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JEL Classification: I10, N33, P25

Keywords: Persistence, COVID-19

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Abstract

This paper studies the historical roots of vaccine hesitancy in the context of Germany. Using digitized data on the existence of naturopathic associations in Germany in the year 1900, we first show that counties with a large number of naturopathic associations in 1900 were disproportionally located in East Germany. Furthermore, counties with a higher number of naturopathic associations in 1900 have significantly lower COVID-19 vaccination rates today. Our IV estimates suggest that the long-term effects of the naturopathic movement can explain about half of the East–West gap in COVID-19 vaccination rates.

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1 Introduction

Vaccines are generally considered one of the most important developments in modern medicine. Yet despite their effectiveness in preventing diseases and deaths, vaccine hesitancy is widespread globally (Larson et al., 2014; Lane et al., 2018; de Figueiredo et al., 2020; Solís Arce et al., 2021). For example, the World Health Organization (WHO) considered vaccine hesitancy as one of ten threats to global health in 2019.[1] More recently, during the coronavirus disease 2019 (COVID-19) pandemic, skepticism about newly developed vaccines became a major obstacle to containing the spread of the virus and to reducing hospitalizations and deaths.

In this paper, we consider the historical roots of vaccine hesitancy today. Specifically, we examine COVID-19 vaccination rates in Germany, in the period after initial restrictions to vaccine availability. Vaccine hesitancy has been particularly pronounced in East German counties, which have an average COVID-19 vaccination rate of 65.2% (with some counties falling below 55%) compared to 71.7% for counties in West Germany, a gap of 6.5 percentage points.[2] We propose that part of this East–West divergence in vaccination rates can be traced back to the naturopathic movement (*Naturheilbewegung*) of the second half of the 19th century. At the time, the naturopathic movement strongly rejected vaccinations and other forms of modern medicine.

We first provide historical evidence on the movement and discuss why the movement may have had lasting effects on health behavior. We then draw on digitized data on the dissemination of naturopathic associations in 1900 and show that naturopathic associations were particularly strong in counties in the East. Further, counties with a greater presence of naturopathic associations in 1900 have lower COVID-19 vaccination rates today. This result holds when we instrument the number of naturopathic associations with a county's distance to the nearest water source with sulfuric acid, which is an indicator of geothermal activity. The availability of a geothermal spring often led to the establishment of therapeutic spas (*Heilbaeder*) and spa towns (*Kurorte*), which were closely tied to the naturopathic movement. We provide evidence that distance to a sulfate area creates plausibly exogenous variation in the number of naturopathic associations. Our IV estimates suggest that the long-term effects of the naturopathic movement can explain about half of the East–West difference in COVID-19 vaccination rates. This result holds for a number of robustness exercises. Finally, we consider as an alternative outcome measles vaccination rates among two-year old children. We show that counties with more naturopathic associations in 1900 have lower measles vaccination rates today.

COVID-19, which is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), first appeared in December 2019 and quickly spread around the globe. It is an airborne disease that can affect numerous organs in the body. Recent estimates suggest that COVID-19 is responsible for 14.83 million excess deaths globally (Msemburi et al., 2023). This includes deaths directly attributable to COVID-19 as well as deaths occurring in the months following infection, as COVID-19 increases the risk of cardiac arrest, diabetes, heart failure, and stroke, among others (Davis et al., 2023). Vaccinations against COVID-19, which became available in 2021,

[1] Source: Link.

[2] These figures refer to having received the initial two doses by late 2021. First-dose vaccination rates were at 68.9% and 76.0% for counties in the East and in the West, respectively, implying a gap of 7.1 percentage points.

have been highly effective in reducing the risk of hospitalization and death, and in containing the spread of the virus (e.g. Mohammed et al., 2022; Nasreen et al., 2022). Achieving high vaccination rates within the adult population has therefore been a key national public health goal. Nevertheless, vaccine hesitancy has been widespread. In addition, there is considerable variation in vaccination rates within countries, although information about the disease and vaccine effectiveness is generally publicly available and efforts to increase vaccination readiness in the population are typically undertaken at the national level. Understanding the causes of such regional differences in vaccination rates can therefore help to increase national vaccine uptake. This is important not only in the context of the current pandemic, but also for future pandemics, as high vaccination coverage is seen as an important tool to combat pandemics (World Health Organization, 2022), which are expected to become more frequent and affect more people (Bernstein et al., 2022).

We document that a significant fraction of the difference in COVID-19 vaccination rates between counties in East and West Germany can be traced back to the naturopathic movement that emerged in the second half of the 19th century, more than one hundred years ago. We thereby build on and contribute to recent research showing that East–West differences in socioeconomic outcomes were already prevalent in the early 20th century, before Germany's division in the aftermath of the Second World War (Becker et al., 2020). In the post-war era, East Germans lived under a communist regime, while West Germans lived in a market-based democracy. It was not until 1990 that Germany was reunified. A large body of work exploits this setting to study post-reunification differences in, for example, attitudes, preferences, and behavior (e.g. Alesina and Fuchs-Schündeln, 2007; Rainer and Siedler, 2009; Fuchs-Schündeln and Schündeln, 2005; Bauernschuster et al., 2012; Laudenbach et al., 2020). Becker et al. (2020) argue that pre-war differences may be a potential confounding factor in the analysis of such post-reunification differences. We provide further evidence of deep-rooted cultural differences between East and West Germany by documenting large differences in the spread of naturopathic views as early as the 19th century. Moreover, we provide causal evidence that these differences can indeed explain differences in outcomes today, thus going beyond the article by Becker et al. (2020).

This paper is related to several other strands of the literature. First, it contributes to our understanding of the uptake of vaccinations against COVID-19. Most other work examines the effectiveness of policies to increase vaccination rates, such as the role of incentives (Changa et al., 2021), nudges (Rabb et al., 2022), social media advertising (Athey et al., 2023), and social signaling (Esguerra et al., 2023). Steinmayr and Rossi (2022) show that in Austria, municipalities with vaccine-skeptic general practitioners have lower COVID-19 vaccination rates. We highlight historical factors that may have contributed to this. If reluctance to vaccinate is partly due to ideological reasons, policies that provide incentives or nudges may have little effect or even backfire.[3]

[3] A large literature addresses the determinants of low immunization rates in the context of other diseases and of the underutilization of health services more generally, as well as policies to increase vaccine uptake and demand for health care (e.g. Banerjee et al., 2010, 2022; Alsan and Eichmeyer, 2022); for a review see Dupas and Miguel (2017). However, it remains unclear whether the results of these studies are directly applicable to vaccination preparedness during a pandemic, where uncertainty about the disease, vaccine efficacy, and potential side effects of available vaccines, among other factors, are high.

Second, this paper is related to the literature that documents persistent effects of past events on public health behavior, including vaccination readiness (Alsan and Wanamaker, 2018; Lowes and Montero, 2021; Martinez-Bravo and Stegmann, 2021). For example, Lowes and Montero (2021) show that past exposure to the medical campaigns organized by the French colonial governments reduced vaccination rates for children and trust in medicine. While these studies estimate the impact of past interventions by the state or state institutions on health behavior and associated outcomes today, we examine the lasting effects of a popular movement that was critical of modern medicine.

