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ABSTRACT

Vaccine-Skeptic Physicians and COVID-19 Vaccination Rates*

What is the role of general practitioners (GPs) in supporting or hindering public health efforts? We investigate the influence of vaccine-skeptic GPs on their patients' decisions to get a COVID-19 vaccination. We identify vaccine-skeptic GPs from the signatories of an open letter in which 199 Austrian physicians expressed their skepticism about COVID-19 vaccines. We examine small rural municipalities where patients choose a GP primarily based on geographic proximity. These vaccine-skeptic GPs reduced the vaccination rate by 5.6 percentage points. This estimate implies that they discouraged 7.9% of the vaccinable population. The effect appears to stem from discouragement rather than from rationing access to the vaccine.

JEL Classification: I12, I18

Keywords: COVID-19, vaccination, vaccine hesitancy, health policy

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1 Introduction

Vaccines are a powerful tool to control infectious diseases, but achieving high immunization coverage is often difficult for health authorities. In the context of the COVID-19 pandemic, the rapid development of vaccines was considered a scientific success. Initially, supply constraints slowed down vaccination campaigns in most European countries. But by early summer 2021, many countries faced problems of vaccine hesitancy and plateauing vaccination rates, despite the implementation of policies to increase vaccination rates, like information campaigns, restrictions for unvaccinated individuals, and various (monetary) incentives.

We study the role of GPs in influencing vaccination decisions. Individuals decide whether to get vaccinated based on their beliefs and the information available about the costs and benefits of being vaccinated (Auld, 2003). GPs are an essential source of information for individuals seeking advice on whether or not to get vaccinated. GPs might also actively reach out to their patients to encourage them to get vaccinated. But GPs skeptical about the usefulness and worried about the risk of vaccines might discourage patients from getting vaccinated, even if official guidelines suggest otherwise.[1]

Quantifying the importance of GPs in the vaccination decision remains difficult. First, the match between GPs (and physicians in general) and patients is typically not random, as patients may seek out physicians who share their views on vaccinations and their "medical philosophy" more broadly. Second, researchers can hardly observe the personal views of GPs and the recommendations given to influence vaccination decisions.

To overcome these issues, we study an event in Austria where a group of 199 physicians declared their opposition to the COVID-19 vaccination campaign in an open letter in December 2021. In this letter, they raised concerns regarding vaccine safety and effectiveness and thus deviated from the scientific consensus and official guidelines. The signatories of this letter are physicians from all over Austria. We use the signing of the letter as a proxy for a vaccine-skeptic view and hypothesize that these physicians also communicate this view to their patients. Many of these physicians are

[1] Jungbauer-Gans and Kriwy (2003) show in a survey that pediatricians' own perceptions of vaccines are highly related to the recommendations made to their child patients and their parents. The share of vaccine-skeptic parents is also higher and the vaccination rates are lower if the pediatrician is less likely to recommend various vaccines. However, it remains unclear to what extent this relationship is due to the sorting of vaccine-skeptic parents to pediatricians with similar views or reflects the influence of the pediatrician.

general practitioners (GPs) located in rural areas where the network of GPs is relatively sparse. Thus, the match between patients and GPs primarily results from geographic proximity (Irlacher et al., 2021).

We use this setting to identify the effect of a vaccine-skeptic GP in a municipality on the municipality's vaccination rate. We compare these *treated* municipalities with observationally similar *control* municipalities without a vaccine-skeptic GP.[2] We find that the presence of a vaccine-skeptic GP reduces the vaccination rate in the municipality population by about 5.6 percentage points. This effect implies that 7.9% of individuals willing to get vaccinated did not, because of a vaccine-skeptic GP and - given the average number of patients - that each of these GPs discouraged 64 individuals from getting vaccinated.

Our preferred estimate (-5.6 pp.) from a rich specification with highly predictive covariates (adjusted $R^2 = 0.63$), among them proxies for demographic differences and vaccine skepticism in the population, is almost identical to the unconditional estimate (-5.76 pp.). We take this as evidence of hardly any sorting based on views concerning vaccines between GPs and patients in rural areas, which allows for a causal interpretation of this relationship. We show that, under reasonable assumptions, this effect can be interpreted as the effect of having a vaccine-skeptic GP on the individual vaccination probability. The effect appears early in the vaccination campaign when vaccines were still scarce and remains constant afterward. The effect is larger in municipalities with a single GP and in municipalities close to a vaccination center. We consider this as evidence that vaccine-skeptic GPs discourage individuals from getting vaccinated instead of rationing access to the vaccine.[3]

We contribute to the literature studying vaccination decisions. Most directly, we provide evidence of the importance of healthcare workers in vaccination campaigns and vaccine uptake. Stamm et al. (2022) conduct a survey experiment in Austria to elicit reasons for vaccine hesitancy. Fear of side effects, the assumption that the own immune system would provide sufficient protection, conspiratorial thinking, low trust in societal institutions, and spiritual beliefs were common among the unvaccinated. GPs might particularly affect the health dimensions leading to vaccine hesitancy.

[2]In our main specification, we identify the effect of the share of vaccine-skeptic GPs among all GPs, which results in the same interpretation of the coefficient. See Appendix A.

[3]Data on the share of COVID-19 vaccinations administered by GPs is not available. However, anecdotal evidence suggests that an overwhelming share of vaccinations were provided in vaccination centers. Thus, the role of GPs was primarily one of information providers.

Heyerdahl et al. (2022) raise the issue that vaccine hesitancy among healthcare workers is an understudied concern and potentially contributes to vaccine hesitancy in the wider population. Our paper provides insights into how such vaccine hesitancy among healthcare workers translates into lower vaccination rates.

Experimental evidence on the effects of different forms of communication about vaccines on the vaccination decision is mixed. Brewer et al. (2017) show that presumptive announcements increased HPV vaccination coverage by 5.4 pp. in children but that in-depth conversations with parents had no effect. They also found no effect on other vaccine outcomes in adolescents. Nyhan et al. (2014) provide parents with different messages regarding the risk of vaccinations and the risk of diseases but found that none of these messages changed vaccination intentions. On the contrary, Horne et al. (2015) find that providing information about disease risk changed parents' vaccination intentions for their children. In contrast to these papers that study communication to increase vaccination rates, we implicitly study a setting where communication *decreases* vaccination rates. Our paper contributes to this debate as it studies a setting where messaging of GPs regarding vaccinations is likely negative and contrary to official guidelines. Thus, we provide evidence of what happens when official messages from health authorities and information from the personal GP do not reinforce but contradict each other.

More recently, several papers studied policies to increase COVID-19 vaccination rates. One of these policies is the introduction of vaccine passports required to enter certain public places, for example, restaurants. A policy that was also implemented in Austria. Gans (2021) provides theoretical arguments that the effects might be limited since they are mitigated in equilibrium by reductions in viral/disease prevalence that themselves reduce the demand for vaccination. Still, Karaivanov et al. (2022) find that the announcement of vaccine passports is associated with a rapid and significant surge in new vaccinations. Mills and Rüttenauer (2022) find that vaccine passports increase vaccination rates in countries with previously below-average vaccine uptake but had no effect in countries that already had average or above-average uptake. In a randomized experiment in Sweden, Campos-Mercade et al. (2021) find that a 24 USD cash incentive increased COVID-19 vaccination rates by about 4 p.p. early in the vaccination campaign.

