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Mona Foertsch, Felix Roesel

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Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
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Abstract

Can public infrastructure help regions to mitigate large shocks? We examine how hospital infrastructure contributes to regional resilience in the event of serious health emergencies. During the 1918 Spanish flu pandemic, four out of every 1,000 Germans died. We find lower influenza mortality rates and no political reaction in cities and rural areas with adequate hospital infrastructure. In contrast, rural areas without adequate infrastructure absorb shocks poorly, and voters punish the governing parties in the next elections. We conclude that public infrastructure can mitigate large external shocks, especially in rural regions.

JEL-Codes: D720, O180, I100.

Keywords: public infrastructure, resilience, health shocks, Spanish flu, Germany.

*Mona Foertsch**
ifo Institute Dresden
Einsteinstrasse 3
Germany – 01069 Dresden
foertsch@ifo.de

Felix Roesel
TU Braunschweig
Spielmannstraße 9
Germany – 38106 Braunschweig
f.roesel@tu-braunschweig.de

*corresponding author

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1 Introduction

Large shocks like economic crises, natural disasters, social upheaval, or health emergencies are major challenges for cities and regions. Resilient places can mitigate or absorb such shocks and create new opportunities for long-term development (Martin and Sunley, 2015). Several economic, social, and institutional factors have been shown to contribute to regional resilience (Martin, 2012; Capello *et al.*, 2015; Martin *et al.*, 2016; Ubago Martínez *et al.*, 2019; Terzo, 2021). Surprisingly, little attention has been paid to the role of local public infrastructure. Public infrastructure is one of the most important determinants of long-term development (Aschauer, 1989; Cutanda and Paricio, 1994; Haughwout, 2002; Romp and De Haan, 2007; Fedderke and Bogetic, 2009; Zhang and Yan, 2022), so politicians try to align public infrastructure with their voters (Hankins *et al.*, 2019; Potrafke and Roesel, 2020).[1] An intriguing question, therefore, is whether public infrastructure can also help regions to absorb shocks in the short run. Psycharis *et al.* (2022) show that public investment spending has a positive impact on regional resilience, but the effect of public infrastructure has not yet been studied.

We examine how public infrastructure contributes to regional resilience in the case of a large health shock. The Spanish flu pandemic hit a largely unprepared Germany in 1918. Four out of every 1,000 Germans died as no containment measures were in place and hospitals were crowded (Michels, 2010). We combine previously unexplored local-level data on influenza mortality rates, hospital infrastructure, and electoral outcomes from the German state of Bavaria in difference-in-differences regressions. Our data allow us to separate influenza mortality rates for men and women, thus eliminating a bias of male World War I casualties. We hypothesize that hospital infrastructure contributes to a region's resilience in two ways: by reducing the magnitude of a health shock and by preventing health shocks from turning into political shocks. The first hypothesis is straightforward as hospital treatment should reduce the probability of dying from influenza (Hobday and Cason, 2009). For the second hypothesis, we argue that shocks reveal hidden public infrastructure

[1] Previous studies have also examined effects on development of specific forms of infrastructure such as roads (Baum-Snow *et al.*, 2020; Marein, 2022), railroads (Heblich *et al.*, 2020), airports (Czernich *et al.*, 2011; Doerr *et al.*, 2020), broadband internet (Czernich *et al.*, 2011; Doerr *et al.*, 2020), or educational institutions (Freier *et al.*, 2021; Berlingieri *et al.*, 2022). Healthcare infrastructure has not been a focus so far.

deficits. Voters will react to infrastructure deficits and blame the incumbent government for failing to provide a sufficient level of infrastructure. Governments, in turn, can learn and respond. Esteves *et al.* (2022) show that US cities, where more people died during the Spanish flu, expanded their hospital capacity after the pandemic.

Our results show that German regions that were well-equipped with hospital infrastructure had fewer deaths from influenza in 1918. Moreover, these regions were better able to mitigate the health shock: voters did not punish the incumbent government in the following elections. In contrast, the parties forming the 1918 German government lost support in rural areas with high influenza mortality rates and without adequate levels of hospital infrastructure. The effect is substantial; 100 deaths translated into 207 fewer votes and persisted in all democratic elections until the Nazi takeover in 1933. We conclude that pre-existing hospital infrastructure reduced both the health shock caused by the Spanish flu as well as the associated political shock. This finding improves our understanding of the 1918/1919 Spanish flu (for an overview of the health effects, see Taubenberger *et al.*, 2019). We show that hospital infrastructure determined mortality rates; previous studies have shown an impact of pollution (Clay *et al.*, 2018; Franke, 2022). The literature concerning the implications of the Spanish flu has mainly focused on the economic outcomes (Karlsson *et al.*, 2014; Basco *et al.*, 2021; Carillo and Jappelli, 2021; Barro *et al.*, 2022; Beach *et al.*, 2022). Few studies have focused on the political effects (Blickle, 2020; Arroyo Abad and Maurer, 2021; Aassve *et al.*, 2021; Bauernschuster *et al.*, 2023). We add to this strand of the literature that the Spanish flu had some persistent political effects, but the effects are limited to rural areas without adequate healthcare infrastructure.