Third, and relatedly, this paper builds on and contributes to the literature on the historical origins of (mis)trust (e.g. Nunn, 2008; Nunn and Wantchekon, 2011) and, more generally, on the long-run effects of past events on outcomes today (e.g. Dell, 2010; Voigtländer and Voth, 2012; Caicedo, 2019); for reviews see Nunn (2020) and Voth (2021). We provide evidence on the persistence of cultural norms over more than a century, during which significant political and social events took place, including World War I, the rise of the Nazi regime and World War II, and Germany's division and reunification.

2 Historical Background

2.1 The Emergence of the Naturopathic Movement and Its Critical Stance Toward Modern Medicine

The origins of naturopathy (*Naturheilkunde*) date back to the first half of the 19th century, when the first water cures and air baths became popular and individual laymen became sought-after naturopathic healers (Krabbe, 1998). The term "naturopathy" itself was established by the mid-19th century (Krabbe, 1998). While the first association was founded in 1832 in Ansbach and further associations emerged in Berlin, Dresden, Eisenach, and Kassel, among others, the movement did not take off until the 1870s (Regin, 1995). As early as 1872, the various associations were organized into an umbrella organization that soon included associations from all over the German Empire. From 1889 onward, the umbrella organization was called the "German Federation of Associations for Health Care and Drugless Medicine" (*Deutscher Bund der Vereine für Gesundheitspflege und arzneilose Heilweise*). By the end of the 19th century, the naturopathic movement was by far the largest "life-reform movement" (*Lebensreformbewegung*) and the most important movement critical of medicine (*medizinkritische Bewegung*) in the German Empire (Regin, 1995; Dinges, 1996).[4]

Naturopathy was based on two central doctrines; holistic medicine and vitalism (Regin, 1995; Dinges, 1996; Krabbe, 1998). Holistic medicine asserted that any treatment should not restrict itself to addressing symptoms, but rather should address the entire human being while considering the interdependency between body, soul, and spirit. The doctrine of vitalism, by contrast, emphasized the self-healing power of the body (Krabbe, 1998, p. 78). Natural healing methods were thus essentially seen as a means of helping the human body strengthen its self-healing powers. Moreover, for a long time the naturopathic movement was against the use of

[4] The life-reform movement was a social reform movement. Other life-reform movements were the clothing reform, the free body culture, the dietary reform, vegetarianism, and the anti-alcohol movement (for details see Krabbe, 1998). The naturopathic movement has some closeness to homeopathy, but differs from it (Dinges, 1996).

vaccines and drugs. Both were considered harmful to the body and ultimately unnecessary; a strong immune system and human body's natural defenses were sufficient to fight any disease. Advocates of the movement strongly opposed the 1874 vaccine mandate against smallpox, arguing that individuals should retain sovereignty over their own bodies (Regin, 1995). Opponents of vaccination accorded excessive weight to the potential negative side effects of vaccination; the basis for individual decision-making should not be objective statistics, but rather that individual's experienced "lifeworld" (*Lebenswelt*) (Wolff, 1996).

The emergence and rise of the naturopathic movement is considered to be closely linked to fundamental changes in the economy and society, as the following quote from Krabbe (1998, p. 77) illustrates:

> Its proponents [...] saw it as the adequate answer to the developments of modernity, which they interpreted as signs of decay. Natural science and technology, industrialization and the changed living conditions of a society characterized by urbanization and the onset of mass consumption demanded, it was believed, a return to natural ways of life. Diseases were considered to be the consequences of environmental influences perceived as negative, which the civilized man had to combat solely with dietary purity (including vegetarian-based), with water treatments, exercise, light and air baths, with massage, hypnosis and suggestion, i.e. through natural healing stimuli.

The naturopathic movement was particularly attractive as an alternative to modern medicine. While modern medicine increasingly relied on scientific methods and had benefited from recent scientific advances, it remained largely ineffective against many infectious and deficiency diseases common at the time (Labisch, 1985; Regin, 1995; Dinges, 1996). Drugs prescribed by professional doctors frequently came with strong side effects, including sometimes death (Regin, 1995; Ludyga, 2004). One example is the heavy use of mercury at the time (Regin, 1996; Ludyga, 2004).

Although industrialization and urbanization, as well as the increasing application of scientific methods in medicine, were common European trends, the naturopathic movement remained a largely German phenomenon. In part, this might be due to idiosyncratic factors, such as the strong support given to the movement in Saxony by the industrialist Johann Zimmermann.[5] In part, however, the introduction of the compulsory health insurance in 1884 – the first of its kind in the world (Bauernschuster et al., 2019) – and the changes that followed might have triggered a certain backlash that, together with the general rise of popular associations, created a momentum that led to the emergence and spread of the naturopathic movement. As Thießen (2017) notes, the life-reform movement was directed against the state's monopoly on intervention in the health sector. Together with the increased use of scientific methods in medicine, the compulsory health insurance system gave rise to the profession of physicians, as free treatment was limited to licensed practitioners (Regin, 1995). These physicians had substantial power vis-à-vis their patients, because the prerequisite for sick leave and the granting of sick pay depended on the physician, and patient compliance was monitored by local sickness inspectors, who would

[5] The particular case of Saxony is further discussed in Appendix Section A.

pay unannounced visits to patients' homes (Labisch, 1985; Regin, 1995; Bauernschuster et al., 2019). Furthermore, according to the naturpathy movement, licensed physicians provided their patients with too little health education, took too little time with their patients, and focused on providing their patients with a quick fix, which contravened the holistic approach promoted by the naturopathic movement (Regin, 1995). The naturopathic movement thus sought to recruit the support of local sickness funds to advance the recognition of naturopathic healers and methods in mainstream medical practice. The recognition of naturopathic healers as licensed physicians was possible because of the *Kurierfreiheit* of 1869, which allowed individuals without special training to carry out medical treatments (Regin, 1995). The movement also lobbied for naturopathic therapies to be covered by local sickness funds, and health insurers (in contrast to the organized medical profession) were not entirely opposed to this, as these therapies were often cheaper (Regin, 1995). Because licensed physicians were required to provide mandatory vaccinations, few were openly critical of vaccinations. Yet there is evidence that a substantial number of physicians issued vaccination exemptions (Thießen, 2017). Thus, on the one hand, the introduction of compulsory health insurance shaped the naturopathic movement. On the other hand, by influencing how local sickness funds operated, the movement permanently changed the nature of health care provision in some regions.

In addition to influencing the formal health care system, naturopathic associations undertook a range of activities to support their members in learning and applying naturopathic methods (Regin, 1995, 1996). This included the provision of medical equipment, the establishment of natural healing baths and even clinics, the circulation of books and the magazine *Der Naturarzt*, and regular public lectures related to health (for details see Appendix Section A). Naturopathic associations thus contributed significantly to strengthening naturopathic norms and perspectives in local communities and to ensuring their persistence.

2.2 The Naturopathic Movement in the 20th and 21st Centuries

At the beginning of the 20th century, the naturopathic movement was at its peak in terms of membership numbers (Krabbe, 1998). While membership in associations generally increased during the interwar period (Satyanath et al., 2017), membership in naturopathic associations declined after World War I and the movement lost its significance (Dinges, 1996; Krabbe, 1998). During the Nazi period, all life-reform movements were co-opted and controlled by the state, as part of the broader policy of *Gleichschaltung*, which sought to "synchronize" all elements of society (Krabbe, 1998).