Several papers studied the effect of the Ohio vaccination lottery and reached different conclusions. Lang et al. (2021) and Walkey et al. (2021) found no evidence that the lottery had a statistically significant impact on the percentage of adults fully vaccinated. In contrast, Brehm et al. (2022) and Barber and West (2022) find that Ohio's lottery increased the vaccination rate by 0.7 pp. at a cost of approximately 70 USD per person persuaded to vaccinate. These estimates serve as a useful benchmark for our findings as they highlight just how influential GPs are relative to other policies that aim at increasing vaccination rates.

We also contribute to the study of widely observed variations in medical resource usage (see, e.g., Skinner 2011; Chandra et al. 2011). A possible explanation are heterogeneities in the provision of care - often termed practice styles (see e.g. Finkelstein et al. 2016; Cutler et al. 2019. For Austria, Ahammer and Schober (2020) document substantial spending heterogeneities among GPs conditional on patient characteristics. Two characteristics are specific to our setting. First, GPs have no direct financial incentive to argue for or against vaccination. Second, by explicitly arguing against vaccination, GPs do not act within potential ambiguities in medical guidelines but explicitly contradict specific official guidelines.

The remainder of the paper is structured as follows. Section 2 provides more background on the Austrian vaccination campaign and the open letter. Section 3 introduces the data and shows descriptive results. Section 5 introduces the empirical strategy. Section 6 shows the results and Section 7 concludes.

2 Background

The Austrian Ministry of Social Affairs, Health, Care and Consumer Protection (subsequently Ministry of Health) developed a plan for the COVID-19 vaccination campaign, organized in three phases (Sozialministerium, 2021). The first phase prioritized healthcare personnel and the most vulnerable, i.e., nursing home residents. In the second phase, as gradually more vaccine doses became available, the group of eligible individuals was expanded. In the third phase, when vaccines were no longer scarce, eligibility was expanded to the entire adolescent and adult population. The vaccination campaign was implemented by the federal states that partly deviated from the national guidelines. Vaccines were provided by physicians, i.e., GPs, vaccination centers, and at vaccination events at large firms or other institutions.

Table 1 provides an overview of significant events in the Austrian COVID-19 vaccination cam-

Table 1: Significant events in the Austrian COVID-19 vaccination campaign

Date	Event
2020-12-27	first vaccinations in Austria
2021-01-11	first vaccinations by GPs
2021-03-11	rapid mass vaccination campaign in the district of Schwaz
2021-03-08	concerns about AstraZeneca vaccine following a death after vaccination
2021-03-15	Austria continues vaccinations with AstraZeneca
2021-05-07	vaccination is possible for everyone older than 30 years
2021-07-03	vaccination possible without prior registration (end of vaccine scarcity)
2021-11-08	restrictions for unvaccinated individuals (2G rule)
2021-11-19	announcement of vaccine mandate
2021-12-02	publication of Austrian Medical Association circular
2021-12-14	publication of open letter by vaccine-skeptic physicians

paign. The first vaccinations were administered at the end of December 2020, vaccinations by GPs started in the second week of January. Concerns about vaccine safety were publicly discussed in the second week of March after a death following vaccination with the vaccine from AstraZeneca. After a brief halt, Austria continued vaccinations with the vaccine from AstraZeneca. Starting in early July, vaccine supply became larger than demand and getting vaccinated was possible without registration or waiting time. In the fall, rising COVID-19 case numbers and still a large share of the population unvaccinated drove concerns about hospital capacity. In the second week of November, a lockdown for unvaccinated individuals started (vaccine passports), in the hope of incentivizing people to get vaccinated. On 2021-11-19, the Austrian government announced a vaccine mandate to further increase pressure on unvaccinated individuals. However, together with other German-speaking countries, Austria remained among the countries with the lowest vaccination rates in Western Europe (Stamm et al., 2022). The vaccine mandate was never enforced and eventually abrogated in June 2022.[4]

2.1 The open letter

On 2021-12-02, the president of the Austrian Medical Association (AMA), Thomas Szekeres, sent a short circular to colleagues regarding COVID-19 vaccinations. It states that - based on the latest scientific evidence - there is no reason to advise against COVID-19 vaccination. Only in cases of

[4]Vaccine mandates have been studied in other contexts, see for example Lawler (2017) and Abrevaya and Mulligan (2011).

medically proven exceptions, such as allergies, may physicians advise against vaccination. Physicians deviating from the official guidelines may be sanctioned by the AMA.[5]

On 2021-12-14, 199 physicians from across Austria responded with an open letter to the AMA. In this open letter, the physicians contradict the recommendations and views of the AMA and provide arguments against the vaccination. The letter argues that the evidence on the safety and efficacy of the approved vaccines is ambiguous. It also states that the number of reported side effects is *"frightening"* and that the AMA, as well as media and politics, are engaged in *"unscientific propaganda"* by declaring the vaccines safe.[6] The largest number of physicians by specialization were GPs (110), followed by dentists (15), and psychiatrists (14).

For our purpose, the letter does not serve as a treatment in itself. Instead, we use the signatures on this letter as an indicator to identify vaccine-skeptic physicians. Thus, we don't seek to evaluate the effects of the letter but hypothesize that the physicians who signed the letter have influenced their patients already before. Such influence might operate through communicating a general vaccine skepticism or skepticism specifically towards the COVID-19 vaccines. They might also not at all or to a lesser extent vaccinate patients themselves, which would make it harder for their patients to get vaccinated.

Signing the open letter was just the most visible signal of opposition to the COVID-19 vaccination campaign. Among GPs who did not sign the letter, there is certainly a wide range of views regarding the COVID-19 vaccination campaign. By comparing GPs who are decidedly skeptical with all other GPs, we necessarily conceal this heterogeneity. The results of this paper should therefore not be taken as the overall effect of GPs on vaccination coverage but rather as a lower bound of this effect.

3 Data

Our analysis builds on municipality-level data from Austria. We exclude municipalities without a GP, as these municipalities might be generally more deprived of healthcare services (453 municipalities). Further, we restrict the sample to municipalities with at most 10,000 inhabitants and at most

[5] The German version of the circular is available here: `https://tinyurl.com/5bfev63n`. Accessed on 2022-06-29.

[6] The German version of the open letter is available here: `https://www.experts4evidence.com`. Accessed on 2022-06-29.

10 GPs (131). In these smaller municipalities, the choice of the GP is to a greater extent driven by geographic proximity. We assess the sensitivity of the results to these choices in the robustness section. Overall, this leaves us with a sample of 1,533 municipalities, out of which 54 have at least one vaccine-skeptic GP.

