), but only if the new doctor is a permanent one. Treatment style matters: while male or older GPs have close to zero impact on most of the healthcare variables listed above, the effect of the new GP being female and being younger is 2-4 %points; we also find some evidence of the interaction of the gender of the doctor and the patient affecting treatment. Finally, local healthcare supply conditions such as practice size do not influence significantly the variables in our case.

JEL codes: I11, I12, I18
Keywords: primary care, discontinuity of care, physician treatment style, event study

Péter Elek
HUN-REN Centre for Economic and Regional Studies
and Corvinus University of Budapest
elek.peter@krtk.hun-ren.hu

Balázs Mayer
HUN-REN Centre for Economic and Regional Studies
and Corvinus University of Budapest
mayer.balazs@krtk.hun-ren.hu

Balázs Váradi
Eötvös Loránd University
and Budapest Institute for Policy Analysis
balazs.varadi@budapestinstitute.eu

Mi teszi jobbá az új orvost?
Az új háziorvosok hatása az egészségügyi ellátásra

ELEK PÉTER – MAYER BALÁZS – VÁRADI BALÁZS

ÖSSZEFOGLALÓ

A háziorvosi ellátás jellemzőinek az egészségügyi ellátásra kifejtett hatását elemezzük magyarországi községekben, az összes magyarországi cukorbeteg egyéni szintű, 2010 és 2017 közötti adminisztratív panel adatbázisán, kihasználva a háziorvos személyének megváltozását átmeneti helyettesítés vagy tartósan új orvos esetén. Eseményvizsgálati (event study) modelleket becslünk, és három mechanizmusra összpontosítunk: (1) az ellátás folytonosságának megszakadására, (2) az orvos kezelési stílusának változására és (3) a helyi egészségügyi ellátás kínálati feltételeinek változására.

Azt találjuk, hogy a háziorvosi ellátás megszakadása szignifikánsan pozitív hatással bír a kezelésre (a járóbeteg-ellátás igénybevételére, a glikált hemoglobinszint-mérésre és a statinfelírásra) – de csak tartósan új orvos esetén. A kezelési stílus számít: míg a férfi vagy idősebb háziorvosoknak lényegében nincs hatásuk a fent felsorolt egészségügyi változók többségére, addig az új női illetve fiatalabb háziorvosok hatása 2-4 %pont; továbbá találunk némi bizonyítékot az orvos és a beteg neme közötti, a kezelést befolyásoló interakcióra is. Végül a helyi egészségügyi ellátás kínálati feltételei, mint például a praxis mérete, nincsenek szignifikáns hatással a változókra esetünkben.

JEL: I11, I12, I18

Kulcsszavak: háziorvosi ellátás, ellátás folytonosságának megszakadása, orvos kezelési stílusa, eseménytörténeti elemzés

What makes a new doctor better? Effects of new primary care physicians on healthcare provision*

Péter Elek[1,2], Balázs Mayer[1,2], and Balázs Váradi[3,4]

[1]HUN-REN Centre for Economic and Regional Studies
[2]Corvinus University of Budapest
[3]Eötvös Loránd University
[4]Budapest Institute for Policy Analysis

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Abstract

Using individual-level administrative panel data of all diabetic patients in Hungary for years 2010-2017, we analyze the effects of primary care characteristics on healthcare provision in rural areas by exploiting the change of the person of the general practitioner (GP), be it a temporary substitution or a permanent new doctor. We estimate event study models and focus on three mechanisms: (1) discontinuity of care itself, (2) changes in GP's practice style and (3) changes in local healthcare supply conditions.

We find that discontinuity of primary care has a significant positive effect on treatment (as measured by the quarterly probability of outpatient care use, glycated hemoglobin testing and statin use), but only if the new doctor is a permanent one. Treatment style matters: while male or older GPs have close to zero impact on most of the healthcare variables listed above, the effect of the new GP being female and being younger is 2-4 %points; we also find some evidence of the interaction of the gender of the doctor and the patient affecting treatment. Finally, local healthcare supply conditions such as practice size do not influence significantly the variables in our case.

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1 Introduction

Proper primary care is generally associated with improved healthcare use and better health outcomes (OECD, 2020). However, the healthcare systems of several countries worldwide struggle to fill primary care practices (PCPs);[1] especially so in underserved, rural areas, where inhabitants with a worse-than-average socioeconomic background have higher healthcare needs and where the practitioner workforce is often aging (Chevillard and Mousquès, 2021). How the (temporary or long-run) institutional solutions health policy offer to this problem affect the use of healthcare services and, ultimately, health outcomes, should be of interest to anyone who cares about the efficacy and efficiency of healthcare systems.

In this paper we analyze the effects of how rural PCP positions that turn vacant are filled by new general practitioners (GPs) upon healthcare use by looking at switches in the person of the GP caring for the PCP, and concentrating on the treatment of diabetic patients in Hungary. We use an anonymized individual-level administrative panel dataset about the healthcare utilization of diabetic patients in Hungary for years 2010-2017. Dependent variables include indicators of outpatient care, inpatient care, pharmaceutical consumption, healthcare management and health outcomes. Given the nature of the settlements and the institutional setup in Hungary (see section 2.3), we contend that our research design makes it possible to isolate the effect of a change in GP upon the health of the patients without the endogeneity of who takes over the practice biasing our results. We also go into the possible mechanisms that could explain such effects, yielding novel findings with respect both to how the discontinuity of care itself matters and whether the fact that the new doctor is there on a temporary or a permanent basis affects the patients, as well as how much doctor characteristics linked to treatment style like the GP's gender and age affect health outcomes. Our analysis extends the growing literature of the field (see Hjalmarsson et al., 2023 or Zocher, 2024 for recent examples and section 2.1 for a more detailed review), but concentrates more on the effects of the new GP taking over the practice than on the old one retiring or otherwise exiting. Methodologically, we estimate event study models with an interaction-weighted estimator (Sun and Abraham, 2021), allowing for variation in treatment timing and cohort-specific effects.

We find that the switch itself and certain characteristics of the new GP have marked effects upon the diagnosis and care of diabetic patients. More specifically, the arrival of a new permanent GP (but not of a temporary GP) increases the quarterly probability of

[1] To avoid confusion, we refer to the practice, i.e. the set of patients, as PCP, and the primary care physician in charge of it as the GP or the doctor.

outpatient care use, glycated hemoglobin (HbA1c) testing and statin prescriptions by 1-2 percentage points in the first two years and statin prescriptions by 3 percentage points in the long run among the 40-79 years old population already diagnosed with diabetes. (In relative terms, these jumps are around 7% for HbA1c testing and statin use.) The number of people consuming oral antidiabetic medication increases, while insulin use does not change, suggesting that less serious cases of diabetes become detected after the change of the GP. These effects are markedly larger if the new permanent GP is female or fewer years have passed since their graduation from medical university, even after controlling for other GP characteristics. In fact, the incoming GP being male or older does not have a significant effect on most of the measured healthcare variables. Also, we find some evidence for an interaction between the gender of the GP and of the patient, with female GPs (compared to male GPs) having a relatively larger impact on male than on female patients. Finally, examining specifically the periods when temporary GPs care for the PCPs, we find no evidence that local healthcare supply conditions such as the practice size would have an effect on the variables in our case.

Because of data availability, in this paper we concentrate on the prevalence, incidence and treatment of diabetes, a chronic disease marked with high glucose levels. Diabetes affects 8.9% of the European population aged 20-79 (IDF, 2017) with comparable rates in Hungary (Kempler et al., 2016). After a number of years, it can lead to severe cardiovascular, cerebrovascular, renal, ocular, neurological and other complications, hence people with diabetes have nearly a two-fold higher risk of premature death than people without diabetes (OECD, 2012). Thus it is hard to overstate the importance of proper care for diabetic patients, most of the burden of which falls on the shoulders of primary care providers.

The rest of the paper is organized as follows. In the next section we review our framework of analysis and pertinent previous work as well as the institutional background; section 3 presents the data, followed by the methods (section 4), the results (section 5), and our conclusions and policy implications (section 6).

2 Background

2.1 Links between changing GP and patient outcomes

When a GP exits a geographically delineated practice, it is either taken over by a new doctor indefinitely, or, in Hungary, arrangements are made by the local government for a substitute GP to take care of the PCP on a temporary basis, until a permanent GP can be found.

Either way, at the time of the switch, several mechanisms may take effect that can cause a change in health variables concerning patients. A growing literature uses variation from primary care closures, retirement and downsizing to study the effects on healthcare (e.g. Bischof and Kaiser, 2021; Fadlon and Van Parys, 2020; Kwok, 2018; Hjalmarsson et al., 2023; Zhang, 2022; Zocher, 2024).

The mechanism most often analyzed in the literature, e.g. by Bischof and Kaiser (2021) or Hjalmarsson et al. (2023) for Switzerland, is the interpersonal (and concomitant partial informational) discontinuity of care: in other words, the change of the primary care provider itself can have an effect on care. This can be an adverse one, since a relationship of knowledge and trust is broken between the doctor and the patient, but it is also possible that a new doctor-patient match precipitates a reassessment of those patients' ongoing medical needs which, for potentially underdiagnosed chronic diseases, can result in more hospital admissions or better care related to those diseases (Hjalmarsson et al., 2023; Sabety et al., 2021; Simonsen et al., 2021; Zhang, 2022; Zocher, 2024). A further difference we can trace in our data that can affect how much and how fast information about the new patients is collected by the new doctor and whether and how fast a bond of trust will form is whether the new doctor fills in the position on a temporary or permanent basis. We did not find any direct antecedent of identifying this effect; what comes the closest is Zocher (2024), who differentiates between "soft" and "hard" transitions: in case of a soft one, the outgoing and the new GP work together a while – this can be conceptualized as the opposite of a period of making do with a substitute doctor.

A second channel is the effect of a change in the treatment style of a GP. If a younger GP, a GP of the other gender or a GP with a different specialized training or skill set takes over the practice, what affects outcomes might not be the change itself, but the fact that this new family doctor might provide better (or worse) healthcare for certain patients than the previous GP simply because he/she has a different treatment style (Ahammer and Schober, 2020; Simonsen et al., 2021). A different treatment style can even result in better health results for different patients. This could be of interest as, e.g. several papers suggest that the gender of the GP might be correlated with treatment style (Hedden et al., 2014; Kaiser, 2017; also, specifically for Hungary, Kovács et al., 2019), and that the interaction between the gender of the doctor and the patient can also have an effect (Eggermont et al., 2022; Greenwood et al., 2018).

A third mechanism is the effect of local healthcare supply conditions such as the change in the actual practice size (Barash, 2023). The increase in practice size might result in a worse healthcare service by the same provider: the GP has simply less time to devote to any individual patient if there is more of them. This, as we will see below, can come up in Hungary, too, where substitution for vacant practices is usually arranged by one or several neighbouring GP taking over on a temporary basis, thereby increasing the number of their patients.

Our ambition here is to add to the existing literature by carefully analysing these casual mechanisms in a rural setting.

2.2 Institutional setting and country background on Hungary

As summarized in OECD (2019), the Hungarian health system is organized around a single health insurance fund providing health coverage for nearly all residents. Funding comes from payroll contributions from employers and employees, and from direct government transfers. The national government is responsible for delivering most outpatient specialist and inpatient care.

In Hungary, per capita health expenditure is among the lowest in the EU; the health system is chronically underfunded. At the same time, it has among the highest mortality from preventable and treatable causes in the EU. Health workforce shortages are a major issue. Within the country, the central region has almost twice as many doctors per capita than the north, and shortages in each region are concentrated in rural areas.