After World War II, the movement did not revive in West Germany until the 1970s. With new medical achievements such as antibiotics and improved surgical techniques, the critical stance of the naturpathic movement had lost its appeal. Since the 1970s, however, criticism of the formal health sector has increased again and naturopathy and vaccine hesitancy have become more popular (Dinges, 1996). Yet formal membership in naturopathic associations has remained low. According to the lobby registry of the German Parliament, the German umbrella association (*Deutscher Naturheilbund e.V.*) only had 7,800 members as of March 2022.[6]

While in the decades after World War II, vaccination obligations were gradually lifted

[6] Source: Link.

in West Germany, the communist government of East Germany, also known as the German Democratic Republic, or GDR, decided early on in favor of mandatory vaccinations, such that already in the 1960s, there were a total of up to 20 mandatory vaccinations (Thießen, 2017, p. 308). Indeed, vaccination rates were seen by the political elite as an indicator of support for the communist regime. Nonetheless, and although the vaccination system was centrally organized, data collected by the state in 1967 revealed vast differences in vaccination rates across counties (Thießen, 2017, p. 298). Anecdotal evidence suggests that significant numbers refused vaccinations and had their primary care physician issue vaccination exemptions (Thießen, 2017).

Thus, overall, the historical evidence suggests that vaccine hesitancy continued to exist in both East and West Germany in the decades after World War II albeit under very different political systems (for more details see Appendix Section B).

3 Data

In the following, we describe our data sources and variables. The summary statistics are provided in Appendix Table A1.

3.1 Historical and Geographic Data

The main independent variable used in this study is the number of naturopathic associations in 1900. We construct this variable by digitizing data from the *Hygienischer Volkskalender* of 1900 (Gerling, 1900). In total, there were 889 associations with 180,288 members, out of which 571 were located within Germany's current borders.[7] As the data on naturopathic associations is available at the municipality level, we can assign municipalities to present counties (*Kreise*) and compute a county's total number of naturopathic associations and their members in 1900. Out of the 401 counties, 171 had at least one association in 1900 (42.6%).

We construct a dummy variable that is equal to one if a county was located in East Germany following Germany's division. Using GIS software, we compute the latitude and longitude of the geographic center (centroid) of each county. We digitize data on sulfuric acid sources in Germany from the *Hydrologischer Atlas von Deutschland* (Richts and Vierhuff, 2003). The atlas includes in total 183 of such sources. Based on a county's centroid, we then compute a county's distance to the nearest sulfate area. For the robustness analysis, we digitize data on the number of doctors in a municipality in 1900 from the *Reichs-Medicinal-Kalender* (Börner, 1900). We use this data to compute the total number of doctors in 1900 at today's county level. We also use data from the German Federal Institute for Geosciences and Natural Resources (BGR) on the location of carboniferous-era geological strata (Asch, 2005) and determine a county's distance to the nearest carboniferous area, similar to Fernihough and O'Rourke (2020) and Esposito and Abrahamson (2021).

[7] The remaining associations were founded either in regions that belonged to Germany around 1900 but are part of other countries today (such as Silesia) or in regions where many ethnic Germans lived (such as Switzerland, Hungary, and even Brazil).

3.2 Modern Data

Our main dependent variable is the COVID-19 vaccination rate at the current county level. To determine the vaccination rate, we take the number of vaccinated adults – i.e. adults with first and second vaccinations – in a county in the last quarter of 2021 from the *Epidemiologisches Bulletin* from the Robert Koch Institute (RKI) (Steffen et al., 2022) and divide this number by the adult population per county in 2021, which is available from the Statistisches Bundesamt (Destatis) (2023). In Germany, the vaccination campaign started in December 2020. As was common in other countries, priority was initially given to adults of advanced age, certain occupational categories, and vulnerable groups. The government thereby followed the recommendations of the Standing Committee on Vaccination at the Robert Koch Institute (STIKO). However, on June 7, 2021, the originally established vaccination prioritization policy was revoked.[8] Thus, as vaccines were sufficiently available, adult immunization status at the end of 2021 depended largely on individual demand. As we show in Appendix Table A3, we obtain very similar results when using first-dose COVID-19 vaccination rates. If anything, the IV estimates on naturopathic associations are stronger.

As an alternative outcome we consider a county's measles vaccination rate. In response to under-vaccination rates, the Measles Protection Act was introduced in 2020, requiring that children attending childcare centers or schools be fully vaccinated against measles. We therefore use the most recent data before 2020 on counties' first-dose measles vaccination rates among two-year old children. The data is from 2014 and is provided by the RKI through the web portal VacMAP.[9]

We draw on several data sources for our control variables. We create a dummy variable that is equal to one if a county is classified as urban (*Stadtkreis*). From the Statistisches Bundesamt (Destatis) (2023) we take the GDP and population of each county in 2018 to determine 2018 per capita GDP. From the *Landatlas* (Thünen-Institut für ländliche Räume, 2020) we use data on the share of individuals who left school between 2011 and 2014 with a high-school diploma. Finally, we retrieve the share of the population aged 65 and older for each county from the *Bund-Länder Demografie-Portal* (link).

4 East–West Differences in the Strength of the Naturapathic Movement in 1900 and in COVID-19 Vaccination Rates

Panel a. of Figure 1 shows a map with the number of naturopathic associations in 1900 at today's county level. The thick black line indicates the border between today's East German states and West German states, which is identical to the border between the Federal Republic of Germany and the German Democratic Republic.[10] The map illustrates that the naturopathic movement was particularly strong in East Germany, especially in counties located in the southern part of

[8] Source: Link.

[9] The reason for using first-dose vaccination rates is that at that time, the vaccination commission of Saxony (*Sächsische Impfkommission*) recommended the second dose only at age 6, and not at the age of 15 to 23 months, as recommended by the STIKO.

[10] After unification in 1990, five new federal states were created in the Eastern part of Germany: Mecklenburg-Vorpommern, Brandenburg, Saxony-Anhalt, Saxony, and Thuringia. East Berlin was integrated into the federal state of Berlin. All other West German states remained unchanged.

East Germany, in Thuringia and Saxony. While 90% of counties (or, 69 out of 77 counties) in East Germany had at least one naturopathic association in 1900, only 31% of counties (or, 102 out of 324) did in West Germany. Moreover, out of the top 20 counties with the highest number of naturopathic associations in 1900, only three are located in West Germany.

Panel b. of Figure 1 shows a map with counties' COVID-19 vaccination rates. Again, we find striking differences in vaccination rates between West and East Germany; counties with low vaccination rates are concentrated in East Germany, particularly in the southern part of East Germany. On average, counties located in East Germany had a vaccination rate of 65.2% in late 2021 compared with 71.7% in their West German counterparts.

Together, the maps suggest a strong negative correlation at the county level between the strength of the naturopathic movement in 1900 and COVID-19 vaccination rates today. This is confirmed in Figure 2, which shows a binned scatterplot of vaccination rates and the strength of the naturopathic movement measured as the natural log of one plus the total number of naturopathic associations in the year 1900. The county with the highest number of associations (32), the *Erzgebirgskreis*, located in Saxony in East Germany, is also the county with the lowest vaccination rate (50.3%). Among the 20 counties with the lowest vaccination rates, the average number of naturopathic associations in 1900 is 8.8. In contrast, among the 20 counties with the highest vaccination rates, all of which are located in West Germany, the average number of naturopathic associations in 1900 is only 0.4. In the next section, we will study this relationship more formally.