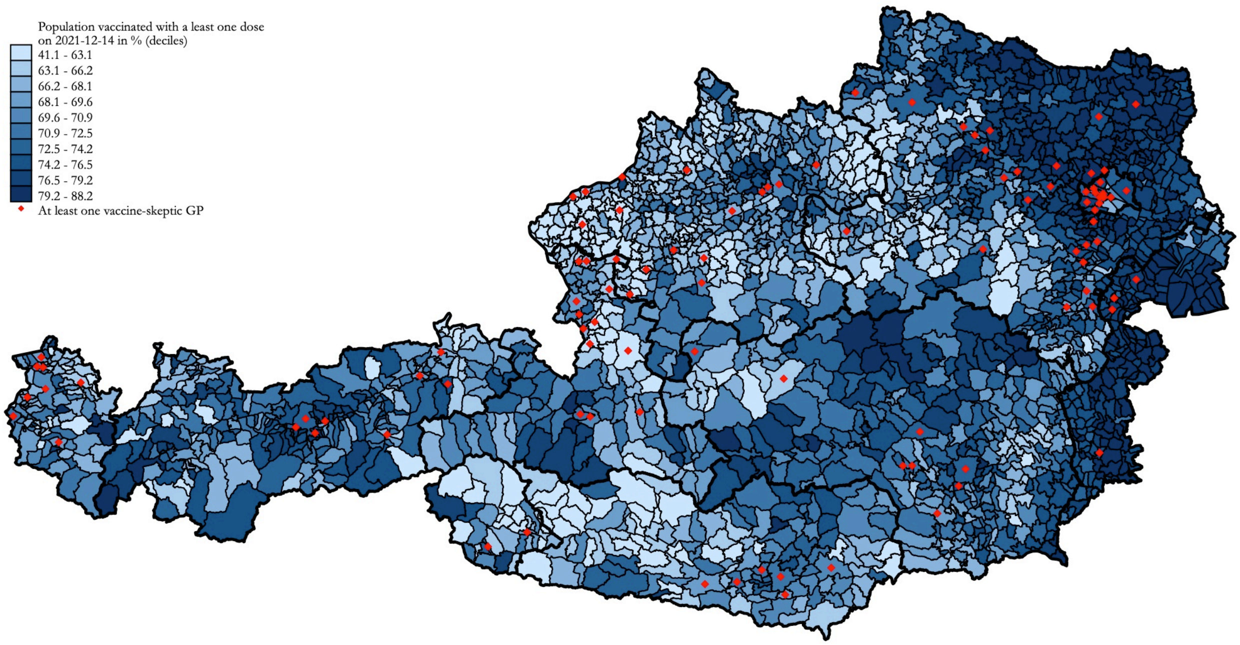
Austria has a digital vaccination register that contains information on all COVID-19 vaccine doses administered. For our purposes, we use information on the number of COVID-19 vaccinations among all individuals with their main residence in a municipality on a daily basis. The Ministry of Health provided data from the central vaccination register on the number of individuals per municipality that received at least one, at least two or three shots of COVID-19 vaccines.

For the daily number of reported COVID-19 infections and deaths, we use data from the Austrian epidemiological reporting system (Österreichisches Epidemiologisches Meldesystem, EMS). These data were provided by the Austrian National Public Health Institute (Gesundheit Österreich GmbH, GÖG). These data also allows us to count the number of infections and deaths among all residents in a municipality. Austria established one of the most extensive COVID-19 testing regimes in the world, with more than 123 million tests in 2021, which equals about 14 registered tests per inhabitant (Mathieu et al., 2020).

The open letter listed the names, fields of specialization, and municipalities of the offices of the signing physicians. From this, we coded the number of signatories per municipality by field of specialization. We distinguish between GPs and other physicians. In case of ambiguities, we conducted an online search to confirm the coding. Additionally, the AMA provided information on the overall number of GPs in each municipality (reference date 2021-12-31) that allows us to calculate the share of vaccine-skeptic GPs.

We use information from Statistics Austria on the age and sex composition of the population, average salaries of full-time employees, average pensions, the highest educational degree of the working-age population, the share of foreign-born citizens, and a detailed classification of how urban or rural a municipality is. We also use data on voting behavior in the parliamentary elections in 2019 and the presidential elections in 2022. The Freedom Party made vaccine-skepticism central to their platform. In February 2021, the party *MFG Austria* was founded and ran almost exclusively on an anti-vaccination platform. We use support for these parties as proxies for vaccine-skepticism in the population.

Figure 1: Municipality vaccination rates and distribution of vaccine-skeptic GPs



Note: The map shows the share of the population that received at least one dose of any COVID-19 vaccine until 2021-12-14. The map also depicts municipalities where at least one GP signed the open letter.

We construct an indicator of whether a vaccination center is in the respective municipality or a neighboring municipality. As another proxy for vaccine-skepticism in the population, we create an indicator of whether a Waldorf school or kindergarten is in the respective municipality or a neighboring municipality.[7] Waldorf institutions and the anthroposophic movement have been among the most vaccine-skeptic groups in the German-speaking area and might thus be closely tight to vaccine-skepticism in the respective municipalities.[8] Information on the location of Waldorf schools and kindergartens stems from the Waldorf World List 2021.

Figure 1 shows vaccination rates (at least one dose) in Austrian municipalities on the day the open letter was published (2021-12-14) and indicates municipalities where at least one GP signed the open letter. We provide descriptive statistics for all variables in Table B.1 in Appendix B.

[7] Vaccine centers and Waldorf institutions are mostly in larger and medium towns. Thus, very few of these institutions are in the rather small municipalities in our sample. Thus, we create this indicator to also include neighboring municipalities as a measure of the closeness to these institutions in the municipalities in our sample.

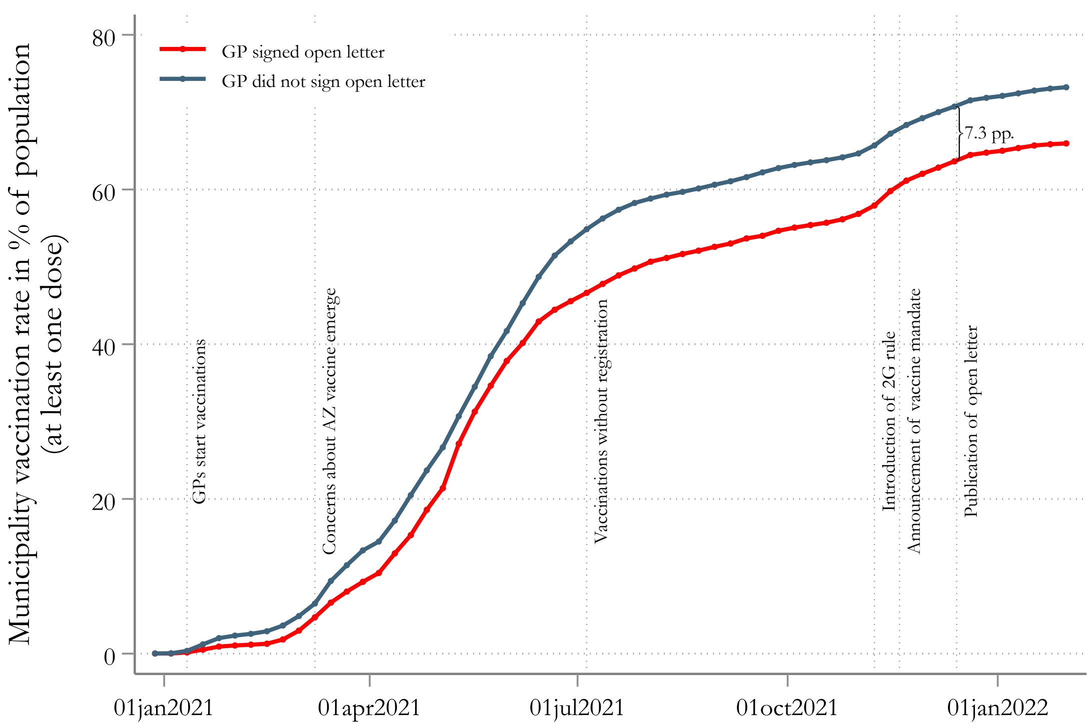
[8] See for example this article in *Der Spiegel* from 2021-11-15: `https://www.spiegel.de/kultur/waldorfschule-und-impfgegner-in-steiners-sekte-a-8242889d-190f-479f-bf6d-a22ccab54013`.