Primary care practitioners play an important role in the healthcare system, as summarized by Gaal et al. (2011) or Wilm et al. (2015). They are the gatekeepers: in most cases they are the first contact of the Hungarian population with the healthcare system and, except for a few specializations, their referral is required to access more specialized care. As explained in more detail in Bíró and Elek (2019), primary healthcare services are mostly provided by single-doctor practices (family doctors, GPs); group practices are rare.

2.3 Doctor-patient matching and vacancy of PCPs in Hungary

While registration of patients as belonging to a PCP or a GP office is not universal in Europe (no such lists are there in France or Germany), it is widespread and is considered a good practice in terms of providing continuity of and access to primary care (Kringos et al., 2013). This is the case in Hungary, where licenses for PCPs can be bought and sold by family doctors, but local governments are responsible for making sure that everyone has access to primary care. This is arranged as follows. PCP licenses are matched to geographically delineated care areas: GPs are not allowed to refuse patients registering as their patients from their own care area, but patients have the right to choose another PCP than the one in charge of where they live – if that family doctor is ready to accept them into their PCP. GPs in charge of PCPs are compensated by capitation, complemented by a correction formula based on variables like the age composition of their patients and the type of settlement they operate in, by the single-payer National Institute of Health Insurance Fund Management (NEAK). The government also evaluates the performance of the PCPs based on the so called Hungarian PCP indicator system (NEAK, 2023). In the 2010-2017 period under scrutiny, there were around 6,300 practising GPs in the country of 9.7 million inhabitants, thus an average GP cared for about 1,550 patients.

If the GP gives up his/her PCP without selling the corresponding license (the presumable reason being that it is not attractive enough for another GP to buy, a frequent case in rural areas), it becomes vacant. Vacant practices are a severe problem of the Hungarian primary care system as their ratio was 5.5% (and exceeded 10% in villages) already in 2015. Vacant practices are more likely to be located in remote, less developed, rural areas of the country populated by inhabitants with worse socioeconomic background and higher healthcare needs than in more urban and well-to-do parts (Bíró and Elek, 2019). The reasons for PCPs to become unfilled are usually the GP retiring, leaving the country or the profession, or withdrawing from the workforce (e.g. giving birth or staying at home with their child).

The rules in case a PCP falls vacant are as follows: as long it is not yet permanently filled again, the PCP and the care area is divided up among neighbouring PCPs. In rural districts this usually implies either the GPs from the neighbouring PCPs travelling to the settlement but available with a lower frequency than the care provided by the PCP's own GP, or the patient having to travel to the neighbouring PCP care area, usually the neighbouring settlement, where their substitute GP normally provides care. In under-served rural areas, the typical history of a vacant PCP is as follows: after the practice becomes vacant, the GP of another PCP substitutes for 1-2 years, then the practice may become permanently filled-in again (Government-decree, 2011).

Prior empirical literature on vacant PCPs in Hungary includes the following papers. Sándor et al. (2018) estimated the effects of the vacancies, but on cross-sectional data. Bíró and Elek (2019) used panel data and a quasi-experimental setting by considering the variation in the vacancy of the practices as exogenous. They found that the vacancy reduces antibiotic consumption, and the quality of the composition of the prescribed antibiotics worsens. Finally, Bíró and Imre (2022) investigated the causal effect of a governmental scheme of financial incentives upon the supply of primary care practitioners in under-served areas in Hungary. They found that the one-time cash subsidy increased the probability of filling a PCP by around 6 %points, providing at most a partial solution to the problem of missing rural GPs.

Given these institutional circumstances, and the empirical literature, we submit that, in our rural sample (see below), a change of the person of the GP is fairly exogeneous to the treatment patients receive.

3 Data

3.1 Individual-level healthcare use data

We use comprehensive patient-level and PCP-level (aggregated from settlement-level) datasets for years 2010-2017, supplemented with additional settlement-level demographic, geographic and socioeconomic indicators (such as the number of inhabitants, the distance from the county centre and the per capita taxable income of the settlement).[2]

First, we make use of an anonymized individual-level administrative dataset that contains outpatient, inpatient, and some pharmaceutical records (together with gender, age and settlement of residence) of all people in Hungary who consumed antidiabetic medication (insulin or oral antidiabetics, defined as the A10 category in the ATC [Anatomical Therapeutic Chemical] classification) at least once between 2010 and 2017.[3] In the analysis we focus on the 40-79 years old population because in the younger cohorts two special patient groups, namely Type 1 diabetes patients, and non-diabetic patients who were prescribed antidiabetic medication as an off-label use (mainly metformin for women in childbearing age suffering from PCOS [polycystic ovary syndrome]) occur disproportinately.[4]

3.2 Outcome variables

We construct a PCP-level and an individual-level quarterly panel dataset from the above data.

[2]This additional settlement-level information comes from the T-STAR territorial statistical system of the Central Statistical Office (KSH).

[3]The anonymized dataset was available on a restricted server at the Databank of the HUN-REN Centre for Economic and Regional Studies (KRTK) under an agreement with the National Healthcare Services Centre (ÁEEK). Ethical approval for the use of the dataset was given by the Hungarian Medical Research Council (ETT TUKEB, 39258/2019/EKU).

[4]Changing the the age cutoff to 30 or 50 years does not alter the results of the paper.

First, we construct a quarterly PCP-level panel dataset (see section 3.3 for the definition of PCPs based on the settlements) that contains per capita (A1) use of antidiabetic medication (prevalence of diabetes), (A2) initiation of antidiabetic medication (incidence of diabetes; first prescription during the observed period), (A3-A4) use of insulin and use of oral antidiabetics without insulin (to describe diabetes severity as less severe cases tend to be treated initially with oral medicines), and finally (A5-A6) lower-limb amputation (a serious consequence of poorly managed diabetes) and in-hospital death as crude health outcome measures[5] (the latter two indicators are calculated on patients already consuming antidiabetics in 2010).

Second, we construct an individual-level quarterly panel dataset that includes various measures of healthcare use by person and quarter. To avoid compositional changes of antidiabetic medication users due to a possible change in prevalence, we follow those who already consumed antidiabetics at least once in 2010. We examine the following binary indicators: (B1) the use of specialist outpatient care (in total, and by specialty), (B2) a HbA1c (glycated hemoglobin) laboratory test, (B3) the use of lipid-modifying agents (predominantly, and for simplicity, statins), (B4) the use of antihypertensive medication[6], (B5) the use of any inpatient care (i.e. hospitalization), (B6) potentially avoidable hospitalization (PAH).

Among these variables, we consider (B1) and (B5) as straightforward measures of healthcare use, and the others as indicators of the quality of the healthcare system in general and diabetes management in particular.

More specifically, a HbA1c laboratory test (B2) evaluates average glucose levels in the past 2-3 months, and conducting such a test is recommended by international guidelines every six months (or every 3-6 months if levels are unstable) (ADA, 2018). In fact, HbA1c testing at least on the annual frequency is part of the Hungarian PCP performance indicator system (NEAK, 2023).

Potentially avoidable hospitalization (B6) is defined as a hospital admission that occurs for a condition that can typically be treated – in the presence of appropriate primary care – without the use of inpatient care. Hence its rate is a measure of the quality of primary care (Eggli et al., 2014). We define the set of corresponding ambulatory care sensitive conditions (ACSCs) based on the ICD-10 category of the primary diagnosis of the inpatient episode, following the list of Purdy et al. (2009) as described in detail by Eggli et al. (2014).

[5] Only in-hospital deaths are observed in the dataset, which make up more than two-thirds of all deaths in Hungary.

[6] Beyond insulin and oral antidiabetics, the relevant medications observed in the dataset are lipid-modifying agents (ATC C10) and antihypertensive drugs (ATC C02-C09)

High blood cholesterol and high blood pressure (B3-B4) are common comorbidities among diabetes patients, and the thorough management of these conditions is recommended. In fact, although there is no consensus among international associations, US guidelines recommend the initiation of statin therapy to decrease lipid levels for all diabetic patients above 40 years, irrespective of the presence of other cardiovascular risk factors (ElSayed et al., 2022). Therefore we use the consumption of lipid-modifying agents and antihypertensive medications as further indicators of the quality of diabetes management.

3.3 PCPs and GPs

As the second main dataset, we use a monthly PCP-level panel database that contains the actual vacancy status of each PCP (i.e. whether it is temporarily served by substitute doctor(s) instead of a permanent GP) and some information on the permanent GP (if exists). In particular, if the permanent GP changed (with or without a temporary period of substitution in-between), we know the gender, the year of graduation from medical school and the number of special exams of the GP.[7]

The PCP-level dataset also contains the list of settlements served by each PCP. Larger settlements are typically covered by more than one PCP, while smaller settlements close to each other may be served by a single PCP. We restrict our attention to PCPs that have a well-defined catchment area, i.e. that exclusively serve a group of settlements (and only them). Among them, PCPs with the same permanent GP throughout the whole period 2010-2017 are chosen as the control group.

We define the treatment group as those PCPs that are served by a permanent GP for at least four quarters before one of the following happens: (1) the practice becomes vacant (and served by a substitute GP) for some time and afterwards may become filled-in again by a permanent GP; or (2) a new permanent GP arrives immediately in the practice. Appendix Figure A1 shows that the examined PCPs are widespread within the country, with slightly more than half of the 174 micro-regions outside the capital Budapest containing at least one and only 8 containing more than three of them.

According to Table 1, both the outgoing and the incoming permanent GP are observed on average for 12-14 quarters, and temporary substitution lasts for around three quarters (five quarters for PCPs with a temporary substitution). Compared to the outgoing GPs, incoming ones have about 11 years less experience on average (average years since graduation

[7]Data on the PCPs were provided by NEAK free of charge in the framework of secondary use of public data. The information on the graduation year and special exams of medical doctors is publicly available.

from medical university: 17.0 vs. 28.1). However, as the histograms of Appendix Figure A2 show, the years since graduation are quite widespread, with a substantial overlap. Not shown in Table 1 is the fact that the years since graduation of the outgoing and the incoming GP are essentially uncorrelated, so the effects of incoming GP characteristics can be examined independently of those of the outgoing GPs.

Turning specifically to the characteristics of incoming GPs, 51% of them are male and 30% have a special exam beyond the usual ones in primary care, internal care or occupational care. Additional special exams are more frequent among the new GPs in practices without vacancy period than in practices with it. Also, incoming GP characteristics are obviously correlated: as the Table shows older GPs are slightly more likely to be male and much more likely to have additional special exams.

Figure 1 displays the evolution of some PCP-level healthcare supply indicators by year relative to the vacancy event (if it exists) and to the time of the arrival of the new permanent GP. Figure 1/a shows the ratio of patients served by the outgoing, incoming and modal GPs (the latter denotes the mode of the GPs of the patients residing in the settlements of the PCP). According to the Figure, if a PCP is not vacant, then around 85% of its population constantly belong to a single GP. This indicates that the vast majority of people in these settlements choose the GP who is legally obliged to serve the settlement anyway. It is also clear from the Figure that the decrease of the share of the outgoing GP and the increase of the share of the incoming GP both occur suddenly around the corresponding event times. Between the two events (under the vacancy period), the share of patients served by the modal GP (who is different from both the outgoing and the incoming GP) only slightly decreases to 75%. This suggests that a single substitute GP serves the patients in most such PCPs during vacancy.

Figure 1/b shows PCP-level supply indicators: the mean distance of the location of the patients from the modal settlement of the modal GP and also the actual diabetes practice size (i.e. the average number of 40-79 years old diabetes patients served by the modal GP) by relative year. During the substitution period, mean distance of the patients from the modal GP increases from around 3km to 6km, while actual diabetes practice size increases from around 180 to more than 250, then these variables decrease roughly to their original level as the PCP gets filled in again.

4 Methods

First, we present and compare the descriptive statistics of the healthcare use indicators in the PCPs affected by the change of GPs, in the control PCPs, and in the country in general. Then, using event study and difference-in-differences models, we formally analyze the effects of temporary substitution and of the arrival of the new GP.