5 The Long-Term Impact of the Naturopathic Movement on COVID-19 Vaccination Rates

5.1 OLS Estimates

This section examines, at the county level, the relationship between the number of naturopathic associations in 1900 and current COVID-19 vaccination rates by estimating the following equation using Ordinary Least Squares (OLS):

$$y_i = \alpha + \beta NaturopathicAssociations1900_i + X_i'\delta + \varepsilon_i, \tag{1}$$

where y_i is the share of adults vaccinated against COVID-19 (in late 2021) in county i. $NaturopathicAssociations1900_i$ is our main independent variable of interest and denotes the log of one plus the total number of naturopathic associations in the year 1900 in county i. Results are similar in terms of both economic and statistical significance when we transform the number of naturopathic associations in 1900 by inverse hyperbolic sine (IHS) rather than the natural logarithm; see Appendix Table A4. X_i is a vector of control variables. As basic controls we include a county's latitude and longitude and dummies identifying counties located in East Germany and counties classified as urban (*Stadtkreise*). The East dummy is included to capture East–West differences in the vaccination rate that are the result of Germany's division. As modern controls, we include a county's log GDP per capita, a county's share of high-school

graduates, and the share of the population aged 65 or older. We add the last variable for two reasons: First, during the early phase of the vaccination roll-out, the elderly were among those population groups that were given priority. Second, the population in East Germany tends to be older: an average of 29% percent of the population is aged 65 or older in counties in East Germany compared with 22% percent in West Germany. This age profile is partly the result of the disproportionate migration of young people (mostly women) from East to West Germany after reunification (Kröhnert and Vollmer, 2012). We generally report robust standard errors. In Appendix Table A5, we report standard errors clustered at the 0.5×0.5 degree and, alternatively, at the 1×1 degree grid cell level. Statistical significance remains strong when accounting for spatial clustering.

The OLS results are reported in columns (1) to (3) of Panel A in Table 1. They indicate a robust negative correlation between the log number of naturopathic associations in 1900 and current vaccination rates. Column (1) shows a raw correlation of -0.032. Adding basic controls reduces the estimate to 0.023 (column 2), while additionally adding modern controls does not change the estimate (column 3). Throughout, the coefficient estimate is statistically significant at the 1% level.

5.2 Instrumental Variable (IV) Estimates

The OLS results presented in the previous section document a robust negative correlation between the number of naturopathic associations in 1900 and COVID-19 vaccination rates, consistent with our hypothesis that the naturopathic movement promoted anti-vaccine views that have persisted to the present. However, the correlation might also be due in part to omitted variables. In this section, we therefore use an instrumental variable strategy to obtain causal estimates. To do so, we need an instrument that explains variation in the strength of the naturopathic movement in 1900 but that is uncorrelated with other factors that are correlated with the naturopathic movement and may influence vaccination rates today. We make use of the fact that *Heilbaeder* influenced the development of the naturopathic movement and the creation of associations through hydropathy, and that in the 19th century, many *Heilbaeder* were founded on water sources with a high content of sulfuric acid (Flechsig, 1883; Mosse, 1889). Native sulfur is formed when hydrocarbons come in contact with sulfate minerals in the presence of liquid water (Labrado et al., 2019). This process does not necessarily mean that sulfur deposits are randomly distributed in the environment. For example, sulfuric acid sources are more likely to occur in volcanic areas (Ferraris and Vila, 1990). Appendix Figure A1 illustrates the distribution of sulfate minerals in Germany. Counties that are located in a sulfate area are colored dark violet. The lighter the color of a county, the further away it is from a sulfate area (based on its centroid). To address the concern that the presence of sulfuric acid sources may be correlated with the presence of other mineral waters or ore deposits, Appendix Table A6 reports the relationship between the presence of sulfuric acid sources in a county and the presence of other mineral waters (column 1), or the presence of ore deposits (column 2), controlling for longitude and latitude. We find no statistically significant relationship between these variables.[11] In ad-

[11] Columns (3) and (4) suggest that counties with carboniferous-era geological strata are more likely to have sulfuric acid sources. We revisit this in the robustness section (Section 5.3).

dition, and important for our IV strategy, sulfuric acid did not play a direct role in mining or in the industrialization of Germany. All in all, this suggests that proximity to a water source that includes sulfuric acid is a plausible driver of exogenous variation in the existence and strength of the naturopathic movement in 1900 that is uncorrelated with other omitted factors that may influence the relationship between naturopathic associations and COVID-19 vaccination rates. We thus use the natural log of one plus the distance from a county's centroid to the nearest water source with sulfuric acid as the instrumental variable.

The IV results are reported in columns (4) to (6) of Table 1. Column (4) presents the results without further controls. In column (5) we add basic controls and in column (6) we additionally add modern controls. The coefficient estimate on our instrument reveals a strong first stage with an F-statistic between 17.4 and 20.4 (Panel B). The farther a county is from a sulfate area, the fewer naturopathic associations there were in 1900. The IV estimate on our associations variable is negative and significant at the 1% level (Panel A). Based on the estimate in our most comprehensive specification (column 6), moving from the 50th to the 90th percentile, which corresponds to a log-point difference in the number of naturopathic associations of 1.39, implies a reduction in the COVID-19 vaccination rate by 3.8 percentage points.

How much of the 6.5 percentage point East–West difference in COVID-19 vaccination rates can be explained by differences in the strength of the naturopathic movement in 1900? The log-point difference in the number of naturopathic associations for counties in the West and in the East is 1.08 (1.38-0.30=1.08). Given the IV estimate of 0.027 (column 6), this implies a difference in COVID-19 vaccination rates of 2.9 percentage points. Hence, almost half of the East–West gap in COVID-19 vaccination rates can be explained by the long-term effects of the naturopathic movement that emerged more than a century ago.

5.3 Robustness

This section assesses the validity of the exclusion restriction and considers alternative measures of our main independent variable. The results of the various exercises are reported in Table 2.

The first two columns examine the potential role of omitted variables. In column (1) we add two historical controls, the natural log of one plus the number of doctors in 1900 and the natural log of one plus the distance to the nearest carboniferous-era geological stratum. The first variable is a proxy for a county's public health infrastructure in 1900. We add the second variable because historical evidence suggests that the naturopathic movement tended to emerge in counties that industrialized early, including Saxony, and the presence of coal deposits likely played an important role in this regard (Fernihough and O'Rourke, 2020; Esposito and Abrahamson, 2021). As the location of coalfields can be considered endogenous, we determine a county's distance to the nearest carboniferous stratum. Previous work has used information on carboniferous-era geological strata to construct instruments for the proximity to or presence of (historical) coalfields (Fernihough and O'Rourke, 2020; Esposito and Abrahamson, 2021). In addition, we find that, at the county level, the presence of carboniferous-era geological strata is positively correlated with the presence of a sulfur deposit (columns 3 and 4 of Appendix Table A6). Reassuringly, adding these controls changes our IV estimate only marginally.

In column (2), we aim to restrict the comparison to counties within a small geographic

area in order to address the concern that our estimate may be biased due to omitted geographic variables. To do so, we assign counties to 1x1 degree grid cells based on their centroid. We then add grid cell fixed effects to our baseline specification. While our first stage becomes weaker, the IV estimate is robust to adding these fixed effects.