4 Descriptive evidence

First, we investigate the vaccination rate in municipalities with one GP. In these municipalities, we observe the best match between the GP and the population she caters to. Figure 2 shows the vaccination rate, measured as the share of the population that received at least one dose, over time. We distinguish between municipalities where the GP signed the open letter ($N = 6$) or did not ($N = 702$).

As soon as the vaccination campaign by GPs started in the first half of January, municipalities with a vaccine-skeptic GP fell behind in their vaccination rate. The majority of first shots were given between March and June 2021. During this period, the gap widened and reached about 7 pp. in early July. While the vaccination rate increased further, albeit more slowly, until the end of the year, the gap remained relatively stable and was 7.3 pp. at the time of the publication of the open letter on 2021-12-14.

Figure 2: Municipality vaccination rate with and without vaccine-skeptic GP



Note: The figure shows the mean share of individuals who received at least one dose of a COVID-19 vaccination in municipalities where the general practitioner signed to open letter / did not sign the open letter. The sample is restricted to municipalities with one general practitioner. Municipalities are weighted by population size.

These statistics hint at a strong association between the presence of vaccine-skeptic GPs and the vaccination rate. However, the number of *treated* municipalities in this comparison is small and the association might be the result of sorting or confounding. Thus, in the next section, we discuss an empirical approach to address these shortcomings.

5 Empirical strategy

The structural model of interest seeks to explain the effect of having a vaccine-skeptic GP w_k on the binary vaccination decision y_{ik} of the GPs patients, where subscript i refers to patients and subscript k to GPs. The following linear probability model exemplifies this relationship:

$$P(y_{ik} = 1) = \alpha_0 + \alpha_1 w_k, \tag{1}$$

In the absence of individual-level data, we aggregate the model to the municipality level

$$\bar{y}_m = \gamma_0 + \gamma_1 \bar{w}_m + \bar{u}_m, \tag{2}$$

where $\bar{y}_m$ is the vaccination rate in municipality m and $\bar{w}_m$ is the share of vaccine-skeptic GPs among all GPs in municipality m. In Appendix A, we argue that under certain plausible assumptions, the coefficient γ_1 from the municipality-level model has the same interpretation as α_1, the coefficient from the individual-level model. Using this model, we can extend the analysis to municipalities with more than one GP, thereby increasing our sample size.

Two types of sorting might create endogeneity problems and challenge a causal interpretation of the coefficients. First, patients might choose a GP aligned with their own views of vaccines. In the small municipalities in our sample, sorting is less likely to occur as the number of GPs in these municipalities is small (mean= 2.31) and the match between GP and patients is mostly due to geographic proximity. However, if it occurs, this type of sorting would create problems akin to a non-compliance problem in experimental studies and as a consequence, γ_1 can only be interpreted as an intention-to-treat effect (ITT). Thus, γ_1 would be a lower bound for α_1. Since this type of sorting is least likely in municipalities with a single GP, we would expect larger estimates in these municipalities, which is indeed the case (see Table B.2).

Second, vaccine-skeptic GPs might locate their doctor's office in municipalities where the population holds similar views or where other structural parameters relevant to the vaccination rate are different. For example, if vaccine-skeptic GPs locate more often in municipalities with a younger population that has a lower vaccination rate. To address these type of sorting concerns, we pursue a selection-on-observable approach. We condition on a set of municipality characteristics that are known to relate to the vaccination rate and attitudes toward vaccinations and that thus might confound the analysis.

To account for the staggered rollout of the vaccination campaign by age, we condition on 15-year age groups. To account for socioeconomic status, which might be related to access and attitudes towards vaccines, we control for the average salary income of full-time workers and the average pension income. In addition, we also control for the share of the working-age population with a) at most secondary education, b) a high-school degree (*Matura*) and c) a university degree. Attitudes towards vaccines vary by political party preference (Partheymüller et al., 2021). Thus, we condition on the Freedom Party vote share in the 2019 parliamentary elections as the Freedom Party publicly supported very vaccine-skeptic positions. Further, we condition on the existence of a Waldorf school or kindergarten in the municipality or a neighboring municipality. In a robustness check, we also condition on the vote share of the candidate of the MFG Austria party in presidential elections 2022. MFG was founded in February 2021 and positioned itself primarily as an anti-vaccination party. Thus, voting for the MFG likely is a particularly good indicator of a vaccine-skeptic attitude. However, since the party did not run in any national elections before the start of the vaccine campaign, we only have vote shares for the presidential elections in 2022, which might themselves be influenced by vaccination rates. For the possibility of this being a bad control, we abstain from including it in the main specification.

To account for differences between more or less rural areas, we control for the number of inhabitants in a quadratic fashion. We include an indicator for the district Schwaz, where a rapid mass vaccination campaign was conducted in March 2021 after an outbreak of the Beta variant of the coronavirus (Paetzold et al., 2022). To account for the (time-)cost of getting vaccinated, we include an indicator of whether a vaccination center is nearby, i.e., in the respective or a neighboring municipality. We include state fixed effects to account for differences in how federal states organized the vaccination campaign.

Finally, we include controls for the number of reported COVID-19 infections among inhabitants in the municipality (as % of the municipality's population) and the number of COVID-19 deaths that occurred before the start of the vaccination campaign. The share of the population with a pre-treatment infection is included to account for potential differences in immunity levels. The number of deaths is included as it might affect how people perceive the risk of a COVID-19 infection.

We perform a set of robustness checks and conduct the bias-adjustment exercise proposed by Oster (2019). Overall, we find very little evidence of sorting and unconditional estimates are almost identical to those from a specification with a rich set of controls.

6 Results

Table 2 shows the effect of the share of vaccine-skeptic GPs in the municipality on the vaccination rate on the day the open letter was published (2021-12-14). Columns (1) to (3) show the effect on the share of the population that received at least one dose. The unconditional estimate of the effect of increasing the share of vaccine-skeptic GPs from zero to one is -5.76 pp. This estimate is hardly influenced by the inclusion of the highly predictive municipal covariates (column 2), state fixed effects (column 3), and prior COVID-19 infections and deaths (column 4). Our main estimate in column (4) suggests that increasing the share of vaccine-skeptic GPs from zero to one decreases the vaccination rate by 5.60 pp. Columns (5) and (6) show the effects on the population share with at least two (-5.99 pp.) and three doses (-5.44 pp.) respectively.

In addition to the coefficient for the share of vaccine-skeptic GPs, we show the coefficients for variables that are directly related to the cost of vaccination (vaccination center nearby) or attitudes towards vaccines (Share of Freedom Party votes and Waldorf school or kindergarten nearby). The coefficients for these variables have the expected signs. Municipalities with a vaccination center nearby have a 0.58 pp. higher vaccination rate while municipalities with a Waldorf institution have a 0.65 pp. lower vaccination rate. A one pp. higher Freedom Party vote share is associated with a 0.2 pp. lower vaccination rate. However, these coefficients should not be interpreted causally. The share of the population with a prior infection is unrelated to the vaccination rate while the number of prior COVID-19 deaths in the municipality is associated with a higher vaccination rate. The full set of coefficients is shown in Table B.3 in Appendix B.