From now on, t denotes time (calendar quarter), while i denotes PCP in the PCP-level analysis and patient in the individual-level analysis. The relevant event times for the treated PCPs (or their patients) are:

- t_i^s : start of the observation period of the outgoing GP (either his/her arrival or $2010q1$);
- t_i^v : start of vacancy (temporary substitution) if there is such;
- t_i^n : arrival of the new permanent GP (and $t_i^n = t_i^v$ if there is no vacancy in-between);
- t_i^e : end of the observation period of the new permanent GP (either his/her departure or $2017q4$).

Hence the outgoing GP provides primary care in $[t_i^s, t_i^v - 1]$, the incoming GP in $[t_i^n, t_i^e]$, and there may be a period of temporary substitution in $[t_i^v, t_i^n - 1]$. The sample is restricted to $t_i^v - t_i^s \geq 4$.

In the event study analyses we estimate

$$y_{it} = \beta_{(-4)-} \times \mathbb{I}_{\{t<t_i^v-12\}} + \sum_{k=-3}^{-2} \beta_k \times \mathbb{I}_{\{\text{floor}\left(t-t_i^v\right)/4=k\}} + \gamma \times \mathbb{I}_{\{t_i^v \leq t \leq t_i^n - 1\}} + \\ + \sum_{k=0}^{2} \delta_k \times \mathbb{I}_{\{\text{floor}\left(t-t_i^n\right)/4=k)\}} + \delta_{3+} \times \mathbb{I}_{\{t \geq t_i^n + 12)\}} + \alpha_i + \tau_t + x_{it}\lambda + \varepsilon_{it}, \quad (1)$$

where y_{it} is an outcome variable (healthcare use or management indicator variable), α_i is PCP or patient fixed effect, τ_t is the time fixed effect, x_{it} are control variables (age group – gender interactions in the individual-level analysis and age group and gender composition in the PCP-level analysis), ε_{it} is the error term, and $\mathbb{I}$ denotes the indicator function.

Here β_{-2}, β_{-3} and $\beta_{(-4)-}$ show the level of the outcome variable in the second, third, and, respectively, up to the fourth relative year before the departure of the outgoing GP in comparison to the first year before the departure (hence β_{-1} is normalized to zero). γ is the effect under the period of temporary substitution (if there is such), while δ_0, δ_1, δ_2 and δ_{3+} are the effects in the first, second, third year and from the fourth year after the arrival of the new permanent GP. In all specification we bin the parameters by relative year and thus assume constant effects in the four relative quarters within each relative year. All the event time dummies are set to zero for the control group.

In the main analysis we estimate equation (1) with the interaction weighted event study estimator of Sun and Abraham (2021). This takes into account the staggered setting, i.e. that there is a variation in treatment timing (time of the change of the GP) across the PCPs. We present the usual fixed-effects event study results as a robustness check. In all individual-level regressions we cluster standard errors on the PCP level.

When there is no pre-trend (i.e. $\beta_k = 0$ for $k < 0$) and treatment effects are constant within the first two years and from the third year after the arrival of the new permanent GP (i.e. $\delta_0 = \delta_1$ and $\delta_2 = \delta_{3+}$) then the following panel regression may summarize the effects during vacancy (γ) and the short- and long-run effects after the arrival of the permanent GP (δ_s and δ_l):

$$y_{it} = \gamma \times \mathbb{I}_{\{t_i^v \le t \le t_i^n - 1\}} + \delta_s \times \mathbb{I}_{\{t_i^n \le t \le \min\left(t_i^n + 7, t_i^e\right)\}} + \delta_l \times \mathbb{I}_{\{t_i^n + 8 \le t \le t_i^e\}} + \alpha_i + \tau_t + x_{it}\lambda + \varepsilon_{it}. \quad (2)$$

In heterogeneity analyses, we interact the parameters γ and δ with individual-, GP- and PCP-level variables. (In these analyses we assume the equality of the short- and medium-term effects, i.e. $\delta = \delta_s = \delta_l$.)

5 Results

5.1 Descriptive analysis

Table 2 shows average healthcare, demographic and socioeconomic indicators of the examined population of the whole country, of the settlements with a single PCP that were served by the same permanent GP throughout the examined period (1165 villages of 766 PCPs, the control group), and of the treated settlements (268 villages of 164 PCPs, further split by the presence or absence of a period of temporary substitution).

Compared to the general diabetic population of the country, the diabetic population of the treated settlements (villages) appears to be in worse health: they are hospitalized substantially more often, have higher in-hospital mortality and higher amputation probability. Similarly, on the settlement level, diabetes prevalence and incidence are both larger in the treated group than in the country on average. On the other hand, the diabetic population of the treated settlements has worse than average access to healthcare as they have lower use of outpatient care and HbA1c testing.

Also, affected settlements are substantially disadvantaged in terms of socioeconomic background: they have much lower per capita taxable income (by around 0.3 on the log scale), and are 50% farther from the county seat than an average settlement in the country. On average, the total population of the (typically 1-2) neighbouring settlements that belong to a treated PCP is 1450 people.

However, when the treated and the control settlements (and not the country in general) are compared, the average differences in the health, demographic and socioeconomic variables are small. (The standardized mean differences, i.e. the differences of the means divided by the standard deviation, are less than 12%.) Some heterogeneity is present within the treated group: settlements with a direct takeover of the PCP are slightly larger and are in a slightly better socioeconomic position than settlements with a vacancy period. Interestingly, observed prevalence is higher in the better socioeconomic group, suggesting that diabetes patients are slightly more likely to be detected there.

5.2 Baseline results

Appendix Figures A3-A4 display the raw trends of the healthcare variables in the treated group around the change of the GP (and in the possible vacancy period in-between) compared to the the control group (in which placebo treatment times were chosen randomly and 100 replications were averaged). Controlling for individual fixed effects, calendar time trends and age group – gender interactions, Figures 2-3 show the event study parameters from equation (1), split by the presence or absence of a vacancy period in the PCP. Table 3 summarizes the effect of the vacancy as well as the short- and medium-term effects of the arrival of the new GP with single parameters estimated from equation (2).

According to the Figures and formal tests, there is no significant pre-trend before the departure of the outgoing permanent GP in the individual-level data (the treated and control curves are roughly parallel in Appendix Figure A3 and pre-treatment parameters are close to zero in Figure 2), however, a slight pre-trend may be present in the PCP-level prevalence data 3-4 years before the departure of the GP (Figure 3 and Appendix Figure A4). Therefore, while estimating equation (2), we only use two pre-departure years (and four years after the arrival of the new GP).

Both the Figures and the Table show that the healthcare variables do not increase when a substitute GP takes over care during vacancy. Then, after the arrival of the new permanent GP, most variables jump or gradually increase to a higher level. In particular, the quarterly probability of outpatient care use, HbA1c testing and statin use increase by 1-2 %points in the first two years and seem to remain elevated afterwards (statin use by 3 %points, the others with large uncertainty). In relative terms, compared to the baseline levels, the jumps are substantial (7%) for HbA1c testing and statin use as well. Probabilities of antihypertensive use, hospitalization and PAH do not change according to the event study estimates.

Looking at the PCP-level variables, observed diabetes prevalence (per capita consumption of antidiabetics) increases by 0.2 %points in the first two years and further to 0.3 %points afterwards, and all of this increase comes from the use of oral antidiabetics (not of insulin), suggesting that less serious diabetes cases become detected by the new GP. Probabilities of in-hospital mortality and lower-limb amputation do not change significantly, which is not surprising given the relatively small number of affected patients and the presumably large response lag of these variables to any change in the quality of care.

When we decompose outpatient care use into particular outpatient specialties (Appendix Table A1), we find positive and (at the 5% level) significant short-run effects of the arrival of the new GP for diagnostic services (laboratory and ultrasound), internal care and neurology. Hence diagnostic services play a major role in the increase of outpatient care use, while the effects on neurology may be a consequence of the increased awareness for diabetic neuropathy, a common complication of diabetes, and the effects on internal care is a sign of an increased number of specialized diabetology appointments.

Appendix Table A2 shows robustness checks for the baseline results of Table 3. First, if the sample is not restricted to the patients already treated for diabetes in 2010 but also includes those who were later diagnosed, the effects are larger. This is because the arrival of the new GP increases the number of newly detected diabetes cases, and healthcare use tends to increase substantially around the time of diagnosis.

As a second robustness check, the standard fixed effects estimator yields results similar to the Sun and Abraham estimator, the only difference being the significant effect on hospitalization and PAH.

5.3 Heterogeneity

We first examine effect heterogeneity by the characteristics of the incoming GP in Figure 4 and then by patient characteristics and local healthcare supply conditions in Table 4. We present results only on outpatient care use, HbA1c testing and statin use because heterogeneites are not significant for the other outcome variables (for which standard errors are large and/or even the average effects are zero).

Figure 4 shows the estimated effects (i.e. $\delta = \delta_s = \delta_l$ in equation (2)) separately (1) by the gender of the GP, (2) by years since graduation ($\leq$ 15 years or $>$ 15 years) of the GP and (3) by the presence or absence of an additional specialized training exam. Beyond showing the separate effects by subgroup, we also display in each panel the differences of these effects (e.g. how the effects differ for male and female GPs). Also, since GP characteristics are correlated (as illustrated in Table 1), we present the controlled differences of the effects, i.e. the part of the difference solely attributable for one characteristic while controlling for the other two.

The left panels of Figure 4 show that the three outcome variables increase by 2-4 %points after the arrival of a new female GP, while the impacts are not significant after the arrival of a new male GP. The difference in the effects is 2 %points for HbA1c testing and statin use, and more than 1 %point for outpatient care use after controlling for the other characteristics of the GP (i.e. taking into account that female incoming GPs are younger on average). In relative terms, compared to the baseline levels, these differences of effects are substantial: 5-8% for HbA1c testing and statin use.

Similar patterns emerge by the years of professional experience of the incoming GP. The outcome variables increase much more after the arrival of a young GP than a more experienced GP, the controlled differences in effects being 1-3 %points (which is e.g. 10% in relative terms for HbA1c testing). Finally, we do not find significantly different effects by the presence or absence of additional special exams of the GP.

Table 4 examines the heterogeneity of effects by patient characteristics and local health-care supply variables. We find in Panel A that the arrival of the new GP increases outpatient care use and HbA1c testing significantly more (by around 2 %points more) for female than for male patients. Also, we know from Figure 4 that female incoming GPs have a larger effect than male ones, so it is natural to ask whether there is an interaction between the gender of the GP and the gender of the patient. Looking at outpatient care use and HbA1c testing, Panel B shows that female GPs have a larger effect than male GPs by roughly the same magnitude irrespective of the gender of the patient. However, for statin use, the larger impact of female GPs compared to male GPs comes exclusively from the difference on male patients (and the difference-in-differences-type estimate of effect heterogeneity is significant). Thus we have some evidence that male patients (who are more difficult to reach) are treated more accurately by female GPs than by male GPs.

Meanwhile, no significant heterogeneities are observed by the age of the patient (Panel C). Also, in line with the results of Figure 2, the effects do not differ by the presence or absence of a period of vacancy before the arrival of the new GP (Panel D).

Finally, in a separate exercise (in Panel E and F of Table 4) we test whether the effect during a temporary substitution (vacancy) differs depending upon the size of the change of the actual practice size and upon the change of the mean distance from the modal GP. We find that these local healthcare supply indicators do not play a significant role during the substitution period.

6 Discussion and conclusions

We analyzed the effect of access to primary care on healthcare use in rural Hungary where people have little choice in GPs. The exogenous change whose effect upon the care of diabetics we measured was the arrival of a new GP to the single village-wide practice. Using a rich dataset, we could differentiate not just between the effects of certain observable characteristics of the GP possibly linked to treatment style like gender, experience and specialized training, but also whether the new GP took over a temporarily vacant PCP as a substitute or settled in it as a new permanent one.