2 Spanish flu in 1918 Germany

The Spanish flu killed approximately 50 to 100 million people worldwide in 1918 and 1919.[2] It was one of the deadliest pandemics in human history (Johnson and Mueller, 2002). It swept through Germany from west to east in three waves (see Michels, 2010,

[2]Spain was not overly affected by the flu, nor was it its country of origin. Because of the more uncensored press during World War I, information about the pandemic first spread primarily through Spanish media.

for details): the first rather harmless wave beginning in the spring of 1918, the second and most severe wave in autumn 1918, and the third and again milder wave in the spring of 1919. The first and third waves were less pronounced but similar in scope. The main wave hit Germany in October 1918, killing thousands of mainly young people between the ages of 20 and 40, while it tended to spare children and the elderly. Estimates for Germany range from around 240,000 deaths (Bogusat, 1923) to 440,000 deaths (Buchholz *et al.*, 2016). Many studies, however, do not separate male war casualties and flu fatalities. According to more recent estimations, approximately 260,000 Germans (140,000 women and 120,000 men), or four out of 1,000 citizens, died from the Spanish flu in Germany in 1918 (Foertsch and Roesel, 2021).

The Spanish flu arrived in Germany at a rather unfortunate time, coinciding with the end of World War I when millions of soldiers were returning home, revolutions were ending the German monarchy, and famine was ravaging the country. After the abdication of the German Emperor in November 1918, two left-wing parties (SPD, USPD) formed an interim government, the *Rat der Volksbeauftragten*. This new government was very busy ending the war, dealing with mass unemployment and malnutrition, and preparing for democratic elections in early 1919. The Spanish flu was not seen as a separate problem but as part of the general hardship that exacerbated these unfortunate conditions. The government did little to contain the pandemic. It recommended closing schools to contain the pandemic, but no concrete action was taken. Other places were not closed to avoid alarming the population. Nose-to-mouth masks to protect against the Spanish flu were also rarely worn. Without containment measures, hospital facilities were critical to individual survival. However, hospitals were so overcrowded that even the most seriously ill often could not find admission (Michels, 2010). These were rather bad starting conditions for the first democracy in Germany. The first national elections after World War I were held on 19 January 1919, immediately after the main wave of the Spanish flu.

3 Data

We collect and combine three previously unexplored historical datasets at the level of 205 counties in the former German state of Bavaria (for our sources, see section B in the Online Appendix).[3] Bavaria was the second largest state in Germany in 1918 after Prussia in terms of both population and area. Bavaria has also published extensive data at the local level which are not available for many other states, including Prussia.[4] The average Bavarian county had about 25,000 inhabitants. 44 out of 205 counties are cities and 161 are rural areas. On average, there is little difference between the two groups regarding population size, but in terms of population density. The x-axis in Figure 1 plots population density. Cities (hollow markers) clearly have a higher population density than rural counties (solid markers).

[Figure 1 about here]

Our first dataset includes mortality and population data. We are interested in the mortality that can be attributed to the Spanish flu of 1918. To calculate mortality rates (deaths per 1,000 inhabitants), we use data of the male and female population for all Bavarian counties from the censuses 1910, 1919 and 1925 as well as the 1916 and 1917 censuses during World War I and interpolate the missing years. Cause of death statistics report deaths from influenza and pneumonia, but these data often suffer from missing data, coding errors, and World War I casualties. Therefore, in this paper, we use the concept of excess mortality. Excess mortality is the difference between the observed (total) mortality rate in 1918 and the expected (total) mortality rate in 1918. Expected mortality rates are a simple average of the mortality rates in the three years before and after 1918 (1915 to 1921, excluding 1918). Since total mortality is available for all Bavarian counties, we have no missing data and can rule out coding errors. However, the deaths of men may still be biased by World War I. Our innovation is to calculate mortality rates for men and women separately. German women were generally not involved in front-line combat during World War I. Excess mortality among women in 1918 should be the most accurate measure of the

[3] We use the territorial status from 1919.

[4] The state boundaries of Bavaria in 1918 are essentially identical to those of today, with the notable exception of the exclave of Palatinate, which was separated in 1945.

local impact of the 1918 Spanish flu. Table 1 shows that 44 out of 1000 (female) Bavarian citizens died from the Spanish flu. There is some spatial heterogeneity with somewhat lower influenza mortality rates in cities.

[Table 1 about here]

Second, we collect and georeference a list of all general hospitals (public and private) in Bavaria in 1910. This list includes the number of hospital beds. Local-level data on hospitals is not available for 1918. However, we can use the 1910 data instead because the number of hospital beds per 1,000 inhabitants did not change much between 1910 (3.9) and 1918 (4.1) in Bavaria (see Figure A1 in the Online Appendix).[5] The map in Figure A2 in the Online Appendix and Figure 1 give a sense of the data. On average, cities have substantially more hospitals and hospital beds per 1,000 inhabitants than rural counties (see also Table 1). However, there is also some considerable variation within both groups.