Table 2: Effect of vaccine-skeptic GPs on COVID-19 vaccination rate

	Percent of population with (at least) ...					
	1^{st} dose				2^{nd} dose	3^{rd} dose
	(1)	(2)	(3)	(4)	(5)	(6)
Share vaccine-skeptic GPs	-5.76*** (1.82)	-5.80*** (1.33)	-5.76*** (1.22)	-5.60*** (1.22)	-5.99*** (1.29)	-5.44*** (1.29)
Vaccination center near (0/1)		0.58*** (0.22)	0.58*** (0.21)	0.58*** (0.21)	0.76*** (0.22)	0.59*** (0.21)
Waldorf school or KiGa near (0/1)		-0.72** (0.31)	-0.75*** (0.27)	-0.65** (0.28)	-0.76*** (0.29)	-0.67** (0.32)
Share votes Freedom Party (2019)		-0.30*** (0.029)	-0.20*** (0.029)	-0.20*** (0.028)	-0.21*** (0.030)	-0.14*** (0.027)
Share pop. pre-treatment infection				-0.023 (0.088)	-0.14 (0.094)	-0.11 (0.090)
Pre-treatment deaths				0.093*** (0.035)	0.11*** (0.039)	0.10*** (0.033)
Municipality characteristics		yes	yes	yes	yes	yes
State FE			yes	yes	yes	yes
Mean dep. var.	71.5	71.5	71.5	71.5	64.8	32.5
Mean dep. var. sample	71.1	71.1	71.1	71.1	64.9	32.7
Adjusted R2	0.01	0.58	0.63	0.63	0.65	0.71
Observations	1533	1533	1533	1533	1533	1533

Note: The table show coefficients from a regression of the share of the population (in percent) receiving at least one dose (columns 1-4), at least two doses (column 5), three doses (column 6) of a COVID-19 vaccine on the share of GPs who signed the open letter among all GPs in the municipality. Vaccination data from 2021-12-14 - the day the open letter was published. Not shown control variables for municipality characteristics include the number of inhabitants (squared), share of the population aged 0-14 years, 15-29 years, 45-59 years, 60-74 years, and 75 years and older, the share of foreign citizens, the share with at most secondary education, the share with high school degree (Matura) and the share with a university degree (among the 25-64 year-old-population), and an indicator for the district Schwaz. The sample is restricted to municipalities with a maximum population size of 10.000 and at least one and at most 10 GPs. *Mean dep. var.* is the mean of the dependent variable in all Austrian municipalities, *Mean dep. var. sample* only in municipalities in the estimation sample. Observations are weighted by number of inhabitants. Values in () are robust standard errors. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. The full list of coefficients from the baseline specification in column (4) is provided in Table B.3 in Appendix B.

6.1 Persuasion

Next, we provide an estimate of the share of individuals that changed their behavior, i.e., did not get vaccinated, as a result of having a vaccine-skeptic GP exposure among those that would have potentially gotten vaccinated. Following DellaVigna and Kaplan (2007) and DellaVigna and Gentzkow (2010) we construct a persuasion rate f that is

$$f = \frac{-\gamma_1}{\Delta e * p_{vac}}, \tag{3}$$

where $-\gamma_1$ is the estimated treatment effect in pp. (see Equation 2) with a reversed sign, Δe is the difference in exposure to a vaccine-skeptic GP by share of vaccine-skeptic GPs. By definition, this takes the value of one. p_{vac} is the share of vaccinated individuals in the absence of a vaccine-skeptic GP.

This persuasion rate captures the effect on *not* getting vaccinated ($-\gamma_1$), adjusted for the share of individuals exposed to a vaccine-skeptic GP, Δe, and for the size of the population that could potentially be convinced to get vaccinated (p_{vac}).

We use the mean vaccination rate in municipalities without a vaccine-skeptic GP as an estimate for the persuadable population $p_{vac} = 71.1\%$. Using $\gamma_1 = -5.6$ from column (4) in Table 2, the estimated persuasion rate f is thus 7.9. In other words, 7.9% of individuals potentially willing to get vaccinated did not do so due to exposure to a vaccine-skeptic GP.

How many people do not get vaccinated because of a vaccine-skeptic GP in absolute numbers? The number of inhabitants per GP in the sample is 1,140. Back-of-the-envelope calculation implies that a vaccine-skeptic GP discouraged on average $0.056 * 1,140 = 64$ individuals from getting vaccinated.

6.2 Effect over time, effect heterogeneity and potential mechanisms

To obtain a better understanding of potential mechanisms at work, we investigate a) how the effect evolves over time and b) effect heterogeneity by municipality characteristics.

Figure 3 shows how the effect of vaccine-skeptic GPs on the cumulative municipality vaccination rate evolved. We estimate the model as in column (3) of Table 2 in a panel for every time period on a weekly basis, by including date indicators and interacting these date indicators with all covariates.

The figure shows that the effect accumulated already during the time when vaccines were still scarce in the first half of 2021. By July, when vaccine scarcity was resolved, the reduction in the vaccination rate was about 6.5 pp. and remained relatively stable thereafter.

This pattern allows for some discrimination between mechanisms. One potential mechanism could be rationing. Vaccine-skeptic GPs might not provide any or fewer vaccine doses to vaccinate their patients. These patients in turn would have to wait longer until it is their turn to receive the vaccine as they had to wait for a slot at a vaccination center. This mechanism would primarily delay the vaccination of these patients, and we should see a catching up once vaccines become more readily available, which is not the case. This pattern is consistent with anecdotal evidence that GPs did not administer many vaccinations themselves but primarily served as information providers.

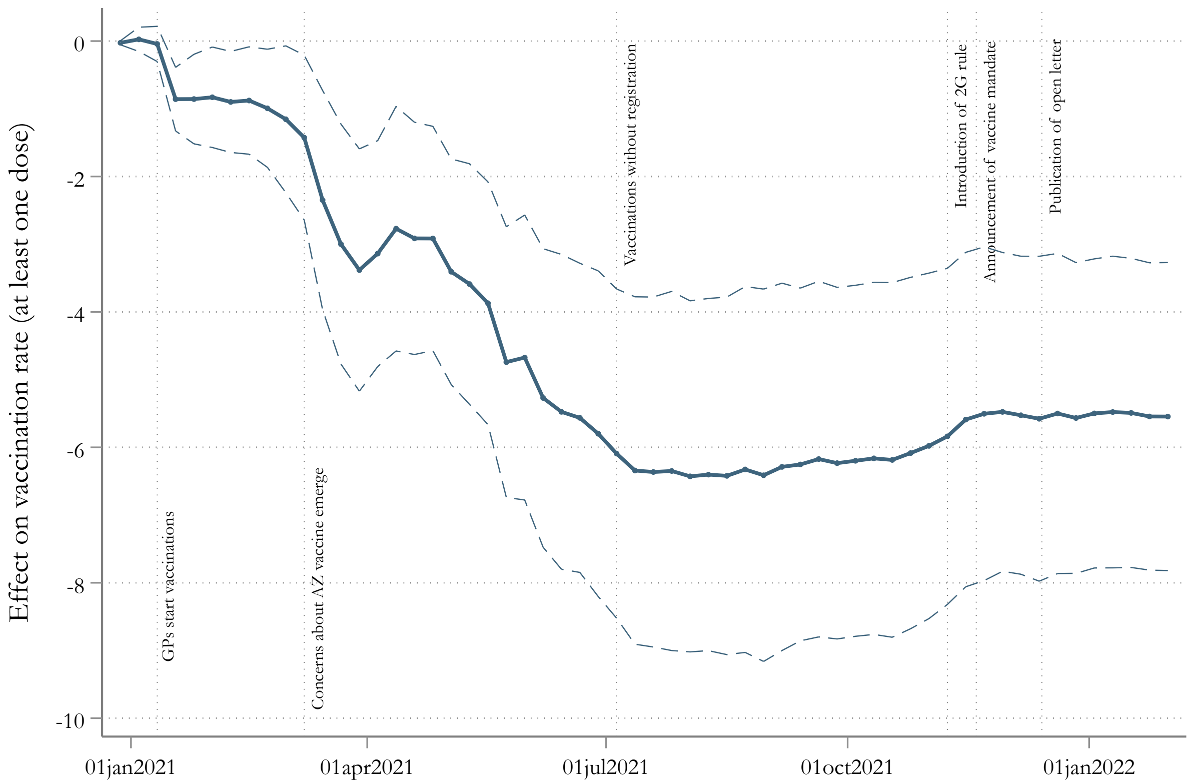
A second potential mechanism would be that vaccine-skeptic GPs do not encourage vaccine-skeptic patients to get vaccinated. This mechanism implies that the effect is zero while the number of individuals willing to get vaccinated is still larger than the number of available vaccine doses. It would only appear once those willing anyway got vaccinated and physicians have to make an effort to convince further patients. The observed pattern is also not consistent with this mechanism.