Our regressions and event studies show a significant uptick in several key variables that measure the kind of care received when a new GP takes over from the previous one (these are the probability of receiving specialized outpatient care, HbA1c testing, statin therapy among diabetic patients, and the ratio of the population consuming antidiabetic medication, in particular oral antidiabetics).

Based on the literature, we identified three mechanisms by which there can be an effect on the style and success of treatment as the GP in charge of the patients changes for mostly exogenous reasons: discontinuity of care, change in treatment style, and change in local healthcare supply conditions.

Our findings strongly support that discontinuity of primary care has an effect on treatment. Moreover, this effect seems to be linked to whether the new doctor is a mere substitute or takes the PCP over permanently. The dependent variables describing quality of care and health outcomes do not change significantly when a substitute GP takes over the practice, but they do when the switch is a permanent one. In particular, outpatient care use, HbA1c testing and statin use probability of the already treated diabetic patients increase significantly in 1-2 years and seem to remain elevated afterwards. A marked uptick in observed diabetes prevalence and oral antidiabetic prescriptions suggest that additional improvement comes from improved diagnosis and treatment of less serious diabetes cases by the new GP.

We submit that the discontinuity of care in this case, like in Simonsen et al. (2021) and Zocher (2024), but unlike in Sabety et al. (2021) comes with a greater effort to detect, diagnose and follow early diabetes among his/her new patients by the new doctor than exerted by the old one. The way we interpret our results is that this extra effort is much less exerted if the new GP is merely a temporary substitute in PCP that fell vacant for a while, and perceived as such by the patients. We think that this link between the nature of the relationship between patients and GPs (permanent or temporary) and their diligence at diagnosing and treating diabetes may have external validity and may have implications for how primary care is organised in other countries as well.

We also obtained noteworthy findings concerning how a change in the treatment style of the GP can have affected diabetes treatment. According to our quasi-experimental results a new female GP has a 1-2 %points greater impact than a new male GP, and a young GP has a 1-3 % points greater impact than an older GP, on the quarterly probability of outpatient care use, HbA1c testing and statin use, independently after controlling for the other characteristics of the GP. By taking into account the correlation of GP characteristics in examining treatment styles we go beyond the previous quasi-experimental (e.g. Hjalmarsson et al., 2023) or cross-sectional (Kaiser, 2017; Kovács et al., 2019) literature.

The positive effect of a shorter experience, paradoxical though it may sound, is easier to explain: it can reflect having received more recently more up-to-date medical training in medical school.

Our findings with respect to the gender of the general practitioner upon our dependent variables are harder to interpret. In fact, why female GPs are more likely to refer their patients significantly more to outpatient care, including HbA1c lab diagnostics, and initiate more often the use of statins than male practitioners do is beyond the confines of this study. Our results point at a different way in which new female GPs diagnose and treat early-stage diabetic patients, as well as difficult-to-reach cases (men) can be better treated by a female doctor. With respect to the use of statins, we found that the interaction between the gender of the patient and the doctor matters: the GP being female, not male relatively improves the statin use of male patients. We are aware that such cross-gender concordance effects are not unheard of in the literature: Eggermont et al. (2022) find that the female GP – male patient dyad results in more referrals than the female – female one, albeit in group practices, not single-doctor ones prevalent in Hungary and with respect to "gender sensitive" diagnoses; Greenwood et al. (2018) also identify higher mortality among female heart attack patients treated by male physicians. Nevertheless, explaining this result requires further research.

Finally, while, as expected, during the vacancy period patients were temporarily served by GPs with more numerous patients, we have not found convincing evidence that, under the practice allocation rules and within the size variation parameters in primary care in Hungary, the practice size would have an effect on the treatment of rural diabetic patients.

The main health policy implications of our study, we submit, are as follows. Discontinuity of care matters in primary care, but, along with its health and other social costs, a new GP taking over the primary care practice, under the right incentives, can also improve the care of their patients suffering from underdiagnosed chronic conditions like diabetes. This effect is likely to be more pronounced if the tenure of the new GP in the practice is not just a temporary one. Thus policies that assure that a new permanent GP can take over the practice as soon as possible can improve outcomes.

The treatment style of the GP also matters for how effectively they diagnose and treat their diabetic patients. Thus policies that could affect treatment style (doctor training, including continuing education, improving soft skills and incentives built into the remuneration of GPs) might matter a great deal for the primary diagnosis and treatment of widespread chronic diseases like diabetes and thereby for health outcomes in general.

References

ADA (2018). 6. Glycemic targets: Standards of medical care in diabetes – 2018. *Diabetes Care 41*(Supplement 1), S55–S64. https://doi.org/10.2337/dc18-S006.

Ahammer, A. and T. Schober (2020). Exploring variations in health-care expenditures – what is the role of practice styles? *Health Economics 29*(6), 683–699. https://doi.org/10.1002/hec.4011.

Barash, J. (2023). Practice size and short-run utilization: Evidence from Norway. *SSRN*. http://doi.org/10.2139/ssrn.4343073.

Bischof, T. and B. Kaiser (2021). Who cares when you close down? The effects of primary care practice closures on patients. *Health Economics 30*(9), 2004–2025. https://doi.org/10.1002/hec.4287.

Bíró, A. and P. Elek (2019). The effect of primary care availability on antibiotic consumption in Hungary: a population based panel study using unfilled general practices. *BMJ Open 9*, e028233. https://doi.org/10.1136/bmjopen-2018-028233.

Bíró, A. and B. Imre (2022). Financial subsidies and the shortage of primary care physicians. Working Paper 2022/10, Institute of Economics, Centre for Economic and Regional Studies. https://kti.krtk.hu/wp-content/uploads/2022/05/CERSIEWP202210.pdf.

Chevillard, G. and J. Mousquès (2021). Medically underserved areas: are primary care teams efficient at attracting and retaining general practitioners? *Social Science & Medicine 287*, 114358. https://doi.org/10.1016/j.socscimed.2021.114358.

Eggermont, D., A. E. Kunst, K. Hek, and R. A. Verheij (2022). Gender and age concordance between patient and GP: an observational study on associations with referral behaviour. *BJGP Open 6*(4), BJGPO.2022.0091. https://doi.org/10.3399/BJGPO.2022.0091.

Eggli, Y., B. Desquins, E. Seker, and P. Halfon (2014). Comparing potentially avoidable hospitalization rates related to ambulatory care sensitive conditions in Switzerland: the need to refine the definition of health conditions and to adjust for population health status. *BMC Health Services Research 14*, 25. https://doi.org/10.1186/1472-6963-14-25.

ElSayed, N. A., G. Aleppo, V. R. Aroda, R. R. Bannuru, F. M. Brown, D. Bruemmer, B. S. Collins, S. R. Das, M. E. Hilliard, D. Isaacs, E. L. Johnson, S. Kahan, K. Khunti,

M. Kosiborod, J. Leon, S. K. Lyons, M. L. Perry, P. Prahalad, R. E. Pratley, J. J. Seley, R. C. Stanton, and R. A. Gabbay (2022). 10. Cardiovascular disease and risk management: Standards of care in diabetes – 2023. *Diabetes Care 46*(Supplement 1), S158–S190. https://doi.org/10.2337/dc23-S010.

Fadlon, I. and J. Van Parys (2020). Primary care physician practice styles and patient care: Evidence from physician exits in Medicare. *Journal of Health Economics 71*, 102304. https://doi.org/10.1016/j.jhealeco.2020.102304.

Gaal, P., S. Szigeti, M. Csere, M. Gaskins, and D. Panteli (2011). Hungary: Health system review. *Health Systems in Transition 13*(5). https://pubmed.ncbi.nlm.nih.gov/22394651/.

Government-decree (2011). 313/2011. (XII. 23.) Government decree on independent medical activity (in Hungarian). Applicable legislation. https://net.jogtar.hu/jogszabaly?docid=a1100313.kor.

Greenwood, B. N., S. Carnahan, and L. Huang (2018). Patient–physician gender concordance and increased mortality among female heart attack patients. *Proceedings of the National Academy of Sciences 115*(34), 8569–8574. https://doi.org/10.1073/pnas.1800097115.

Hedden, L., M. L Barer, K. Cardiff, K. M McGrail, M. R. Law, and I. L. Bourgeault (2014). The implications of the feminization of the primary care physician workforce on service supply: a systematic review. *Human Resources for Health 12*, 32. https://doi.org/10.1186/1478-4491-12-32.

Hjalmarsson, L., B. Kaiser, and T. Bischof (2023). The impact of physician exits in primary care: A study of practice handovers. *Health Policy 135*, 104867. https://doi.org/10.1016/j.healthpol.2023.104867.

IDF (2017). *IDF Diabetes Atlas, 8th edition.* International Diabetes Federation. https://diabetesatlas.org/upload/resources/previous/files/8/IDF_DA_8e-EN-final.pdf.

Kaiser, B. (2017). Gender-specific practice styles and ambulatory health care expenditures. *European Journal of Health Economics 18*, 1157–1179. https://doi.org/10.1007/s10198-016-0861-7.

Kempler, P., Z. Putz, Z. Kiss, I. Wittmann, Z. Abonyi-Tóth, R. Gy, and J. Gy (2016). Prevalence and financial burden of type 2 diabetes mellitus in Hungary between 2001–2014 – Results of the analysis of the National Health Insurance Fund database (in Hungarian). *Diabetologia Hungarica 24*(3), 177–188.

Kovács, N., O. Varga, A. Nagy, A. Pálinkás, V. Sipos, L. Kőrösi, R. Ádány, and J. Sándor (2019). The impact of general practitioners' gender on process indicators in Hungarian primary healthcare: a nation-wide cross-sectional study. *BMJ Open 9*(9), e027296. https://doi.org/10.1136/bmjopen-2018-027296.

Kringos, D., W. Boerma, Y. Bourgueil, T. Cartier, T. Dedeu, T. Hasvold, A. Hutchinson, M. Lember, M. Oleszczyk, P. D. Rotar, I. Svab, P. Tedeschi, S. Wilm, A. Wilson, A. Windak, J. Van der Zee, and P. Groenewegen (2013). The strength of primary care in Europe: an international comparative study. *British Journal of General Practice 63*(616), e742–50. https://doi.org/10.3399/bjgp13X674422.

Kwok, J. H. (2018). How do primary care physicians influence healthcare? Evidence on practice styles and switching costs from Medicare. *SSRN*. https://doi.org/10.2139/ssrn.4030445.

NEAK (2023). Hungarian primary care indicator system. https://www.neak.gov.hu/felso_menu/szakmai_oldalak/gyogyito_megeleozo_ellatas/alapellatas/indikatorrendszer---haziorvosi-fogorvosi.

OECD (2012). *The diabetes epidemic and its impact on Europe.* European Diabetes Leadership Forum. https://www.oecd.org/els/health-systems/50080632.pdf.

OECD (2019). *Hungary: Country health profile 2019. State of health in the EU.* OECD Publishing / European Observatory on Health Systems and Policies. https://eurohealthobservatory.who.int/publications/m/hungary-country-health-profile-2019.

OECD (2020). *Realising the potential of primary health care.* OECD Health Policy Studies. OECD Publishing. https://doi.org/10.1787/a92adee4-en.

Purdy, S., T. Griffin, C. Salisbury, and D. Sharp (2009). Ambulatory care sensitive conditions: terminology and disease coding need to be more specific to aid policy makers and clinicians. *Public Health 123*(2), 169–173. https://doi.org/10.1016/j.puhe.2008.11.001.

Sabety, A. H., A. B. Jena, and M. L. Barnett (2021). Changes in health care use and outcomes after turnover in primary care. *JAMA Internal Medicine 181*(2), 186–194. https://doi.org/10.1001/jamainternmed.2020.6288.