Third, we use data on national elections between 1907 and 1933. The government in charge during the 1918 Spanish flu pandemic (the *Rat der Volksbeauftragten*) was formed by the Social Democratic Party (SPD) and the more radical left-wing party USPD which in main parts later became the Communist Party (KPD). Throughout the paper, we refer to these parties as the 1918 government. We compute the vote shares of the 1918 government parties for all elections. On average, the 1918 government parties have more support in the cities than in rural places, which are often more conservative (Table 1).

Finally, the maps in Figure 2 summarize the regional variation in our data. Influenza mortality (excess female mortality in 1918) in map (a) shows no clear regional pattern. The virus emerged abruptly and spread from west to east. It is unclear why one county was more affected than another. There is also no clear pattern when comparing cities to rural areas. Map (b) shows the absolute change in vote shares for the 1918 government party between 1912 (the last election before the Spanish flu) and 1919 (the first election after the pandemic). The changes in vote shares seem to correspond with the impact of the flu: the least affected areas in the east have increasing support for the 1918 government parties.

[5]The number of hospitals decreased by 10%.

Maps (c) and (d) show hospital infrastructure. Hospitals are more evenly distributed across counties than hospital beds, which are more concentrated in southern Bavaria.

[Figure 2 about here]

4 Identification

We want to know how hospital infrastructure can help mitigate the effect of large health shocks such as the Spanish flu of 1918. As a first step, we investigate whether hospital infrastructure made a difference in 1918 influenza mortality rates in Bavarian counties. We estimate a cross-sectional OLS model with standard errors robust to heteroskedasticity:

$$Influenza_i = \alpha + \beta_1 Hospitals_i + \beta_2 Beds_i + X_i'\gamma + \varepsilon_i \tag{1}$$

where $Influenza_i$ denotes the female excess mortality in 1918 in county $i = 1, ..., 205$. The coefficients β_1 and β_2 refer to our variables of interest, the number of hospitals and hospital beds per 1,000 inhabitants. The vector X_i is a set of control variables (population size in logs, population density in logs, a dummy for cities, proportion of the Catholic population) that could have influenced the spread of the Spanish flu. Finally, α is a constant, and ε_i denotes the error term. We also use yearly raw mortality rates in event study estimations described below.

As a second step, we use the female excess mortality in 1918 ($Influenza_i$) to explain voting behavior. In the most straightforward difference-in-differences specification, we analyze whether counties with high influenza rates had different changes in electoral outcomes between 1912 and 1919 than counties less affected by the virus. Our identifying assumption is that in the absence of the 1918 Spanish flu, high-mortality counties would have developed similarly to low-mortality counties and vice versa. We follow previous studies, such as Karlsson *et al.* (2014), which treat local incidence rates of the Spanish flu as quasi-experimental. Our results from the first step do not speak against this assumption, as we do not find statistically significant correlations other than hospital infrastructure (see Table 2 later). We estimate the following specification using OLS, with standard errors clustered at the county level:

$$Votes_{it} = \alpha + \theta Influenza_i + \delta Year1919_t + \beta(Influenza_i \times Year1919_t) + Z_i'\gamma + \varepsilon_i \quad (2)$$

where $Votes_{it}$ denotes the vote share for the 1918 government parties (SPD, USPD) the election $t = 1912, 1919$ in county $i = 1, ..., 205$. $Influenza_i$ is the female excess mortality in 1918, $Year1919_t$ is a dummy variable for the 1919 election (with 1912 as the base category). The vector Z_i is a set of dummies for one of the eight districts of Bavaria, α is a constant, and ε_i denotes the error term. We run separate regressions for cities and rural areas. The coefficient β is our difference-in-differences estimate of interest.

Finally, we extend our difference-in-differences approach to an event study setting covering all elections between 1907 and 1933. This allows us to examine long-term trends before and after the Spanish flu and to include fixed effects for all counties. We use the following two-way fixed effects specification, estimated with OLS and standard errors clustered at the county level:

$$Votes_{it} = \alpha_i + \delta_t + \sum_{T \neq 1919} \beta_T(Influenza_i \times Year_T) + \varepsilon_i \quad (3)$$

where $Votes_{it}$ denotes the vote share for the 1918 government parties (SPD, USPD) the election $t = 1907, ..., 1933$ in county $i = 1, ..., 205$. The vector of β coefficients refers to the interaction between the female excess mortality in 1918 ($Influenza_i$) and year fixed effects as our difference-in-differences estimates. We standardize to the year 1912. α_i refer to county fixed effects which account for time-invariant unobservable differences across counties, δ_t are year fixed effects, ε_i denotes the error term. Later, we also include control variables in robustness tests. We use a similar event study setup as a robustness test for the health effects when we regress yearly mortality rates on an interaction of year fixed effects and hospital beds.