A third mechanism would be that GPs discourage individuals actively from getting vaccinated. This could be specific to the COVID-19 vaccines or GPs could have created a general vaccine-skeptic environment resulting in a lower take-up. The observed pattern is most consistent with this explanation, where a gap opens up already at the start of the vaccination campaign and then remains almost constant.

The figure also highlights several important dates. The first effect appears when GPs start vaccinating in the second week of January. In the second week of March, concerns about the safety of the vaccine from AstraZeneca emerged. The subsequent strong widening of the gap suggests that vaccine-skeptic GPs and their patients reacted strongly to these concerns. We see that the GAP is mostly stable between early July and the end of the observation period, with a slight narrowing in early November when a debate regarding restrictions for unvaccinated individuals started.

Table B.2 in Appendix B studies effect heterogeneity. Columns (1) and (2) compare the effect in municipalities with just one (1) or more than one GP (2). We expect the influence of the GP to be stronger if there is just one GP in the municipality. Indeed, the estimated effect is larger (-7.24 pp.) in municipalities with just one GP than in municipalities with multiple GPs (-4.71 pp.). Columns

Figure 3: Effect of vaccine-skeptic GPs on COVID-19 vaccination rate over time



Notes: The figure shows the coefficients from a regression of the cumulative vaccination rate (at least one dose) as of Monday of every week on the share of vaccine-skeptic GPs in a municipality. We interact the share of vaccine-skeptic GPs with date indicators to obtain the effect over time. Control variables are the same as in the full specification in column (3) of Table 2. All covariates are also interacted with date indicators. Observations are weighted by population size. 95%-confidence intervals are based on robust standard errors clustered at the municipality level.

(3) and (4) show effect heterogeneity between municipalities having a vaccination center near or not. This heterogeneity allows us again to infer more about the potential mechanism at work. In the case of rationing, we expect the effect to be stronger in municipalities with no vaccination center near. In case of discouragement, we would expect no difference in the effect between municipalities with centers near and fear. The effect is *larger* in municipalities with a vaccination center near (-5.94 pp.) than in those without (-3.93 pp.). However, the difference is not significant. In any case, this is further evidence in support of the discouragement mechanisms and against rationing.

6.3 Potential bias and robustness

With some additional assumptions, we can use the estimates in Tables 2 to gauge not only the importance of the observables, but also of the unobservables, as potential sources of bias to our estimated effect of vaccine-skeptic GPs. Altonji et al. (2005) and Oster (2019) provide conditions under which one can bound the omitted variable bias stemming from unobservables on the basis of how much the coefficient of interest changes when one adds additional observable regressors X_m to the model. Oster (2019) provides a bias adjustment that yields a consistent estimator under three conditions. These are: (i) the ratios of the coefficients on the variables in X_m are equal to the ratios of the coefficients on the variables in X_m in a regression of $\bar{w}_m$ on X_m; (ii) selection on observables is equal to selection on unobservables; and (iii) the maximum R-squared, denoted R^2_{max}, is known, where the R^2_{max} is the R-squared that would result if one could control for all observables and unobservables.

Of course, a limitation of this approach is that the first two assumptions are untestable and the third is unlikely to hold. Nonetheless, under certain conditions, the bias adjustment below may provide a useful, if rough, gauge of the extent to which the estimates in Tables 2 may be biased due to omitted variables. Although Oster (2019) notes that condition (i) is guaranteed only in the case of a single unobserved regressor, she argues that limited departures from this condition may leave her bias adjustment procedure approximately valid. Altonji et al. (2005) argue that assumption (ii) may be justified if researchers seek to measure and control for the most important variables, that is, the variables that could cause the greatest bias. If so, then selection on observables may actually be more important than selection on unobservables. Finally, replacing the unknown R^2_{max} with its upper bound over-adjusts for bias.

A consistent, bias-adjusted estimate of γ in Equation 2, under these assumptions, is given by

$$\gamma^* = \hat{\gamma} - [\hat{\gamma}_c - \hat{\gamma}][\frac{R^2_{max} - R^2}{R^2 - R^2_c}] \tag{4}$$

where $\hat{\gamma}$ is the estimate from a regression that includes all observable regressors; $\hat{\gamma}_c$ is the estimate from a constrained regression that includes only a subset of the observables; and R^2 and R^2_c are the R-squared statistics from the corresponding regressions.

We take $\hat{\gamma}_c$ from column (1) and $\hat{\gamma}$ from column (4) of Table 2. Since R^2_{max} is unknown, we set it equal to one. The resulting bias-adjusted estimate is $\alpha^* = -5.51$ and thus similar in magnitude as the unadjusted estimate $\hat{\gamma}$.

Table B.3 in the appendix provides the results from a set of further robustness exercises. Column (1) provides the full set of covariates from the baseline specification as in Table 2, column (4). In column (2), we additional add the vote share of the candidate of the anti-vaccination party MFG in presidential elections 2022.[9] This covariate is highly significant and has substantial explanatory power, increasing the adjusted R2 from 0.63 to 0.67. However, its inclusion hardly changes the coefficient of vaccine-skeptic GPs. Column (3) shows the same specification as column (1) but replaces the 15-year age groups with more narrow 5-year age groups to account in a more detailed fashion for demographic differences. Column (4) shows the same specification as the baseline but includes municipalities with more than 10.000 inhabitants or more than 10 GPs. Column (5) replicates the baseline specification without population weights. Column (6) excludes municipalities in the district of Schwaz. Column (7) uses the share of vaccine-skeptic physicians among all physicians instead of the share of vaccine-skeptic GPs. Results remain relatively stable across all these specifications and estimates range from -4.64 to -5.63.

7 Conclusion

We show that vaccine-skeptic GPs played a significant role in discouraging their patients from getting vaccinated against COVID-19. Patients of GPs that voiced their opposition against the vaccines in an open letter are about 5.6 pp. less likely to be vaccinated against COVID-19. This amounts to a persuasion rate of 7.9 percent. In absolute numbers, we calculate that every one of these vaccine-skeptic GPs discouraged about 64 individuals from getting vaccinated.