In columns (3) to (6) we use alternative measures for our independent variable of interest. In column (3) we use a dummy that is equal to one if the county had at least one naturopathic association in 1900. The F-statistic on the IV is weaker as we lose variation (9.4 compared to 18.9). The IV estimate of -0.059 suggests that the COVID-19 vaccination rate is 5.9 percentage points lower for counties that had naturopathic associations in 1900. This confirms the economic significance of the effect. Note that 31.69% of counties in West Germany were home to naturopathic associations in 1900 compared with 89.47% of counties in East Germany. Taken at face value, our estimate thus implies that differences in the exposure to the naturopathic movement can explain 3.4 percentage points of the East–West gap in COVID-19 vaccination rates of 6.5 percentage points, or about half of the gap.

In columns (4) and (5) we make use of information about membership numbers of these associations. That is, our main independent variable is now defined as the natural log of one plus the total number of members across associations in a county in 1900. Counties with naturopathic associations in 1900 counted on average 438 members, with 10% of these counties counting more than 1,000 members in total. In column (4), we consider all counties and obtain an estimate of -0.008, which is statistically significant at the 5% level. The estimate thus confirms that greater exposure to the naturopathic movement in 1900 can account for almost half of the East–West difference in COVID-19 vaccination rates at the county level.[12] In column (5) we restrict our sample to the 171 counties with at least one naturopathic association in 1900. In doing so, we rule out selection on the extensive margin and only draw on variation in membership numbers across counties with at least one association. Reassuringly, we find that the number of association members has a negative and statistically significant effect on COVID-19 vaccination rates.

Finally, column (7) examines the robustness of our results to measles vaccination rates among two-year old children. In 2014, the measles vaccination rate was on average 95.3% at the county level and varied between 77.8% and 99.1%. We obtain a strong first stage with an F-statistic of 18.9. The IV estimate on our associations variable is -0.044 and significant at the 1% level. If taken at face value, the estimate implies that moving from the 50th to the 90th percentile, which corresponds to a log-point difference in the number of naturopathic associations of 1.39, reduces the measles vaccination rate by 6.1 percentage points.

Overall, these results confirm a strong causal relationship between naturopathic associations in 1900 and vaccination rates today.

6 Conclusion

In this paper, we studied the historical roots of vaccine hesitancy in the context of Germany. Drawing on digitized data on the spread of naturopathic associations in 1900, we showed that

[12] The log-point difference in members between counties in the East and counties in the West is $5.19 - 1.59 = 3.6$. 3.6 multiplied by 0.008 gives 0.029, or 2.9 percentage points.

counties with a stronger naturopathic movement in 1900 have lower COVID-19 vaccination rates today. To establish causality, we used an instrumental variable approach exploiting the fact that a county's distance to the nearest sulfate area creates plausible exogenous variation in the number of naturopathic associations in 1900. Our IV estimates suggest that the long-term effect of the naturopathic movement in 1900 accounts for about half of the 6.5 percentage point difference in COVID-19 vaccination rates across counties in East and West Germany. This finding is robust to a range of different specifications. By documenting a causal relationship between the naturopathic movement in 1900 and COVID-19 vaccination rates, this paper provides further evidence for socioeconomic differences that existed in Germany even prior to the country's post-war division (Becker et al., 2020) – meaningful differences that persist to this day.

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Figures

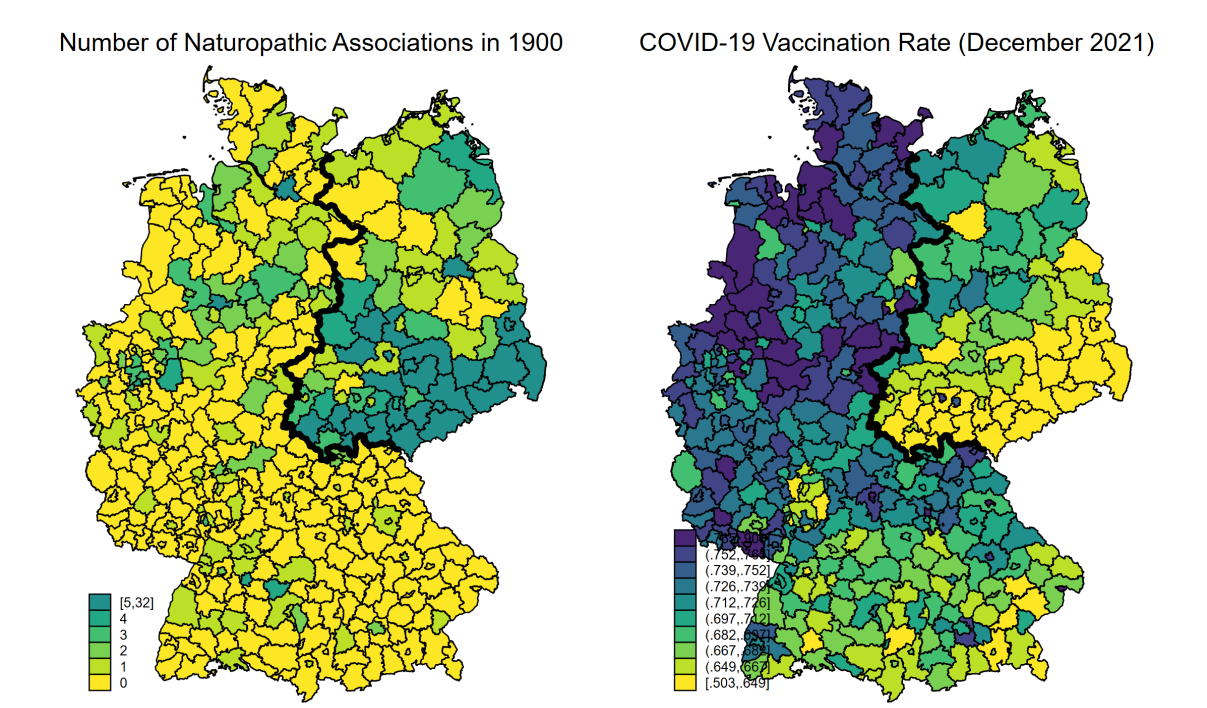

Figure 1 East–West Differences in the Number of Naturopathic Associations in 1900 and COVID-19 Vaccination Rates

Notes: Panel a. shows the total number of naturopathic associations in 1900 at the level of today's counties. Panel b. shows counties' COVID-19 vaccination rates at the end of 2021. The thick black line indicates the border between the Federal Republic of Germany (West Germany) and the German Democratic Republic (East Germany).