5 Results

5.1 Health effects

Table 2 shows how pre-existing hospital infrastructure correlates with influenza mortality in 1918 in Bavarian counties. The number of hospitals per 1,000 inhabitants does not predict female excess mortality (column (1)). By contrast, the effect of hospital beds per 1,000 capita is statistically significant at the 1% level: more hospital beds are associated with fewer deaths from the Spanish flu (column (2)). In column (3), we use both hospital variables in a regression. The point estimate of hospitals becomes positive and marginally statistically significant at the 10% level, while the effect of hospital beds is again statistically significant at the 1% level. The results implicate some size effects within hospitals: holding the number of hospital beds in a county constant, more hospital locations, i.e., smaller hospitals, tend to be associated with higher influenza mortality rates. However, the positive correlation between hospitals and mortality is not robust when we add control variables (column (4)). In column (5), we also include fixed effects for the eight Bavarian districts to account for regional heterogeneity. Each district includes, on average, about 25 counties. All results hold when we exclude variation between districts. The effects are also quantitatively important: doubling the number of hospital beds in the average county would reduce influenza mortality by about 20 percent.[6] More hospital beds go along with lower influenza mortality rates; adequate hospital infrastructure seems to reduce health shock like the Spanish flu.

[Table 2 about here]

A serious concern could be that mortality rates are generally lower in counties with more hospital beds. We, therefore, regress yearly female mortality rates on an interaction of time fixed effects and hospital beds. The base year is 1917, the year before the Spanish flu. The event study results in Table A1 in the Online Appendix show that mortality rates do not change significantly with the number of hospital beds in any year other than 1918—the

[6]Doubling the number of beds corresponds to an increase of 3.592 beds per 1,000 inhabitants (Table 1). Given the point estimate of our least parsimonious regression (column (5) in Table 2, -0.239, we derive an effect of ($3.592 \times -0.239 = 0.858$), which corresponds to a 20% increase in our mean influenza mortality rate of 4.351)

year of the Spanish flu. In this year, we observe a negative statistically significant effect at the 10% level (column (1)). The effects are driven by rural counties (column (3)), a result we will confirm later in other regressions. We conclude that hospital infrastructure increases regional resilience in years with large health shocks such as influenza pandemics.

5.2 Political effects

We then examine whether the health shock caused by the Spanish flu has political implications. We begin with simple cross-sectional analyses. Table 3 shows that 1918 influenza mortality does not predict the vote share of the parties forming the 1918 government in the national election of 1912, the last election before the Spanish flu (column (1)). In contrast, influenza mortality rates in 1918 correspond with lower vote shares for the 1918 government parties in 1919, the first election after the Spanish flu (column (2)). The effect is statistically significant at the 10% level. However, these results from cross-sectional analyses do not allow for a causal interpretation. We combine the two national elections in 1912 and 1919 and estimate the difference-in-differences specifications as described by equation (2). The results in column (3) in Table 3 show that the interaction effect of influenza mortality and the 1919 election is both positive and statistically significant at the 5% level. This implies that higher influenza mortality reduces the 1918 government's vote shares in the 1919 election, taking into account pre-existing differences in vote shares of 1912. The coefficients are also substantial in quantitative terms. In an average county, 100 more deaths are associated with 207 fewer votes for the 1918 government parties. Thus, the regions that suffered most from the Spanish flu seem to have punished the incumbent government.

[Table 3 about here]

We submit our baseline difference-in-differences estimation to several robustness tests. The results can be found in Table A2 in the Online Appendix. First, we interpolate the population data without the data from the war censuses of 1916 and 1917, as wartime data may be less reliable. The inferences do not change (column (2)) compared to our baseline specification (column (1)). Second, we use only the vote share for the main and more moderate left-wing party, the Social Democrats (SPD), as the dependent variable because the left-wing camp became fragmented in 1919. The point estimate increases in magnitude but does not change qualitatively. Third, we use only mortality rates in 1915, 1916, and 1917 as reference years to calculate excess mortality in 1918. The point estimate decreases slightly but remains statistically significant at the 5% significance level (column (4)). Fourth, we include some control variables (number of eligible voters, dummy for cities, Catholic population share, population (logs), and population density (logs)) in our estimation, and all results hold (column (5)). Fifth, we include time trends in our estimation, but all effects are robust (column (6)). Sixth and finally, a major concern could be that war casualties bias our results. Therefore, we collect data on male war mortality between 1914 and 1918 for all counties. Column (7) shows that all results hold. Influenza mortality in 1918 still has a negative and statistically significant effect on the 1918 government's vote shares, but war casualties do not predict changes in vote shares from the 1912 to the 1919 national election. Our evidence on the political impacts of the Spanish flu in the 1919 national election in Germany is robust.

5.3 Hospital infrastructure

Now, we examine the role of hospital infrastructure. We first run separate regressions for the 44 cities and 161 rural counties. Figure 1 has shown that, on average, cities were already well equipped with hospital infrastructure—compared to many rural places. We hypothesize that large shocks reveal inadequate levels of public infrastructure, and voters then punish the incumbent government. We would therefore expect to see political effects of the Spanish flu in rural places with few hospital beds but not in cities or well-equipped rural places. Table 4 confirms our expectations: when we split the sample into cities and rural counties, we can only confirm statistically significant effects for the latter (column (3)). We also split the sample of rural counties at the median number of hospital beds per 1,000 inhabitants. The results show that within the group of rural counties, the effects are only statistically significant in places where the number of hospital beds is below the median (column (4)). In contrast, when rural places have a more adequate level of hospital infrastructure, the point estimate of influenza mortality in 1918 is still negative but not statistically significant. This suggests that pre-existing public infrastructure, in our case hospital beds, is essential for regions to absorb shocks in the short run.