Simonsen, M., L. Skipper, N. Skipper, and P. R. Thingholm (2021). Discontinuity in care: Practice closures among primary care providers and patient health care utilization. *Journal of Health Economics 80*, 102551. https://doi.org/10.1016/j.jhealeco.2021.102551.

Sun, L. and S. Abraham (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics 225*(2), 175–199. https://doi.org/10.1016/j.jeconom.2020.09.006.

Sándor, J., A. Pálinkás, F. Vincze, V. Sipos, N. Kovács, T. Jenei, Z. Falusi, L. Pál, L. Kőrösi, M. Papp, and R. Ádány (2018). Association between the general practitioner workforce crisis and premature mortality in Hungary: Cross-sectional evaluation of health insurance data from 2006 to 2014. *International Journal of Environmental Research and Public Health 15*(7), 1388. https://doi.org/10.3390/ijerph15071388.

Wilm, S., P. Vajer, , and I. Rurik (2015). Hungary. In A. Hutchinson and R. B. Saltman (Eds.), *Building primary care in a changing Europe: Case Studies*, Chapter 12, pp. 107–114. European Observatory on Health Systems and Policies. https://www.ncbi.nlm.nih.gov/books/NBK459030/.

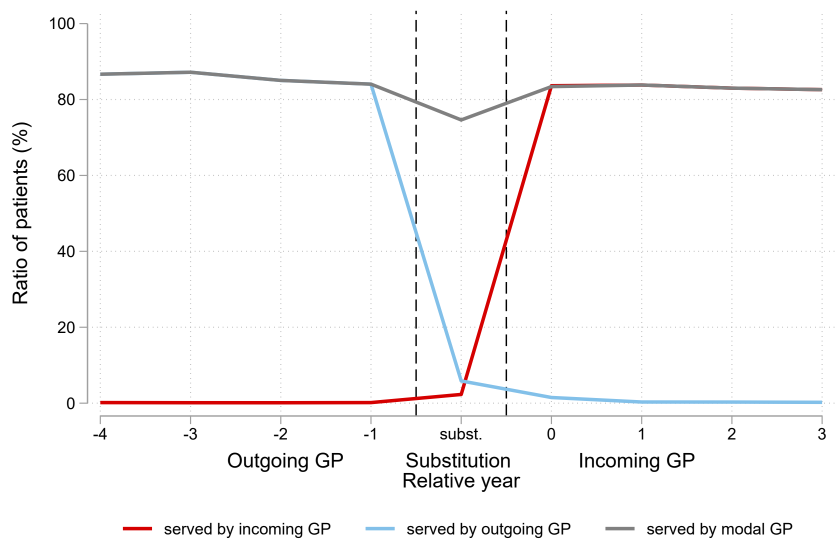
Zhang, X. (2022). The effects of physician retirement on patient outcomes: Anticipation and disruption. *Journal of Public Economics 207*, 104603. https://doi.org/10.1016/j.jpubeco.2022.104603.

Zocher, K. (2024). Exiting primary care providers. *Health Economics 33*(5), 1033–1054. https://doi.org/10.1002/hec.4800.

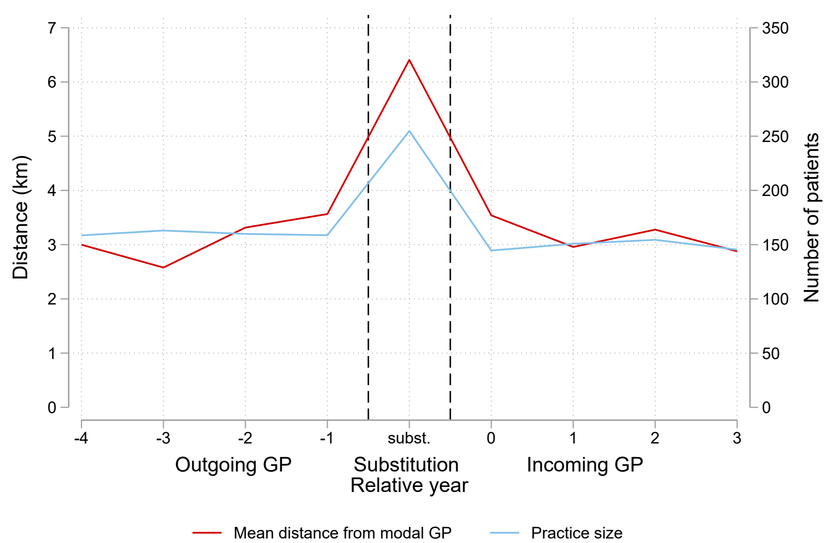
Figures and Tables

Figure 1: Evolution of PCP-level indicators

(a) Ratio of patients served by various GPs



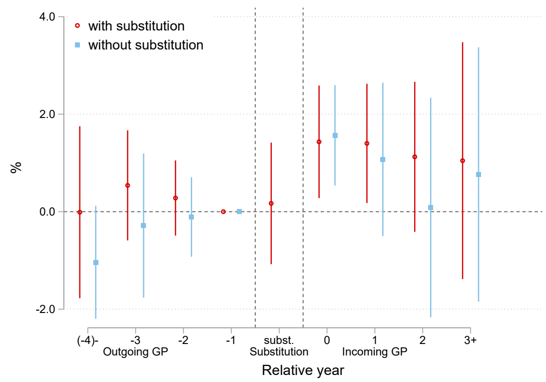
(b) PCP-level supply variables



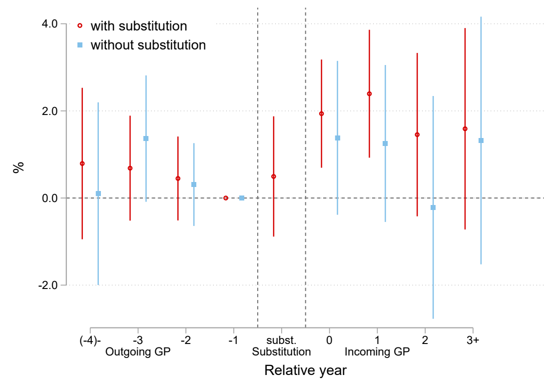
Note: Panel a) shows the percentage share of patients served by the outgoing, incoming and modal GP, while panel b) shows the mean distance of the patients from the settlement of the modal GP and the number of diabetes patients served by the modal GP (the actual diabetes practice size) in the treated PCPs by relative year during the period of outgoing, substituting and incoming GP.

Figure 2: Individual-level event studies

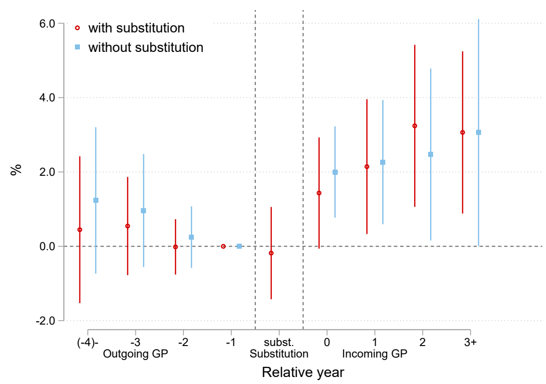
(a) Outpatient probability



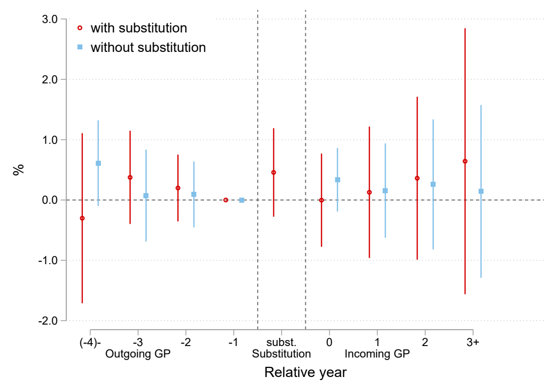
(b) HbA1c probability



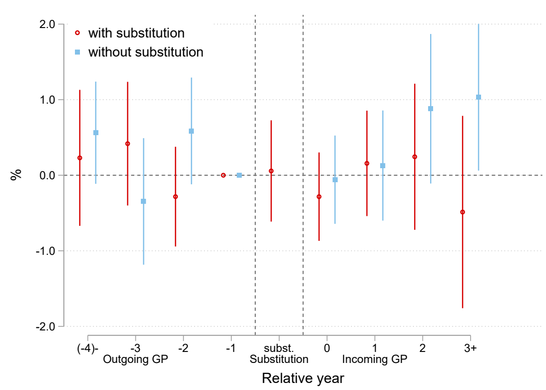
(c) Statin use probability



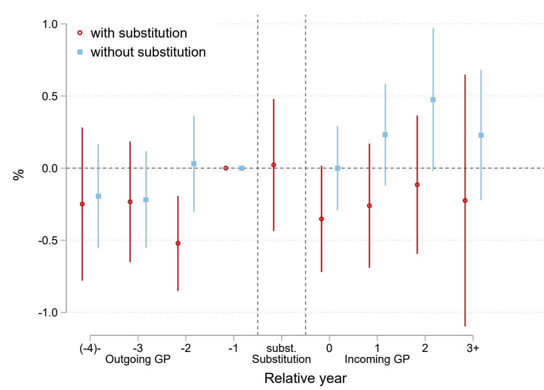
(d) Antihypertensive use probability



(e) Inpatient probability



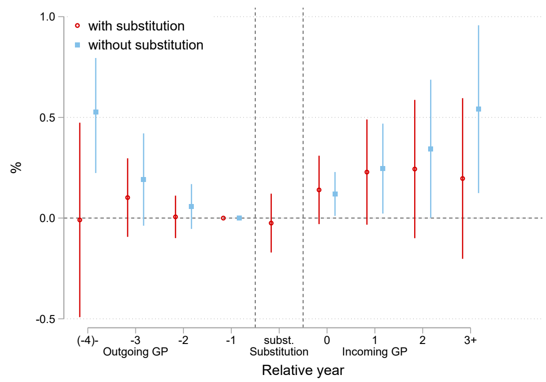
(f) PAH probability



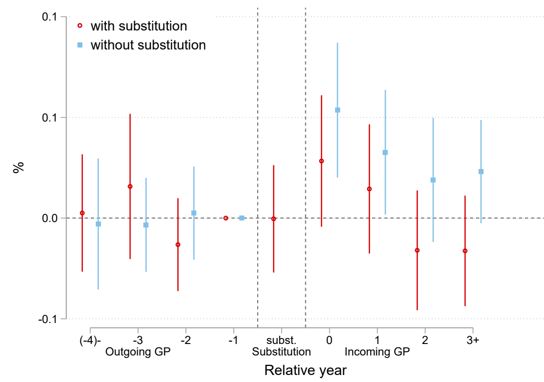
Note: Figures show the Sun-Abraham event study estimates (with 95% confidence intervals, using standard errors clustered at the PCP level) from equation (1) on individual-level panel data for 40-79 years old patients consuming antidiabetics in 2010. Quarterly parameters are binned by relative year (four quarters). The baseline is the last year before the departure of the outgoing GP. Controls: individual and time fixed effects, age group – gender interactions. Number of observations: 1,686,583. Number of individuals: 64,866.