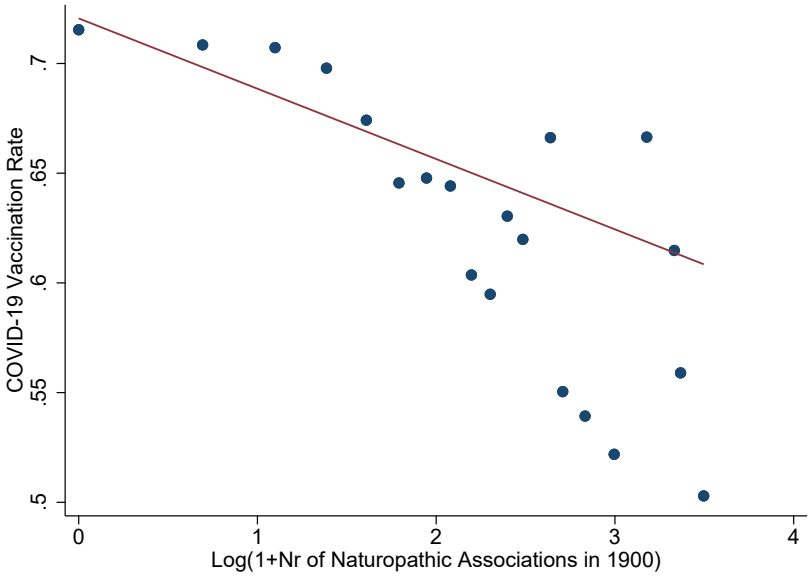

Figure 2 Binned Scatterplot: Naturopathic Associations in 1900 and COVID-19 Vaccination Rates

Notes: This figure depicts the unconditional relationship, at the county level, between the natural log of one plus the total number of naturopathic associations in 1900 and COVID-19 vaccination rates in a binned scatterplot. There are 401 counties in total.

Tables

Table 1 Naturopathic Associations and COVID-19 Vaccination Rates

	Panel A: Vaccination Rate Against COVID-19					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Log(1+Nr of Naturopathic Associations)	-0.032***	-0.023***	-0.023***	-0.051***	-0.027**	-0.027**
	(0.004)	(0.003)	(0.003)	(0.013)	(0.011)	(0.011)
Basic Controls	No	Yes	Yes	No	Yes	Yes
Modern Controls	No	No	Yes	No	No	Yes
Observations	401	401	401	401	401	401
F-Statistic on IV				17.389	20.377	18.857
				Panel B: First Stage		
				(4)	(5)	(6)
Log(1+Distance to Sulfate Area)				-0.040***	-0.035***	-0.034***
				(0.010)	(0.008)	(0.008)
Observations				401	401	401
R^2				0.058	0.412	0.416

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Notes: This table assesses the relationship, at the county level, between the strength of the naturopathic movement – measured as the natural log of one plus the number of naturopathic associations in 1900 – and COVID-19 vaccination rates. Columns (1) to (3) of Panel A report OLS estimates, columns (4) to (6) of Panel A report IV estimates with the naturopathic associations variable instrumented by the natural log of one plus a county's distance to the nearest sulfate area. Estimates from the first stage are reported in columns (4) to (6) of Panel B. Basic controls include latitude, longitude, a dummy that is equal to one if the county was part of the German Democratic Republic (East Germany), and a dummy that is equal to one if the county is classified as urban. Modern controls include the log of GDP per capita, the share of high-school graduates, and the share of the population aged 65 or older. Appendix Table A2 reports the full OLS results. Standard errors are robust to heteroskedasticity. In Appendix Tables A4 and A5 we report results using the inverse hyperbolic sine function of the number of naturopathic associations in 1900 and accounting for spatial clustering, respectively.

Table 2 Robustness of IV Results

	Panel A: Vaccination Rates Against COVID-19					*Measles*
	(1)	(2)	(3)	(4)	(5)	(6)
Log(1+Nr of Naturopathic Associations)	-0.029**	-0.039**				-0.044***
	(0.013)	(0.017)				(0.014)
=1 if Naturopathic Association(s) in 1900			-0.059**			
			(0.029)			
Log(1+Nr of Members in Associations)				-0.008**	-0.029***	
				(0.004)	(0.008)	
Historical Controls	Yes	No	No	No	No	No
Grid Cell Fixed Effects	No	Yes	No	No	No	No
Observations	401	401	401	401	171	401
F-Statistic on IV	13.847	9.060	9.404	16.056	18.560	18.857
	Panel B: First Stage					
	(1)	(2)	(3)	(4)	(5)	(6)
Log(1+Distance to Sulfate Area)	-0.029***	-0.027***	-0.015***	-0.109***	-0.081***	-0.034***
	(0.008)	(0.009)	(0.005)	(0.027)	(0.019)	(0.008)
Observations	401	401	401	401	171	401
R^2	0.457	0.598	0.325	0.390	0.258	0.416

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Notes: This table assesses the robustness of the IV results reported in column (6) of Table 1. Column (1) adds two historical controls, the natural log of one plus the number of doctors in 1900 and the natural log of one plus the nearest distance to a carboniferous area. Column (2) adds 1x1 degree grid cell fixed effects. In columns (3) to (6) we use alternative measures for our naturopathic associations variable. In column (3), we use a dummy that is equal to one for counties with at least one naturopathic association in 1900. In columns (4) and (5), we use the natural log of one plus the total number of members across associations in a county in 1900. In column (5), we restrict the sample to counties with at least one naturopathic association. In column (6), we consider counties' first-dose measles vaccination rates among two-year old children in 2014. Standard errors are robust to heteroskedasticity.

Online Appendix

Table of Contents

A Further Background on the Naturopathic Movement

As outlined in the main text, the naturopathic movement was critical towards the formal health care system and lobbied for its understanding of human health and medicine. It also, and importantly, engaged in various activities to support its members in learning and applying naturopathic methods (for details see Regin, 1995, 1996). Before 1892, these methods were attractive to patients as they tended to be cheaper than the treatments and drugs prescribed by licensed physicians. But even after 1892, when patients were no longer required to pay for the cost of their therapy, many people sought naturopathic methods to prevent illness or improve their health, as sick pay did not provide sufficient coverage for most households. Also, the system created little incentive for physicians to limit the use of drugs, and patients also had little say in the matter. According to the naturopathic movement, this led to excessive reliance on drugs. Hence, many naturopathic associations gave their members access to certain medical equipment such as tubs, steam baths, and blankets, and provided free or cheap counseling. Many associations established natural healing baths and some even natural health clinics, often in collaboration with the local sickness fund. Based on the magazine *Der Naturarzt*, 73 naturopathic health clinics and 181 naturopathic spas were managed by federal members (Regin, 1995, p. 157). The large natural health clinics in Hamburg and Altona counted 10,000 to 11,000 treatments per month in the early 20th century, many of which were paid for by sickness funds (Regin, 1995, p. 158, based on *Der Naturarzt*). Members who could not finance their stay in such baths would receive financial support. Some associations even had their own garden plots (*Schrebergärten*) that members could lease and they promoted sports and physical training. Many associations had their own libraries with magazines and books on health, naturopathy, and social hygiene, and many organized public lectures – for example, to teach about hygiene and to provide women with health knowledge related to female health. According to Regin (1995, p. 149, based on *Der Naturarzt*), 422 naturopathic associations had their own libraries in 1898, sometimes with more than 1,000 volumes. In 1902, more than 3,000 public lectures were held (sometimes with an audience of 500 to 1,000), i.e., an average of more than 3 lectures per association (Regin, 1995, p. 150, 153, based on *Der Naturarzt*). From the beginning of the movement, the magazine *Der Naturarzt*, which had a circulation of more than 100,000 in 1900, provided associations and their members with news on naturopathy and supported their activities – for example, by providing lists of potential speakers (Regin, 1995, p. 51).