[Table 4 about here]

Finally, we investigate the persistence of the political effects. Event studies allow us to follow the effects over time and examine trends before the Spanish flu. We include all national elections between 1907 and 1933 in our estimation, using the same regional subsamples as in Table 4. For the full sample, column (1) in Table 5 shows that only the election after the main wave of the Spanish flu was affected by influenza mortality rates. The point estimate of -0.441 replicates the findings from our baseline difference-in-difference estimations, where we only consider the national elections of 1912 and 1919. The coefficients in all other election years are not statistically significant at any conventional level, including the 1907 election. The results also hold when we account for war casualties, which are never correlated with vote shares of the 1918 government parties (see Figure A3 in the Online Appendix). Thus, for the full sample, we cannot confirm long-term effects.[7]

[Table 5 about here]

When we split the sample into cities and rural areas, we again find substantial heterogeneity in the effects. For cities, we find no statistically significant effect of influenza mortality rates on vote shares of the 1918 government parties (column (2)). In contrast, the effects in rural areas are substantial and statistically significant in the 1919 and 1920 national elections (column (3)). The parties of the 1918 government have less support in rural counties where the Spanish flu hit harder. In columns (4) and (5), we again split the sample of rural counties at the median number of hospital beds per 1,000 inhabitants. The results reveal substantial differences. In rural counties with fewer hospital beds, we find negative and statistically significant effects of the Spanish flu in all elections between 1919 and 1933 (column (4)). In contrast, we find no such effect in rural counties with adequate hospital infrastructure (column (5)). This strongly confirms all our previous findings: adequate hospital infrastructure helped rural areas in 1918 Germany absorb the

[7] Blickle (2020) finds that the vote share of the Nazi party in 1932 and 1933 is positively correlated with the Spanish flu. We replicate this estimation but find no statistically significant correlation between influenza mortality in 1918 and Nazi vote shares a decade later (see Table A3 in the Online Appendix).

Spanish flu's health shock.. When counties were less well equipped with hospital beds, influenza mortality was higher in 1918, and the health shock translated into long-lasting political effects. Our main conclusion is that public infrastructure contributes to regional resilience.

6 Conclusion

We have shown that pre-existing hospital infrastructure has contributed to resilience in German regions shocked by the Spanish flu pandemic in late 1918. Specifically, influenza mortality was lower in regions with more hospital beds, and mortality did not translate into a political effect. In contrast, the parties that formed the 1918 government lost support in rural counties without adequate health infrastructure. The effects of infrastructure deficits persist for almost 15 years. This mirrors the results of previous studies showing the long-term effects of favorable policies on electoral outcomes (Bechtel and Hainmueller, 2011).

In general, we conclude that adequate infrastructure is an important determinant of regional resilience. Public infrastructure is not only an investment for long-term development but does also help mitigate exogenous shocks like pandemics in the short run. Building infrastructure thus may work as an insurance. Future studies may examine how other types of public infrastructure, such as roads, schools, or universities, can help regions and communities absorb and recover from large shocks and promote future development.