We focus on rural Austria and exploit the fact that the match between GPs and their patients is mostly due to geographic proximity. Indeed, we find no evidence of systematic sorting of GPs into municipalities, supporting the idea that the observed relationship is causal.

Exploratory analysis of the mechanisms suggests that these GPs discouraged their patients from getting vaccinated instead of just rationing access to the vaccine.

[9] As the presidential election took place only on 2022-9-10, we cannot rule out that support for the MFG candidate is itself a function of the vaccination rate. Thus, we abstained from including this covariate in our main specification and referred it to a robustness check instead.

In the episode under study, signing the open letter was just the most visible signal of opposition to the COVID-19 vaccination campaign. Among GPs who did not sign the letter, there is certainly a wide range of views regarding the COVID-19 vaccination campaign. This study compares GPs who are decidedly skeptical with all other GPs and therefore conceals this heterogeneity. The results of this paper should therefore not be taken as the overall effect of GPs on vaccination coverage but rather as a lower bound of this effect.

More generally, this paper highlights the role of GPs in implementing public health policies. GPs who do not support the goals of the health authorities have a significant detrimental impact on the achievement of these goals.

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Appendix

A Relating the individual- to the municipality-level model

Consider the following linear probability model that describes the effect of having a vaccine-skeptic GP w_{km} on the vaccinations decision y_{ikm} of patient i of GP k in municipality m:

$$P(y_{ikm} = 1|w_{km}) = \alpha_0 + \alpha_1 w_k, \tag{A.1}$$

As $P(y_{ikm} = 1|w_{km}) = E(y_{ikm} = 1|w_{km})$, this yields the linear model $y_{ikm} = \alpha_0 + \alpha_1 w_{km} + u_{ikm}$. For a given number of patients per GP, N_{km}, we can average this individual-level model over the N_{km} individuals in the group:

$$\frac{1}{N_{km}} \sum y_{ikm} = \gamma_0 + \gamma_1 w_{km} + \frac{1}{N_{km}} \sum u_{ikm}, \tag{A.2}$$

To conduct the analysis at the municipality level, we further assume that patients only visit GPs in their municipality, do not sort on vaccine preferences, and are equally split by the GPs in a municipality. We will discuss the consequences of violations of these assumptions below. The total number of patients in the municipality is $N_m = K_m * N_{km}$. This allows us to further average the model at the municipality level:

$$\begin{aligned} \frac{1}{N_m} \sum y_{ikm} &= \gamma_0 + \gamma_1 \frac{1}{K_m} \sum w_{km} + \frac{1}{N_m} \sum u_{ikm}, \\ \bar{y}_m &= \gamma_0 + \gamma_1 \bar{w}_m + \bar{u}_m, \end{aligned} \tag{A.3}$$

The coefficient γ_1 from a regression of the municipality vaccination rate on the share of vaccine-skeptic GPs (Equation A.3) can be interpreted as the effect of having a vaccine-skeptic GP on an individual's probability to get vaccinated. Next, we discuss potential violations of the assumptions required for this interpretation.

First, vaccine-skeptic GPs could disproportionally locate in municipalities where the population is less willing to get vaccinated. This would introduce a negative correlation between $\bar{w}_m$ and $\bar{u}_m$ and negatively bias the estimate, i.e., we would overestimate the magnitude of the effect. We address this concern by introducing a rich set of potential confounding factors and show that no evidence of selection of this type exists (see Section 6.3).

Second, patients could choose a GP aligned with their views on vaccines. In the extreme scenario, that patients anyway unwilling to get vaccinated choose a vaccine-skeptic GP and those willing to get vaccinated choose a non-skeptic GP, GPs would have no influence on their patients' vaccination decisions. This type of sorting is akin to non-compliance problems in experiments. As a consequence, γ_1 can only be interpreted as an intention-to-treat effect (ITT) that can be considered a lower bound for the magnitude of α_1. Since this type of sorting is least likely in municipalities with a single GP, we would expect larger estimates in these municipalities, which is indeed the case (see Table B.2).

Third, patients might not be evenly distributed among GPs in a municipality. If vaccine-skeptic GPs have a lower (higher) share of patients than $\frac{1}{K_m}$, we would overestimate (underestimate) the share of the population exposed to a vaccine-skeptic GP. As a consequence, γ_1 can be considered a lower (upper) bound for the magnitude of α_1. Given that most GPs have a contract with the public health insurance, we have no reason to expect large deviations from $\frac{1}{K_m}$. Again, this is of least concern in municipalities with just one GP, where we in fact see larger estimates (see Table B.2).

Fourth, we assume that GPs only influence their own patients, i.e., the individuals who consider them their "family doctor". But these GPs might have a larger influence also on non-patients, for example by interactions with individuals other than their patients or spillover effects. If these influences happen within municipalities, we would again underestimate the population exposed to a vaccine-skeptic GP and γ_1 can be considered an upper bound for the magnitude of α_1. Within-municipality influences would imply that the effect is smaller in municipalities with just one GP, where we in fact see larger estimates (see Table B.2). If these influences happen across municipalities, they would introduce control group contamination and thus bias our estimates towards zero and we would obtain a lower bound for the magnitude.

Taken together, we consider γ_1 a good proxy for α_1. If anything, the potential concerns discussed above would imply that γ_1 has to be considered a lower bound for the magnitude of α_1.

B Further tables

Table B.1: Summary statistics

	Mean	S.D.	Minimum	Maximum
Share pop. with 1^{st} dose	71.3	6.0	44.0	85.9
Share pop. with 2^{nd} dose	65.2	6.5	35.4	80.8
Share pop. with 3^{rd} dose	32.9	6.7	12.5	58.5
Number of GPs	2.31	1.8	1	10
Share vaccine-skeptic GPs (in %)	1.35	8.7	0	100
Vaccination center near (0/1)	0.31	0.5	0	1
Number of inhabitants (in thousands)	2.64	1.7	0.33	9.85
Share pop. female	50.2	1.2	40.0	55.3
Share pop. below 15 years	14.5	2.0	5.88	22.8
Share pop. 15-29 years	15.5	1.9	8.59	23.0
Share pop. 30-44 years	18.7	1.9	10.3	26.5
Share pop. 45-59 years	23.5	1.6	16.3	31.5
Share pop. 60-74 years	17.8	2.5	10.9	27.6
Share pop. 75 years and older	9.89	2.2	4.73	23.8
Share pop. lower secondary edu.	14.4	4.2	5.26	38.4
Share pop. high school	14.1	3.4	6.13	28.6
Share pop. university	12.3	5.2	2.47	43.0
Share pop. foreign born	8.48	5.7	0.62	51.0
Average salaries (in 1.000 EUR)	41.7	4.2	33.6	76.5
Average pension (in 1.000 EUR)	24.9	3.0	13.9	40.1
Waldorf school or KiGa near (0/1)	0.091	0.3	0	1
Share votes Freedom Party (2019)	18.3	4.8	4.20	41.9
Share votes MFG candidate (2022)	2.28	0.9	0	6.23
Share pop. pre-treatment infection	3.86	1.6	0.47	10.8
Pre-treatment deaths	2.16	3.5	0	39
Observations	1533	.	.	.