Figure 3: PCP-level event studies

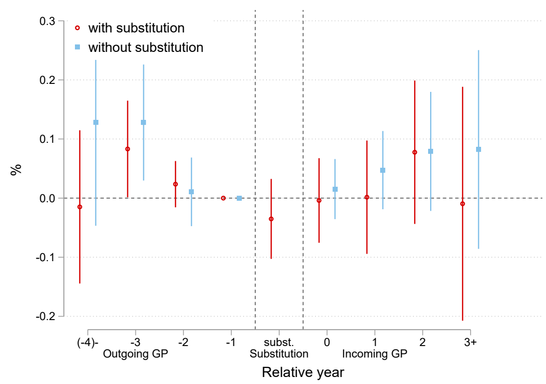
(a) Antidiabetics use ratio



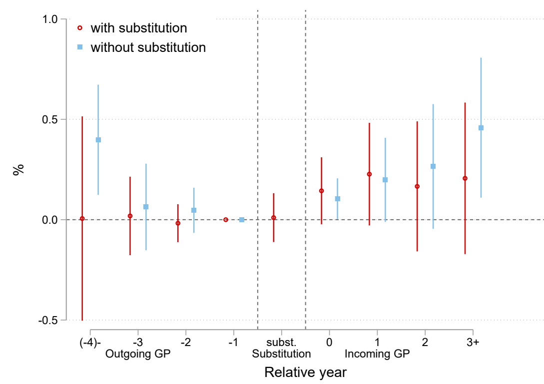
(b) Antidiabetics initiation ratio



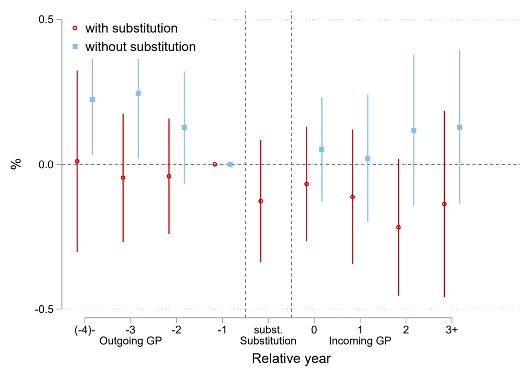
(c) Insulin use ratio



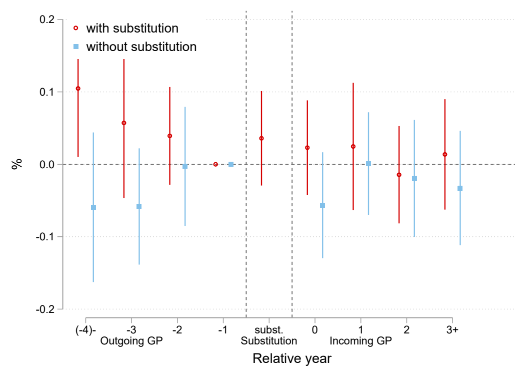
(d) Oral antidiabetics use ratio



(e) In-hospital death ratio



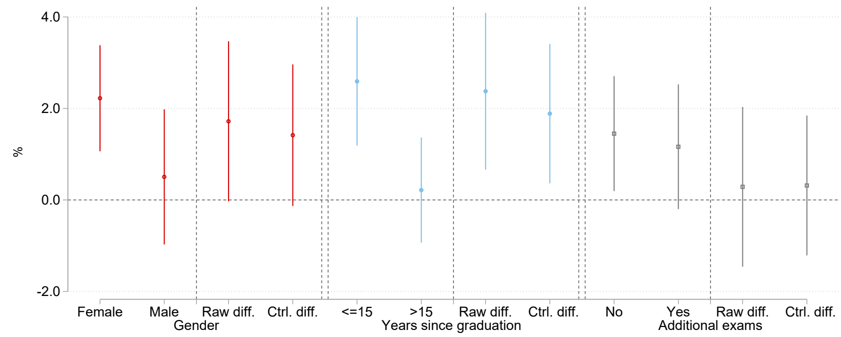
(f) Lower-limb amputation ratio



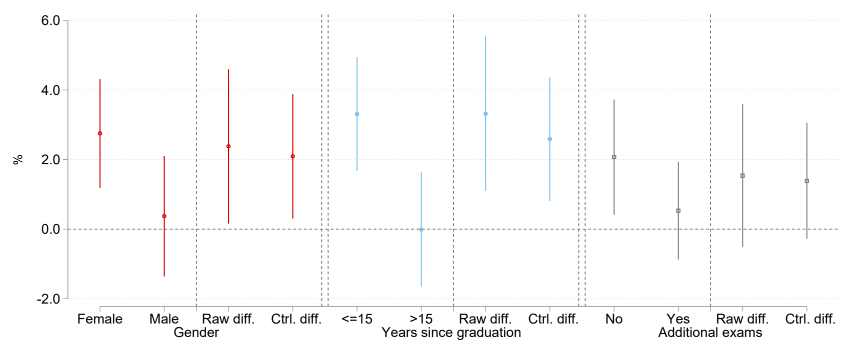
Note: Figures show the Sun-Abraham event study estimates (with 95% confidence intervals) from equation (1) on PCP-level data. Variables in panels (a)-(d) are defined as proportions of the 40+ years old population, variables in panels (e)-(f) are defined as a proportion of the 40-79 years old population consuming antidiabetics in 2010. Quarterly parameters are binned by relative year (four quarters). The baseline is the last year before the departure of the outgoing GP. Controls: PCP and time fixed effects, age group and gender composition. Number of observations: 28,190. Number of PCPs: 930.

Figure 4: Heterogeneous effects by GP characteristics

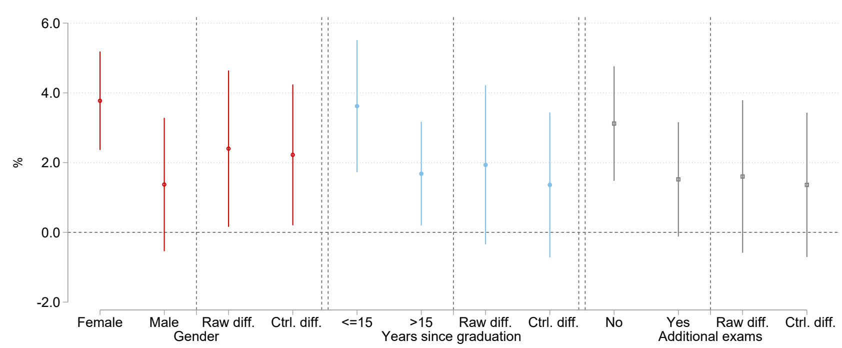
(a) Outpatient probability



(b) HbA1c probability



(c) Statin use probability



Note: Each figure displays three panels (heterogeneity by the incoming GP's gender, by time since graduation and by the presence of additional special exams). Within each panel, the left two sticks show the Sun-Abraham panel regression estimates δ (with 95% confidence intervals, using standard errors clustered at the PCP level) from equation (2) for two subgroups. The third stick shows the difference of the effects in the two subgroups, while the fourth stick shows controlled differences of the effects where the other two GP characteristics are controlled for. Sample: individual-level data for 40-79 years old patients consuming antidiabetics in 2010. Controls: individual and time fixed effects, age group – gender interactions. Number of observations: 1,670,307. Number of individuals: 64,142.

Table 1: Descriptive statistics of the treated PCPs

	All treated		With subst.		Without subst.	
Length of episodes (quarters)	Mean	S.D.	Mean	S.D.	Mean	S.D.
Outgoing GP	13.4	7.4	13.5	7.3	13.3	7.6
Temporary substitution	2.7	4.4	4.8	4.9	0.0	0.0
Incoming GP	12.4	7.6	11.1	7.3	14.2	7.7
Event date (calendar year)	Mean	S.D.	Mean	S.D.	Mean	S.D.
Departure of outgoing GP	2013.3	1.9	2013.2	1.9	2013.4	1.9
Arrival of incoming GP	2013.9	2.0	2014.3	2.0	2013.4	1.9
GP's years since graduation	Mean	S.D.	Mean	S.D.	Mean	S.D.
Outgoing GP	28.1	13.5	28.2	13.5	27.8	13.4
Incoming GP	17.0	10.8	18.1	11.1	15.5	10.2
Characteristics of incoming GP	Ratio		Ratio		Ratio	
GP's experience is $\geq$ 15 years	0.47		0.43		0.52	
GP is male	0.51		0.48		0.54	
GP is male if exp. $\geq$ 15 years	0.55		0.47		0.64	
GP is male if exp. $<$ 15 years	0.48		0.51		0.44	
GP has additional special exam	0.30		0.24		0.37	
GP has add. spec. exam if exp. $\geq$ 15 years	0.40		0.36		0.45	
GP has add. spec. exam if exp. $<$ 15 years	0.18		0.10		0.25	
Number of PCPs	164		93		71	

Note: Table shows descriptive statistics of lengths of episodes, event times and GP characteristics in the treated PCPs and two subgroups (with and without temporary substitution). Information on the years since graduation and additional special exams is missing for 9 incoming GPs (5.5%) and 28 outgoing GPs (17.1%).

Table 2: Descriptive statistics for the whole country, the control and the treated group

	Whole country (1)	Control (2)	Treated (3)	Treated with subst. (4)	Treated without subst. (5)	Stand. mean diff. (%) (3)-(2)
Quarterly individual-level variables (for the 40-79 years old diabetic population, 2010)						
Outpatient pr. (%)	71.8	68.6	68.8	68.7	68.9	0.4
HbA1c pr. (%)	28.2	25.7	25.8	26.1	25.6	0.2
Statin use pr. (%)	46.5	42.8	43.4	42.5	44.3	1.2
Antihypert. use pr. (%)	83.6	84.7	85.1	84.9	85.4	1.1
Inpatient pr. (%)	10.7	11.6	11.5	11.8	11.2	-0.4
PAH pr. (%)	3.0	3.6	3.4	3.5	3.3	-0.9
Quarterly PCP- (settlement-) level variables (for the 40+ years old population, 2010)						
Antidiab. use ratio (%)	8.6	9.1	9.2	9.0	9.5	2.9
Antid. initiation ratio* (%)	0.23	0.25	0.27	0.27	0.25	6.1
Insulin use ratio (%)	2.3	2.6	2.6	2.5	2.8	4.8
Oral antid. use ratio (%)	6.3	6.5	6.6	6.5	6.7	1.2
In-hosp. death ratio* (%)	0.86	0.92	0.90	0.79	1.05	-0.8
Amputation ratio* (%)	0.11	0.15	0.14	0.14	0.14	-1.4
Demographic variables (for the 40-79 years old diabetic population, 2010)						
Male (%)	48.2	46.2	45.6	45.2	46.0	-1.2
Age (year)	63.2	62.6	62.9	62.8	63.0	2.0
Settlement-level indicators (2010)						
Log income per cap.	6.65	6.36	6.36	6.32	6.40	-0.5
Dist. from county seat (km)	22.3	33.5	34.9	35.4	34.3	8.0
PCP-level indicator (2010)						
Total population of settlements		1513	1446	1369	1546	-11.2
Sample size (2010)						
Individuals	484,082	54,279	11,366	5,885	5,481	
Settlements	2,869	1,165	268	153	115	
PCPs	6,596	766	164	93	71	

Note: The upper two panels of the table show means of variables on the individual level (for the 40-79 year-old population who consumed antidiabetics in 2010) and on the PCP- (settlement-) level (for the 40+ years old population, after division with the corresponding population of the settlements). (As exceptions, in-hospital death and amputation ratio are calculated on the PCP- [settlement-] level for the 40-79 years old diabetic population. All means refer to 2010, except for * cases, which refer to 2012.) The third panel shows demographic characteristics of the 40-79 years old diabetic population. The fourth and the fifth panels show settlement-level and PCP-level socioeconomic and geographic indicators. Variables refer to the population of (1) the whole country, (2) the control settlements with a single PCP that were served by the same permanent GP throughout the period, (3) the examined settlements with a single PCP where the GP changed during the period, and of their two subgroups: (4) with and (5) without temporary substitution. Standardized mean difference is the difference of means displayed as a percentage of the standard deviation.