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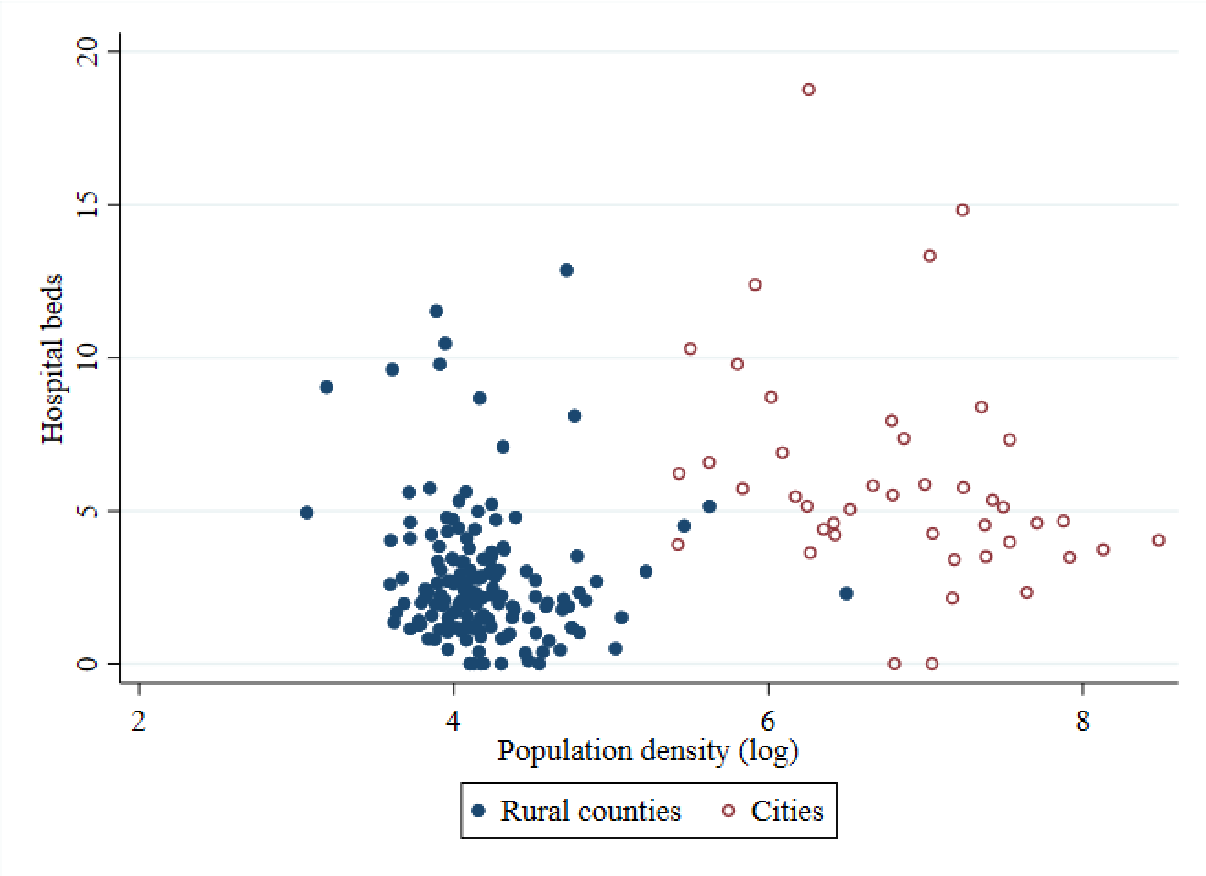
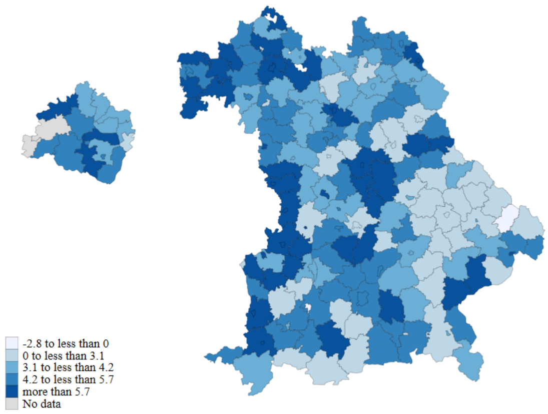
Figure 1: Population density and hospital beds in Bavarian counties (1910)



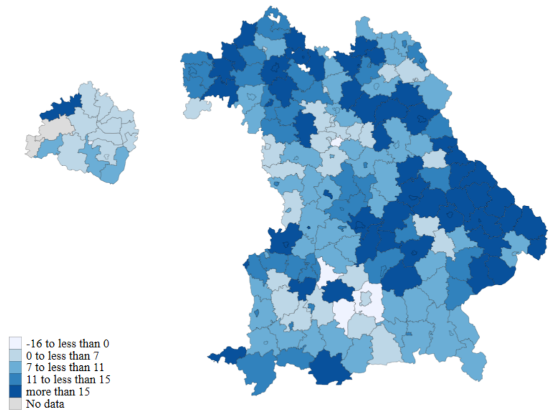
Notes: The figure plots population density in 1910 (in logs) against the number of hospital beds per 1,000 inhabitants. The unit of observation is 205 counties in the German state of Bavaria; solid (blue) markers represent 181 rural areas, and hollow markers (red) are 44 cities. We omit the outlier of Bad Kissingen (37.7 hospital beds per 1,000 inhabitants because of two children's sanatoriums).

Figure 2: Regional variation in the data

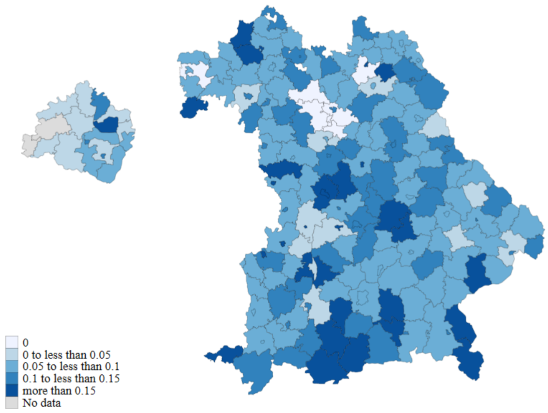
(a) Influenza mortality 1918



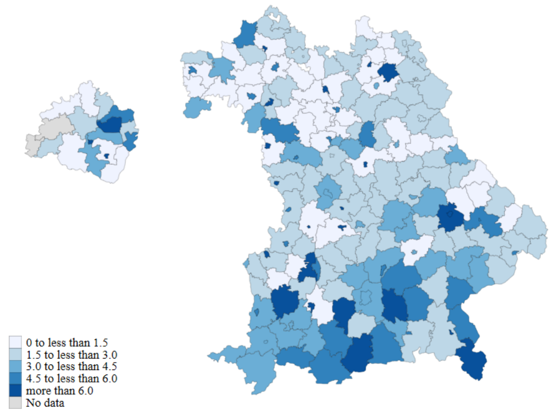
(b) Vote share of 1918 gov. parties (Δ1912-1919)



(c) Hospitals



(d) Hospital beds



Notes: The maps show the regional variation of (a) female influenza mortality 1918 in Bavarian counties, (b) the vote share change for parties forming the 1918 government (SPD, USPD) between the national elections in 1919 and 1912, (c) the number of hospitals per 1,000 capita in 1910, and (d) the number of hospital beds per 1,000 capita in 1910 (d). The unit of observation is 205 counties in the German state of Bavaria; we use the territorial status from 1919.