Among which socioeconomic groups was the movement particularly popular? Data from the German Federation suggests that many association chairmen belonged to the middle class and included teachers (especially elementary school teachers), craftsmen, and merchants (Regin, 1995). Among association members, the largest occupational groups were workers and craftsmen. Together they made up 55% of members in 1908 (Regin, 1995, p. 78). Yet members from all social strata relied on naturopathy. The German Federation did not collect data on members' religious affiliation. While early on the movement was concentrated in Saxony and Thuringia, both Protestant areas, it later spread to predominantly Catholic areas. Also, in Catholic areas, the so-called Kneipp associations became popular, which relied, among other things, on hydropathy (well-known are in particular water cures with treading water). Overall, the movement was supported by all religious groups (Regin, 1995; Krabbe, 1998).

Saxony played a leading role in the emergence of the naturopathy movement. In part, this may be the result of its early industrialization (Regin, 1995, 1996). In addition, a major industrialist from Chemnitz, Johann Zimmermann, heavily supported the movement through his commitment and strong financial backing. He believed that the use of naturopathic practices had helped to cure his children of scarlet fever. Together with his workers and employees he founded the first naturopathic association in Chemnitz in 1868. He helped finance a local natural health clinic, supported the training of lay practitioners and helped the naturopathic movement expand and grow (Regin, 1995, 1996). Finally, according to Wolff (1996), vaccination opposition became more popular after a public lecture given by the physician Nittinger in Saxony in the year 1869. Nittinger was highly skeptical towards the benefits of the smallpox vaccination and, from the 1850s onwards, had started to mobilize against it. Before his lecture, vaccination rates in Saxony were high, while shortly after his lecture, physicians reported increasing reluctance to vaccinate (Wolff, 1996).

B Vaccinations and Vaccine Hesitancy in East and West Germany After World War II

Soon after the formation of the German Democratic Republic (that is, the communist East German government), the state took a leading role in health issues. According to Thießen (2017, p. 297), "Health represented the fruits of socialist progress and thus the success of socialism itself." Vaccinations played an important role in this matter. Early on, the state decided in favor of mandatory vaccinations (Thießen, 2017, p. 308f). Nonetheless, significant numbers of parents circumvented mandatory vaccinations for their children. This was partially attributable to "vaccination fatigue," as up to 20 vaccinations were required in total, and it was not possible to receive multiple vaccinations at once. Some, however, refused vaccinations and had their primary care physician issue vaccination exemptions. In 1967, when counties received performance points based on their vaccination rates, vast differences in vaccination rates were revealed across counties (Thießen, 2017, p. 298).

In contrast to East Germany, vaccination obligations were gradually lifted in West Germany. Instead of mandatory vaccinations, the Standing Committee on Vaccination at the Robert Koch Institute (STIKO) – the equivalent to the Centers for Disease Control and Prevention (CDC) in the United States – issues recommendations for vaccinations of children and adults, and publishes a vaccination calendar for children. In general, there was a tendency in West Germany to limit state intervention in health care matters. To be sure, this was partially attributable to the growing immunity of the population to major diseases, which decreased the perceived need for vaccinations (Thießen, 2017).

Before the COVID-19 pandemic, vaccine hesitancy caused concerns particularly with regard to the measles vaccination, and measles outbreaks happened with some frequency in child care facilities and schools.[13] As a result, the Measles Protection Act of 2020 reintroduced mandatory measles vaccination by requiring children to be fully vaccinated before attending child care facilities and elementary schools.

[13] In the peak year of 2015, there were a total of 2,465 cases of measles infection in Germany (Source: Link).

C Summary Statistics

Table A1 Summary Statistics

	Mean	Std. Dev.	Min	Max
Variables based on Historical and Geographic Data:				
Nr of naturopathic associations in 1900	1.42	3.56	0.00	32.00
Log(1+nr of naturopathic associations in 1900)	0.50	0.72	0.00	3.50
=1 if naturopathic associations existed in 1900	0.43	0.50	0	1
Total nr of members across associations in 1900	186.75	509.65	0.00	4136.00
Log(1+ total nr of members in 1900)	2.27	2.75	0.00	8.33
Nr of doctors in 1900	24.77	38.35	0.00	404.68
=1 if located in East Germany	0.19	0.39	0	1
Latitude	50.62	1.74	47.56	54.78
Longitude	9.86	2.02	6.16	14.75
Distance to nearest sulfate area (in m)	18824.69	23122.74	0.00	106461.50
Distance to nearest carboniferous area (in m)	47526.59	56012.32	0.00	283482.84
Variables based on Modern Data:				
COVID-19 vaccination rate (initial two doses)	0.70	0.05	0.50	0.91
First-dose COVID-19 vaccination rate	0.75	0.06	0.54	0.95
First-dose measles vaccination rate (children)	0.95	0.03	0.78	0.99
=1 if classified as urban	0.27	0.45	0	1
Log of GDP per capita	10.47	0.34	9.70	12.11
Share of high-school graduates	32.35	7.34	16.30	57.80
Share of the population aged 65+	22.86	3.02	16.00	33.00

Notes: County-level data (N=401). Details on the variables are provided in Section 3.

D Additional Results

Table A2 OLS Estimates: Full Results

	COVID-19 Vaccination Rate		
	(1)	(2)	(3)
Log(1+Nr of Naturopathic Assocations)	-0.032***	-0.023***	-0.023***
	(0.004)	(0.003)	(0.003)
Latitude		0.015***	0.014***
		(0.001)	(0.001)
Longitude		-0.004***	-0.004***
		(0.001)	(0.001)
=1 if Part of East Germany		-0.048***	-0.061***
		(0.007)	(0.008)
=1 if Urban		0.000	-0.002
		(0.005)	(0.007)
Log of GDP per Capita			-0.003
			(0.011)
Share of High-School Graduates			0.001***
			(0.000)
Share of the population aged 65+			0.002**
			(0.001)
Constant	0.721***	0.027	0.021
	(0.003)	(0.052)	(0.154)
Observations	401	401	401
R^2	0.194	0.532	0.552

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table reports OLS estimates on the relationship, at the county level, between the strength of the naturopathic movement – measured as the natural log of one plus the number of naturopathic associations in 1900 – and COVID-19 vaccination rates. Controls include latitude, longitude, a dummy that is equal to one if the county was part of the German Democratic Republic (East Germany), a dummy that is equal to one if the county is classified as urban, log of GDP per capita, the share of high-school graduates, and the share of the population aged 65 or older. Standard errors are robust to heteroskedasticity.

Table A3 Naturopathic Associations and First-Dose COVID-19 Vaccination Rates

	Panel A: Vaccination Rate Against COVID-19					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Log(1+Nr of Naturopathic Associations)	-0.033***	-0.023***	-0.023***	-0.067***	-0.038***	-0.039***
	(0.004)	(0.003)	(0.003)	(0.016)	(0.012)	(0.011)
Basic Controls	No	Yes	Yes	No	Yes	Yes
Modern Controls	No	No	Yes	No	No	Yes
Observations	401	401	401	401	401	401
F-Statistic on IV				17.389	20.377	18.857
				Panel B: First Stage		
				(4)	(5)	(6)
Log(1+Distance to Sulfate Area)				-0.040***	-0.035***	-0.034***
				(0.010)	(0.008)	(0.008)
Observations				401	401	401
R^2				0.066	0.409	0.412

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Notes: This table assesses the relationship, at the county level, between the strength of the naturopathic movement – measured as the natural log of one plus the number of naturopathic associations in 1900 – and first-dose COVID-19 vaccination rates. Columns (1) to (3) of Panel A report OLS estimates, columns (4) to (6) of Panel A report IV estimates with the naturopathic associations variable instrumented by the natural log of one plus a county's distance to the nearest sulfate area. Estimates from the first stage are reported in columns (4) to (6) of Panel B. Basic controls include latitude, longitude, a dummy that is equal to one if the county was part of the German Democratic Republic (East Germany), and a dummy that is equal to one if the county is classified as urban. Modern controls include the log of GDP per capita, the share of high-school graduates, and the share of the population aged 65 or older. Standard errors are robust to heteroskedasticity.