Table 3: Individual-level and PCP-level panel regression estimates

	Effect on quarterly probability in %point, individual level					
	Outpat.	HbA1c	Statin	Antihyp.	Inpat.	PAH
Vacant (γ)	0.08	0.17	-0.04	0.31	0.20	0.29
	(0.58)	(0.67)	(0.58)	(0.34)	(0.32)	(0.21)
New GP, first two years (δ_s)	1.34***	1.70***	1.84***	0.02	-0.10	0.02
	(0.40)	(0.54)	(0.55)	(0.29)	(0.19)	(0.11)
New GP, after two years (δ_l)	0.81	1.26	2.91***	0.27	0.41	0.19
	(0.79)	(0.85)	(0.85)	(0.51)	(0.31)	(0.18)
Test: $\delta_s = \delta_l$	n.s.	n.s.	*	n.s.	*	n.s.
Baseline prob. (%)	68.6	25.7	42.8	84.7	11.6	3.56
	Effect on quarterly proportion in %point, PCP level					
	Antidiab. use	Antidiab. init.	Insulin use	Oral a.d. use	In-hosp. death	Amput.
Vacant (γ)	-0.00	0.01	-0.02	0.02	-0.08	0.01
	(0.08)	(0.01)	(0.03)	(0.07)	(0.09)	(0.03)
New GP, first two years (δ_s)	0.16**	0.04***	0.00	0.16**	-0.05	-0.00
	(0.07)	(0.01)	(0.03)	(0.07)	(0.05)	(0.02)
New GP, after two years (δ_l)	0.33**	0.00	0.05	0.28**	-0.01	-0.02
	(0.13)	(0.01)	(0.06)	(0.12)	(0.07)	(0.02)
Test: $\delta_s = \delta_l$	*	***	n.s.	n.s.	n.s.	n.s.
Baseline prop. (%)	9.1	0.25	2.6	6.5	0.9	0.14

Note: Table shows Sun-Abraham panel regression estimates from equation (2) on the individual level for the 40-79 year-old population who consumed antidiabetics in 2010 and on the PCP-level for the 40+ years old population. (In-hospital death and amputation ratio are calculated on the settlement level for the 40-79 years old diabetic population.) Standard errors clustered at the PCP level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, n.s. not significant. Tests show the significance of the difference of the short- and medium-term effects. Controls: individual or PCP and time fixed effects, age group – gender interactions. Number of observations: 1,686,583 in the individual-level regressions and 28,190 in the PCP-level regressions. Number of individuals: 64,866. Number of PCPs: 930.

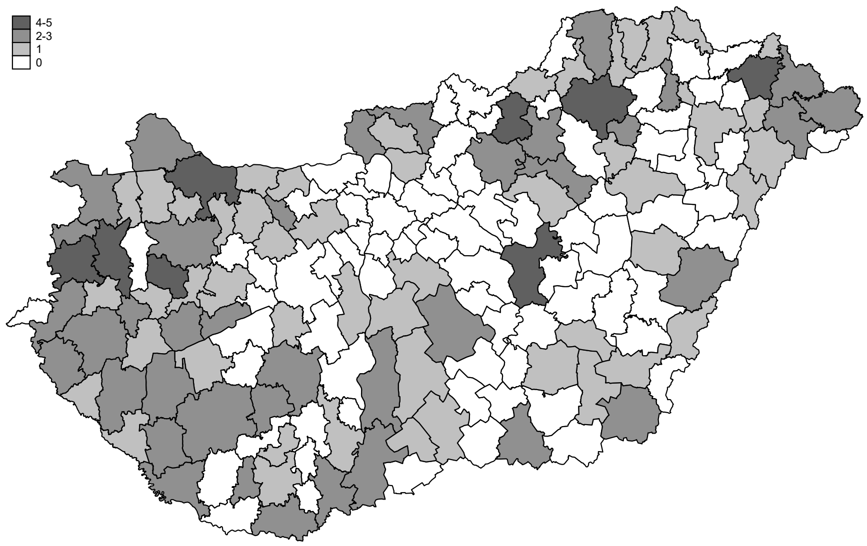
Table 4: Heterogeneous effects by individual-, GP- and PCP-level variables

	Effect on quarterly probability in %point		
Panel A	Outpat.	HbA1c	Statin
New GP if patient is male	0.25	0.51	1.60*
	(0.64)	(0.69)	(0.84)
New GP if patient is female	1.94***	2.47***	2.89***
	(0.57)	(0.67)	(0.74)
Test of equality	***	***	n.s.
Panel B	Outpat.	HbA1c	Statin
(1) New GP if patient is male & GP is male	-0.91	-1.05	-1.01
	(0.86)	(0.94)	(1.20)
(2) New GP if patient is male & GP is female	1.43*	2.04**	4.14***
	(0.82)	(0.83)	(0.88)
(3) New GP if patient is female & GP is male	0.86	1.07	2.46**
	(0.78)	(0.83)	(0.96)
(4) New GP if patient is female & GP is female	3.04***	3.85***	3.32***
	(0.73)	(0.93)	(0.97)
((2)-(1))-((4)-(3))=0	0.17	0.31	4.29**
	(1.16)	(0.92)	(1.58)
Panel C	Outpat.	HbA1c	Statin
New GP if patient is 40-59 year-old	0.87	1.43*	2.34**
	(0.709	(0.79)	(1.00)
New GP if patient is 60-79 year-old	1.26**	1.61**	2.27***
	(0.55)	(0.63)	(0.69)
Test of equality	n.s.	n.s.	n.s.
Panel D	Outpat.	HbA1c	Statin
New GP, with vacancy in-between	1.26**	1.94	2.18***
	(0.63)	(0.69)	(0.83)
New GP, without vacancy in-between	1.08	1.22	2.43***
	(0.80)	(1.01)	(0.95)
Test of equality	n.s.	n.s.	n.s.
Panel E	Outpat.	HbA1c	Statin
Vacant, mean distance from modal GP is below median	-0.53	0.29	-0.40
	(0.75)	(0.77)	(0.75)
Vacant, mean distance from modal GP is above median	0.36	0.35	0.01
	(0.77)	(0.90)	(0.73)
Test of equality	n.s.	n.s.	n.s.
Panel F	Outpat.	HbA1c	Statin
Vacant, diff log practice size is below median	0.10	0.04	-0.04
	(0.69)	(0.78)	(0.67)
Vacant, diff log practice size is above median	0.05	0.46	-0.18
	(0.94)	(1.02)	(0.94)
Test of equality	n.s.	n.s.	n.s.
Baseline prob. (%)	68.6	25.7	42.8

Table shows Sun-Abraham panel regression estimates of heterogeneous effects by individual-, GP- and PCP-level variables from equation (2) on the individual level for the 40-79 year-old population who consumed antidiabetics in 2010. Standard errors clustered at the PCP level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, n.s. not significant. Tests show the significance of the difference of the effects in two subgroups. Controls: individual and time fixed effects, age group – gender interactions. Number of observations: 1,686,583. Number of individuals: 64,866.

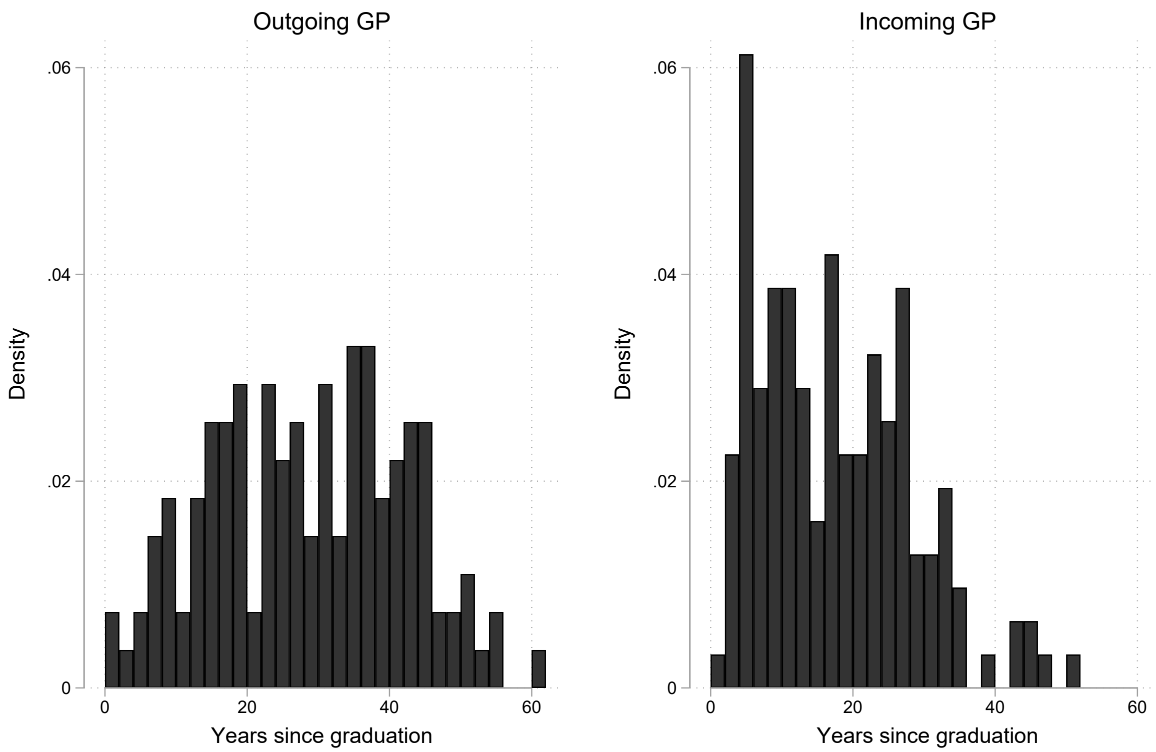
Appendix

Appendix Figure A1: Number of treated PCPs by micro-region in Hungary



Note: Figure shows the number of treated PCPs by micro-region.

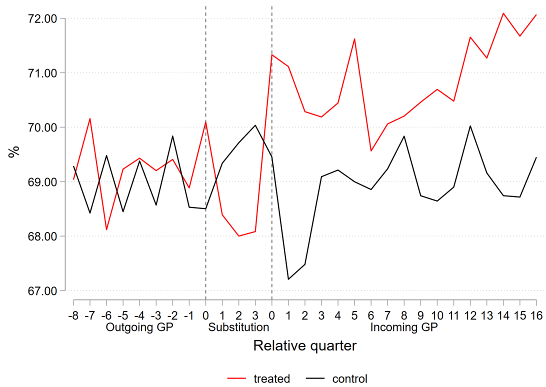
Appendix Figure A2: Histograms of the years since graduation of the outgoing and incoming GPs



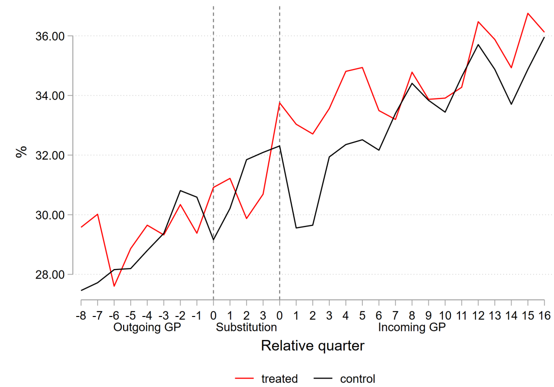
Note: Figure shows the histogram of the years since graduation (from medical university) of outgoing and incoming GPs.