Table 1: Descriptive statistics

	Obs.	Mean	SD	Min	Max	Mean		Obs. Period
						Rural	Cities	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Influenza mortality 1918	205	4.351	2.246	-2.789	16.078	4.473	3.941	1918
Mortality 1915-1921 w/o 1918	205	16.095	2.702	10.525	33.552	15.973	16.539	1918
Mortality 1918	205	20.446	3.457	12.863	37.476	20.436	20.480	1918
War mortality	205	19.823	2.774	11.827	30.418	20.180	18.509	1918
Hospitals	205	0.102	0.078	0.000	0.857	0.095	0.126	1910
Hospital beds	205	3.592	3.738	0.000	37.729	2.730	6.745	1910
Vote share for 1918 government parties	2,229	21.237	13.212	0.093	71.110	18.767	30.144	1907-1933
Population (log)	3,464	10.150	0.635	8.340	13.43	10.245	9.803	1910-1925
Population density (log)	3,464	4.749	1.207	3.013	8.594	4.175	6.832	1910-1925
City (0/1)	3,464	0.215	0.411	0.000	1.000	0.000	1.000	1910-1925
Share of Catholics	205	0.729	0.319	0.024	0.998	0.752	0.642	1910

Notes: The table reports the descriptive statistics of the dataset. Influenza mortality 1918 is female excess mortality in 1918. Mortality 1915-1921 is female mortality, averaged over the years 1915, 1916, 1917, 1919, 1920, and 1921. Mortality 1918 are female mortality rates in the year 1918. War mortality is defined as the sum of war casualties between 1914 and 1918 per 1,000 inhabitants as of 1910. Hospitals and hospital beds are measured per 1,000 capita. Vote share for 1918 government parties is the aggregated vote share for SPD, USPD and KPD in German national elections. We use population and population density in logs. City is a dummy variable for 44 cities (*Kreisunmittelbare Städte*). The share of the Catholic population refers to 1910.

Table 2: Determinants of influenza mortality in 1918

	Influenza mortality 1918				
	(1)	(2)	(3)	(4)	(5)
Hospitals	-1.953		5.599*	5.525	5.583
	(2.002)		(3.035)	(3.344)	(3.518)
Hospital beds		-0.110***	-0.202***	-0.211**	-0.239***
		(0.041)	(0.072)	(0.082)	(0.088)
Population (log)				-0.499	-0.491
				(0.324)	(0.304)
Population density (log)				0.454	0.501
				(0.511)	(0.594)
City (0/1)				-1.312	-1.448
				(1.725)	(2.041)
Share of Catholics				-0.369	0.065
				(0.502)	(0.753)
Mean dep. var.	4.351	4.351	4.351	4.351	4.351
Counties	205	205	205	205	205
Obs.	205	205	205	205	205
District fixed effects	No	No	No	No	Yes
R^2	0.005	0.033	0.048	0.063	0.167

Notes: The table shows the results of cross-sectional OLS regressions using influenza mortality 1918 as dependent variable. Hospitals and hospital beds are measured per 1,000 inhabitants and refer to the year 1910. Controls are total population (log), population density (log), a dummy for cities, and the population share of Catholics. Districts fixed effects refer to the eight Bavarian districts as of 1919. Bavarian counties are the unit of observation. Significance levels (robust standard errors in brackets): *** 0.01, ** 0.05, * 0.1.

Table 3: Political effects of the influenza mortality 1918

	Vote share for 1918 government parties		
	1912	1919	1912/1919
	(1)	(2)	(3)
Influenza mortality 1918	-0.390	-0.743*	-0.346
	(0.364)	(0.384)	(0.355)
Influenza mortality 1918 × Year 1919			-0.441**
			(0.191)
Mean dep. var.	20.065	31.727	25.896
Counties	205	205	205
Obs.	205	205	410
District fixed effects	Yes	Yes	Yes
Year fixed effects	No	No	Yes
R^2	0.316	0.235	0.369

Notes: The table shows the results of OLS regressions using the vote shares in German national elections for the 1918 government parties as dependent variable. The main explanatory variable is the influenza mortality 1918, which we interact with a dummy for the 1919 election. Districts fixed effects refer to the eight Bavarian districts as of 1919. Bavarian counties are the unit of observation. Significance levels (robust standard errors (column (1) and (2)) and standard errors clustered at the county level (column (3)) in brackets): *** 0.01, ** 0.05, * 0.1.