Notes: The table show descriptive statistics for outcomes, treatments and covariates of municipalities in the estimation sample. The estimation sample comprises all municipalities with a population size of at most 10.000 and at least one GP but no more than 10 GPs. Vaccination rates refer to the situation on 2021-12-14 - the day the open letter was published. *Share vaccine-skeptic GPs (in %)* is the share of GPs who signed the open letter among all GPs in the municipality. Demographic variables refer to the situation on 2021-01-01. Income and pension data are for the calendar year 2019. The share of Freedom Party votes is from the parliamentary election of 2019. Municipalities with a Waldorf school or kindergarten are identified from the Waldorf world list 2021. The variables *Vaccination center near* and Waldorf school or KiGa near take the value of one if such a facility is in the respective municipality or a neighboring municipality.

Table B.2: Effect heterogeneity

	Number of GPs		Vaccination center	
	(1) one GP	(2) more than one	(3) near	(4) far
Share vaccine-skeptic GPs	-7.24*** (1.42)	-4.71*** (1.66)	-5.94*** (1.28)	-3.93** (1.99)
Municipality characteristics	yes	yes	yes	yes
State FE	yes	yes	yes	yes
Adjusted R2	0.59	0.65	0.62	0.64
Observations	708	825	472	1061

Notes: The table shows coefficients from a regression with the share of the population (in percent) receiving at least one dose as the dependent variable. Vaccination data from 2021-12-14 - the day the open letter was published. Covariates as in Column (3) of Table 2. Values in () are robust standard errors. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table B.3: Robustness table

	(1) Baseline	(2) Antivax voting	(3) Detailed age	(4) No population restriction	(5) Unweighted	(6) Excluding Schwaz	(7) All doctors
Share vaccine-skeptic GPs	-5.60***	-5.47***	-5.47***	-5.34***	-4.64***	-5.63***	
	(1.22)	(1.14)	(1.24)	(1.22)	(1.19)	(1.22)	
Share vaccine-skeptic physicians							-4.89***
							(0.78)
Number of inhabitants (in thousands)	-0.083	0.032	-0.10*	-0.023*	-0.24	-0.080	-0.079
	(0.20)	(0.19)	(0.062)	(0.012)	(0.20)	(0.20)	(0.20)
Number of inhabitants (squared)	-0.0038	-0.012		0.000038	0.0077	-0.0038	-0.0047
	(0.019)	(0.018)		(0.000025)	(0.021)	(0.019)	(0.019)
Share pop. female	0.27***	0.24**	0.27***	0.065	0.33***	0.26**	0.26**
	(0.10)	(0.096)	(0.10)	(0.11)	(0.12)	(0.10)	(0.10)
Share pop. below 15 years	-0.97***	-0.88***		-1.06***	-0.85***	-0.98***	-0.98***
	(0.13)	(0.13)		(0.13)	(0.14)	(0.13)	(0.13)
Share pop. 15-29 years	-0.47***	-0.43***		-0.32***	-0.31***	-0.47***	-0.47***
	(0.12)	(0.11)		(0.11)	(0.12)	(0.12)	(0.12)
Share pop. 45-59 years	0.21**	0.21**		0.15	0.15	0.21**	0.21**
	(0.096)	(0.092)		(0.091)	(0.098)	(0.097)	(0.096)
Share pop. 60-74 years	0.047	0.087		0.017	0.19*	0.051	0.045
	(0.10)	(0.095)		(0.10)	(0.10)	(0.10)	(0.10)
Share pop. 75 years and older	-0.19**	-0.19**		-0.20**	-0.17*	-0.20**	-0.20**
	(0.083)	(0.079)		(0.080)	(0.091)	(0.083)	(0.083)
Share pop. lower secondary edu.	0.25***	0.25***	0.25***	0.21***	0.22***	0.25***	0.25***
	(0.040)	(0.038)	(0.040)	(0.036)	(0.042)	(0.041)	(0.040)
Share pop. high school	0.33***	0.29***	0.34***	0.41***	0.32***	0.34***	0.33***
	(0.063)	(0.060)	(0.063)	(0.060)	(0.068)	(0.064)	(0.063)
Share pop. university	-0.058*	-0.027	-0.064*	-0.049	-0.083**	-0.055	-0.059*
	(0.035)	(0.034)	(0.035)	(0.034)	(0.038)	(0.035)	(0.035)
Average salaries (in 1.000 EUR)	0.054	0.035	0.065	0.042	0.084	0.054	0.056
	(0.059)	(0.058)	(0.059)	(0.054)	(0.065)	(0.059)	(0.059)
Average pension (in 1.000 EUR)	0.68***	0.56***	0.75***	0.68***	0.69***	0.67***	0.67***
	(0.070)	(0.068)	(0.069)	(0.066)	(0.072)	(0.071)	(0.070)
Share pop. foreign born	-0.25***	-0.27***	-0.24***	-0.23***	-0.23***	-0.25***	-0.25***
	(0.029)	(0.028)	(0.031)	(0.027)	(0.028)	(0.029)	(0.029)
District Schwaz (0/1)	3.06***	3.64***	3.31***	2.58***	3.52***		3.07***
	(0.65)	(0.59)	(0.60)	(0.67)	(0.59)		(0.65)
Vaccination center near (0/1)	0.58***	0.60***	0.58***	0.43**	0.48**	0.57***	0.59***
	(0.21)	(0.20)	(0.21)	(0.20)	(0.23)	(0.21)	(0.21)
Waldorf school or KiGa near (0/1)	-0.65**	-0.61**	-0.51*	-0.71***	-0.70**	-0.68**	-0.65**
	(0.28)	(0.28)	(0.28)	(0.24)	(0.30)	(0.28)	(0.28)
Share votes Freedom Party (2019)	-0.20***	-0.21***	-0.19***	-0.16***	-0.21***	-0.20***	-0.20***
	(0.028)	(0.026)	(0.028)	(0.028)	(0.029)	(0.028)	(0.028)
Share pop. pre-treatment infection	-0.023	-0.036	-0.026	0.066	-0.068	-0.026	-0.025
	(0.088)	(0.085)	(0.088)	(0.085)	(0.087)	(0.090)	(0.089)
Pre-treatment deaths	0.093***	0.091***	0.084**	0.018*	0.12***	0.095***	0.094***
	(0.035)	(0.034)	(0.034)	(0.010)	(0.034)	(0.036)	(0.035)
Share votes MFG candidate (2022)		-1.63***					
		(0.13)					
Age in 5-year categories			yes				
State FE	yes	yes	yes	yes	yes	yes	yes
Adjusted R2	0.63	0.67	0.64	0.66	0.60	0.63	0.63
Observations	1533	1533	1533	1641	1533	1513	1533

Notes: The table show coefficients from a regression with the share of the population (in percent) receiving at least one dose as the dependent variable. Vaccination data from 2021-12-14 - the day the open letter was published. Column (1) is identical to the baseline specification in column (4) in Table 2. Column (2) shows the same specification but replaces the 15-year age groups with more narrow 5-year age groups. Column (3) shows the same specification as the baseline but without population restriction. Column (4) replicates the baseline specification without population weights and column (5) uses the log of the number of inhabitants as weights. Column (6) excludes municipalities in the district of Schwaz. Column (7) uses the share of vaccine-skeptic physicians among all physicians instead of the share of vaccine-skeptic GPs. Except for columns (4) and (5), observations are weighted by population size. Values in () are robust standard errors. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level.