Appendix Figure A3: Evolution of individual-level variables

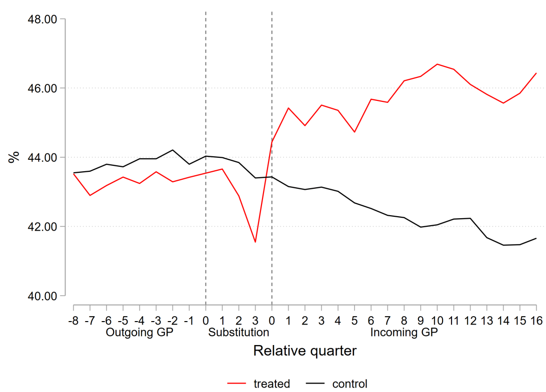
(a) Outpatient probability



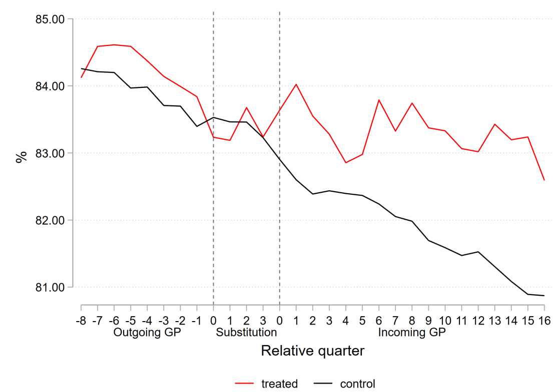
(b) HbA1c probability



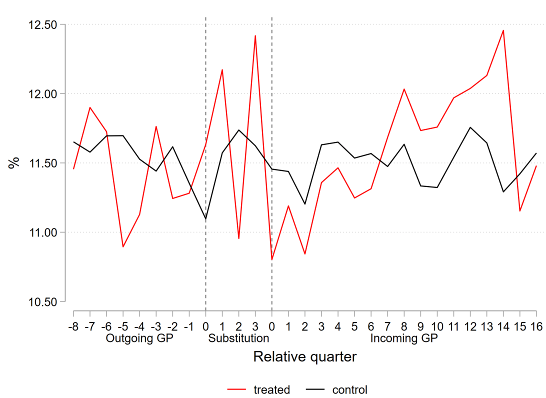
(c) Statin use probability



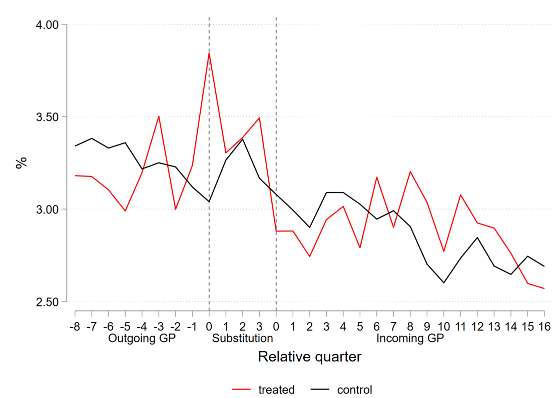
(d) Antihypertensive use probability



(e) Inpatient probability



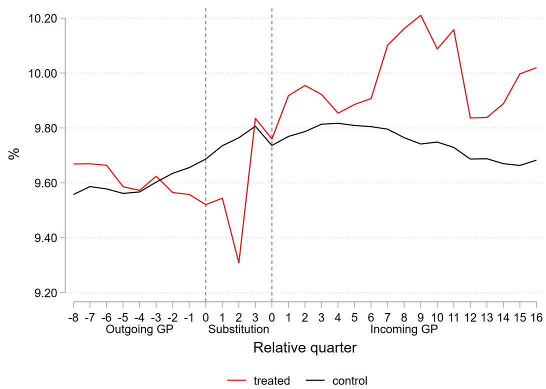
(f) PAH probability



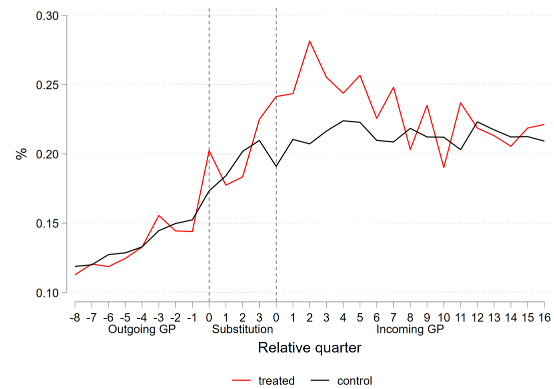
Note: Figures show the raw means of individual-level variables for the treated and control group by relative quarter (placebo event times are chosen randomly for the control group and 100 replications are averaged).

Appendix Figure A4: Evolution of PCP-level variables

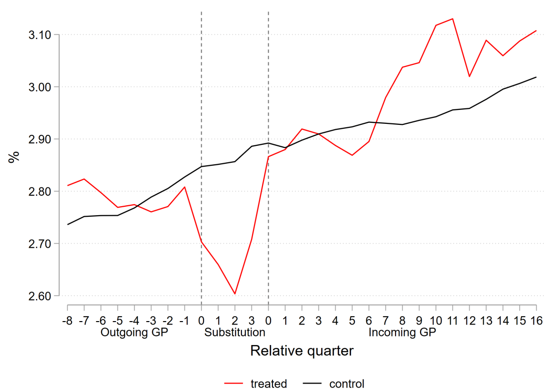
(a) Antidiabetics use ratio



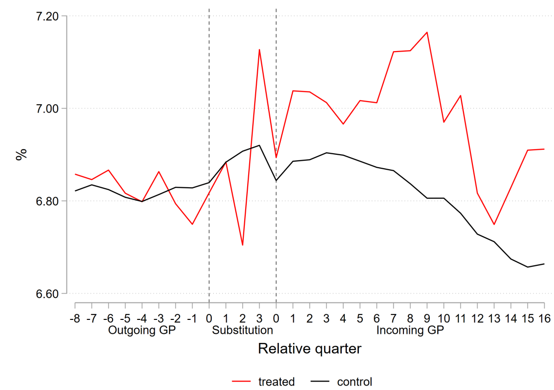
(b) Antidiabetics initiation ratio



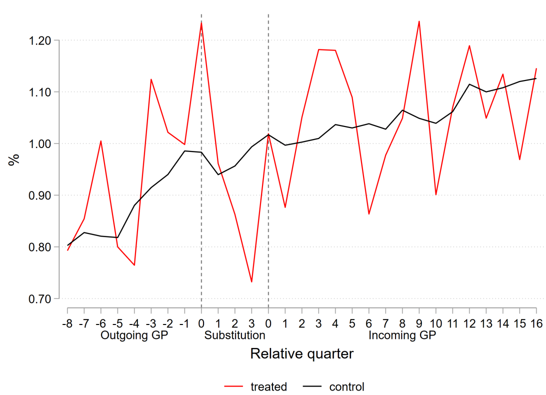
(c) Insulin use ratio



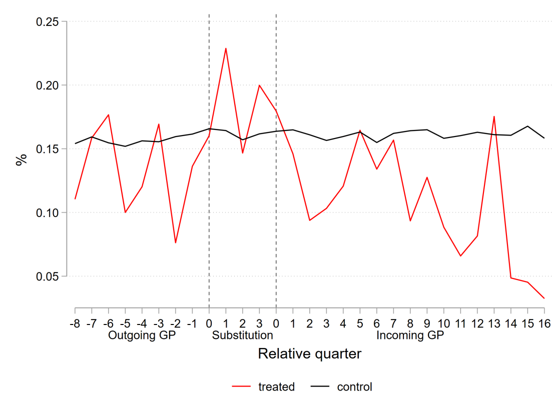
(d) Oral antidiabetics use ratio



(e) In-hospital death ratio



(f) Amputation ratio



Note: Figures show the raw means of PCP-level variables for the treated and control group by relative quarter (placebo event times are chosen randomly for the control group and 100 replications are averaged).

Appendix Table A1: Effects on outpatient specialties

	Baseline in %	New GP, first two years in %point (δ_s)		New GP, after two years in %point (δ_l)	
Internal care	33.8	0.86**	(0.38)	-0.56	(0.68)
Cardiology	8.7	0.12	(0.27)	-0.34	(0.47)
Surgery	6.8	-0.33**	(0.16)	0.05	(0.23)
Traumatology	2.9	0.07	(0.12)	0.19	(0.19)
Otolaryngology	3.3	0.10	(0.11)	0.08	(0.16)
Ophthalmology	14.3	0.15	(0.26)	0.51	(0.49)
Dermatology	3.2	-0.06	(0.14)	-0.17	(0.22)
Neurology	5.5	0.37**	(0.15)	0.38	(0.23)
Orthopedics	2.4	0.02	(0.11)	0.11	(0.23)
Urology	4.5	0.08	(0.13)	0.30	(0.23)
Oncology	2.6	-0.12	(0.11)	0.09	(0.21)
Rheumatology	8.0	0.26	(0.18)	0.10	(0.24)
Psychiatry	4.6	0.05	(0.11)	0.02	(0.22)
Pulmonology	9.5	0.22	(0.30)	0.21	(0.42)
Lab diagnostics	48.3	1.83***	(0.47)	1.26	(0.82)
X-ray diagn.	14.5	0.41	(0.27)	0.39	(0.34)
Ultrasound diagn.	10.1	0.57**	(0.22)	0.47	(0.37)

Note: Table shows panel regression estimates from equation (2) on the probability of use of outpatient specialties for the 40-79 year-old population who consumed antidiabetics in 2010. Standard errors clustered at the PCP level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Controls: individual and time fixed effects, age group – gender interactions. Number of observations: 1,686,583. Number of individuals: 64 866.

Appendix Table A2: Robustness for baseline results

Panel A. Sun-Abraham estimator, without cohort condition for 2010						
	Effect on quarterly probability in %point					
	Outpat.	HbA1c	Statin	Antihyp.	Inpat.	PAH
Vacant (γ)	-0.02	0.07	0.37	-0.01	-0.01	0.06
	(0.49)	(0.55)	(0.509	(0.27)	(0.23)	(0.13)
New GP, first two years (δ_s)	1.59***	1.83***	2.45***	0.35	0.09	-0.01
	(0.38)	(0.44)	(0.51)	(0.24)	(0.14)	(0.07)
New GP, after two years (δ_l)	0.90	1.58**	3.98***	0.60	0.11	0.10
	(0.67)	(0.68)	(0.82)	(0.45)	(0.22)	(0.11)
Test: $\delta_s = \delta_l$	n.s.	n.s.	***	n.s.	n.s.	n.s.
Baseline prob. (%)	60.7	18.2	35.0	76.4	9.65	2.63
Panel B. Standard FE estimator, with cohort condition for 2010						
	Effect on quarterly probability in %point					
	Outpat.	HbA1c	Statin	Antihyp.	Inpat.	PAH
Vacant (γ)	0.13	-0.23	-0.01	0.23	0.76**	0.53**
	(0.52)	(0.64)	(0.53)	(0.32)	(0.32)	(0.21)
New GP, first two years (δ_s)	1.44***	1.36**	1.70***	0.03	0.49**	0.24**
	(0.41)	(0.56)	(0.52)	(0.28)	(0.21)	(0.10)
New GP, after two years (δ_l)	0.71	0.60	2.80***	0.11	0.96***	0.43***
	(0.70)	(0.80)	(0.71)	(0.45)	(0.32)	(0.15)
Test: $\delta_s = \delta_l$	n.s.	n.s.	**	n.s.	n.s.	n.s.
Baseline prob. (%)	68.6	25.7	42.8	84.7	11.6	3.56

Note: Table shows panel regression estimates from equation (2) on the individual level. Panel A displays Sun-Abraham results for the 40-79 year-old population who consumed antidiabetics at least once between 2010-2017. Number of observations: 2,808,539. Panel B displays standard fixed-effects results for the 40-79 year-old population who consumed antidiabetics in 2010. Number of observations: 1,686,583. Standard errors clustered at the PCP level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, n.s. not significant. Tests show the significance of the difference of the short- and medium-term effects. Controls: individual or PCP and time fixed effects, age group – gender interactions.