Table A4 Naturopathic Associations and COVID-19 Vaccination Rates: Inverse Hyperbolic Sine Transformation

	Panel A: Vaccination Rate Against COVID-19					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Nr of Associations (IHS Transformation)	-0.025***	-0.018***	-0.018***	-0.041***	-0.022**	-0.021**
	(0.003)	(0.003)	(0.003)	(0.011)	(0.009)	(0.009)
Semi-elasticity	-0.029	-0.021	-0.021	-0.047	-0.025	-0.025
Basic Controls	No	Yes	Yes	No	Yes	Yes
Modern Controls	No	No	Yes	No	No	Yes
Observations	401	401	401	401	401	401
F-Statistic on IV				17.342	20.417	18.950
	Panel B: First Stage					
				(4)	(5)	(6)
Log(1+Distance to Sulfate Area)				-0.050***	-0.043***	-0.042***
				(0.012)	(0.010)	(0.010)
Observations				401	401	401
R^2				0.056	0.413	0.416

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Notes: This table assesses the relationship, at the county level, between the strength of the naturopathic movement – measured as the inverse hyperbolic sine function of the number of naturopathic associations in 1900 – and COVID-19 vaccination rates. Semi-elasticities are computed following Bellemare and Wichman (2020). Columns (1) to (3) of Panel A report OLS estimates, columns (4) to (6) of Panel A report IV estimates with the naturopathic associations variable instrumented by the natural log of one plus a county's distance to the nearest sulfate area. Estimates from the first stage are reported in columns (4) to (6) of Panel B. Basic controls include latitude, longitude, a dummy that is equal to one if the county was part of the German Democratic Republic (East Germany), and a dummy that is equal to one if the county is classified as urban. Modern controls include the log of GDP per capita, the share of high-school graduates, and the share of the population aged 65 or older. Standard errors are robust to heteroskedasticity.

Table A5 Naturopathic Associations and COVID-19 Vaccination Rates: Accounting for Spatial Clustering

	Panel A: Vaccination Rate Against COVID-19					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Log(1+Nr of Naturopathic Associations)	-0.032 [0.004]*** (0.006)***	-0.023 [0.003]*** (0.004)***	-0.023 [0.004]*** (0.004)***	-0.051 [0.016]*** (0.022)**	-0.027 [0.012]** (0.013)**	-0.027 [0.012]** (0.012)**
Basic Controls	No	Yes	Yes	No	Yes	Yes
Modern Controls	No	No	Yes	No	No	Yes
Observations	401	401	401	401	401	401
F-Statistic on IV (0.5×0.5 clustering)				13.816	18.162	17.253
F-Statistic on IV (1×1 clustering)				10.090	13.971	13.602

	Panel B: First Stage		
	(4)	(5)	(6)
Log(1+Distance to Sulfate Area)	-0.040 [0.013]*** (0.013)***	-0.035 [0.009]*** (0.009)***	-0.034 [0.009]*** (0.009)***
Observations	401	401	401
R^2	0.058	0.412	0.416

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Notes: This table assesses the relationship, at the county level, between the strength of the naturopathic movement – measured as the natural log of one plus the number of naturopathic associations in 1900 – and COVID-19 vaccination rates. Standards errors account for spatial clustering at the 0.5×0.5 degree (square brackets) and, alternatively, at the 1×1 degree (parentheses) grid cell level. Columns (1) to (3) of Panel A report OLS estimates, columns (4) to (6) of Panel A report IV estimates with the naturopathic associations variable instrumented by the natural log of one plus a county's distance to the nearest sulfate area. Estimates from the first stage are reported in columns (4) to (6) of Panel B. Basic controls include latitude, longitude, a dummy that is equal to one if the county was part of the German Democratic Republic (East Germany), and a dummy that is equal to one if the county is classified as urban. Modern controls include the log of GDP per capita, the share of high-school graduates, and the share of the population aged 65 or older.

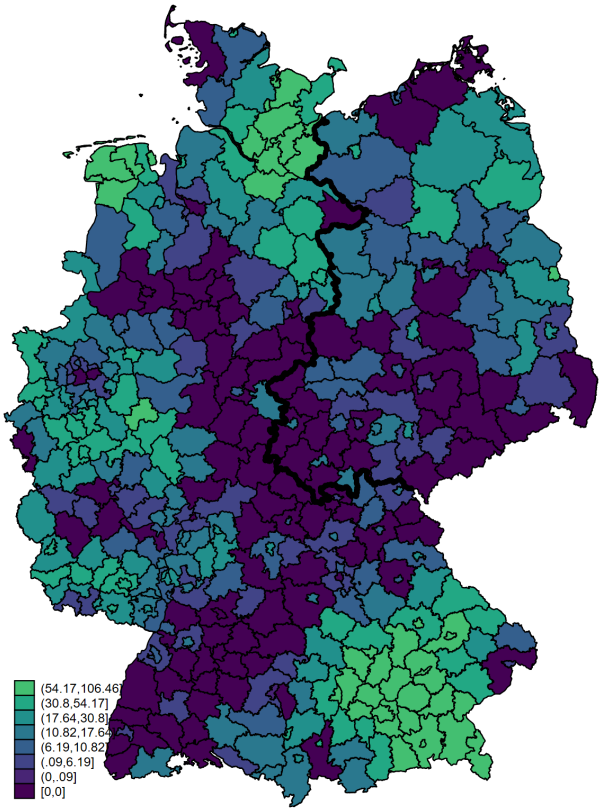

Figure A1 Counties' Distance to the Nearest Sulfate Area

Notes: This map illustrates counties' distance to the nearest sulfate area. Counties with a distance of zero are shown in dark violet. The lighter the color of a county, the further away it is (in meters) from a sulfate area (based on its centroid). The thick black line indicates the border between the Federal Republic of Germany (West Germany) and the German Democratic Republic (East Germany).

Table A6 Sulfate and Other Mineral Deposits

	=1 if Sulfuric Acid Sources			
	(1)	(2)	(3)	(4)
=1 if Other Mineral Waters	-0.009			-0.022
	(0.044)			(0.045)
=1 if Ore Deposits		0.007		-0.035
		(0.102)		(0.103)
=1 if Carboniferous Surface Strata			0.163***	0.167***
			(0.055)	(0.056)
Geographic Controls	Yes	Yes	Yes	Yes
Observations	401	401	401	401
R^2	0.006	0.006	0.031	0.032

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Notes: This table examines whether the presence of sulfuric acid sources in a county is correlated with the presence of other mineral waters, the presence of ore deposits, and the presence of carboniferous surface strata. Geographic controls include longitude and latitude. OLS estimates are reported with robust standard errors in parentheses.