Table 4: Effect heterogeneity

	Vote share for 1918 government parties				
	All	Cities	Rural	Rural	
				≤ Median	> Median
	(1)	(2)	(3)	(4)	(5)
Influenza mortality 1918	-0.346	0.393	-0.311	0.610	-0.668
	(0.355)	(0.663)	(0.530)	(0.891)	(0.634)
Influenza mortality 1918 × Year 1919	-0.441**	-0.250	-0.586**	-0.806**	-0.526
	(0.191)	(0.278)	(0.264)	(0.345)	(0.394)
Mean dep. var.	25.896	35.261	23.337	24.228	22.456
Counties	205	44	161	80	81
Obs.	410	88	322	160	162
District fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
R^2	0.369	0.391	0.431	0.475	0.462

Notes: The table shows the results of OLS regressions using the vote shares in German national elections for the 1918 government parties as dependent variable. Column (1) refers to the full sample, columns (2) to (5) are subsamples. The subsample of rural counties is further split at the median of the number of hospital beds per 1,000 capita in 1910. The main explanatory variable is the influenza mortality 1918, which we interact with a dummy for the 1919 election. Districts fixed effects refer to the eight Bavarian districts as of 1919. Bavarian counties are the unit of observation. Significance levels (standard errors clustered at the county level in brackets): *** 0.01, ** 0.05, * 0.1.

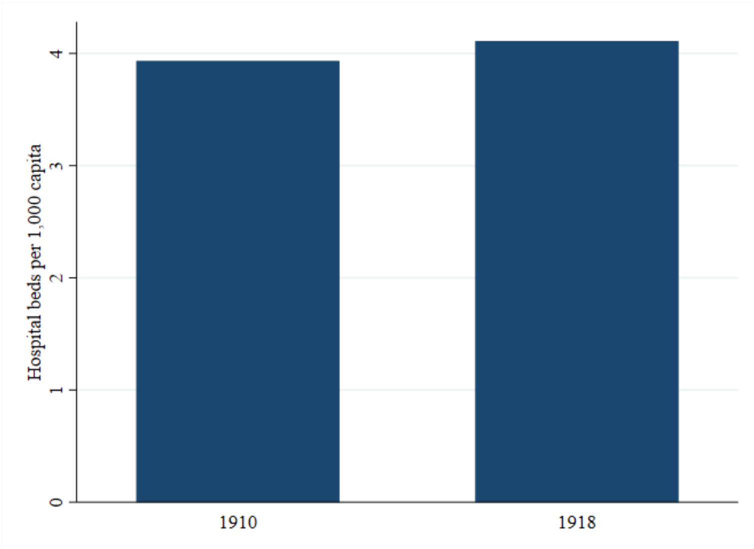
Table 5: Event studies

	Vote share for 1918 government parties				
	All	Cities	Rural	Rural	
				≤ Median	> Median
	(1)	(2)	(3)	(4)	(5)
Influenza mortality 1918 × Year 1907	-0.080	0.092	-0.164	-0.087	-0.140
	(0.162)	(0.291)	(0.165)	(0.244)	(0.224)
Influenza mortality 1918 × Year 1912					
Influenza mortality 1918 × Year 1919	-0.441**	-0.250	-0.586**	-0.806**	-0.526
	(0.189)	(0.267)	(0.261)	(0.338)	(0.385)
Influenza mortality 1918 × Year 1920	-0.251	0.228	-0.558**	-1.005***	-0.171
	(0.231)	(0.330)	(0.249)	(0.338)	(0.376)
Influenza mortality 1918 × Year 1924/1	-0.009	0.367	-0.318	-0.894**	0.169
	(0.246)	(0.427)	(0.269)	(0.379)	(0.340)
Influenza mortality 1918 × Year 1924/2	0.082	0.302	-0.091	-0.724*	0.406
	(0.218)	(0.316)	(0.284)	(0.384)	(0.346)
Influenza mortality 1918 × Year 1928	0.022	0.468	-0.287	-0.973**	0.288
	(0.244)	(0.328)	(0.290)	(0.378)	(0.335)
Influenza mortality 1918 × Year 1930	0.018	0.439	-0.296	-0.948**	0.219
	(0.263)	(0.400)	(0.292)	(0.380)	(0.375)
Influenza mortality 1918 × Year 1932/1	-0.220	0.123	-0.481	-1.192**	0.097
	(0.313)	(0.490)	(0.381)	(0.536)	(0.435)
Influenza mortality 1918 × Year 1932/2	-0.286	0.107	-0.593	-1.331**	0.045
	(0.308)	(0.479)	(0.368)	(0.519)	(0.413)
Influenza mortality 1918 × Year 1933	-0.088	0.196	-0.329	-0.940*	0.189
	(0.289)	(0.508)	(0.334)	(0.479)	(0.402)
Mean dep. var.	21.237	30.144	18.767	19.381	18.169
Counties	205	44	161	80	81
Obs.	2,229	484	1745	861	884
County fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Within R^2	0.564	0.582	0.567	0.607	0.552

Notes: The table shows the results of fixed effects OLS regressions using the vote shares in German national elections for the 1918 government parties as dependent variable. Column (1) refers to the full sample, columns (2) to (5) are subsamples. The subsample of rural counties is further split at the median of the number of hospital beds per 1,000 capita in 1910. The main explanatory variable is the influenza mortality 1918, which we interact with a dummy for the dummy variables for all elections between 1907 and 1933 (1912 is the base category). Bavarian counties are the unit of observation. Significance levels (standard errors clustered at the county level in brackets): *** 0.01, ** 0.05, * 0.1.

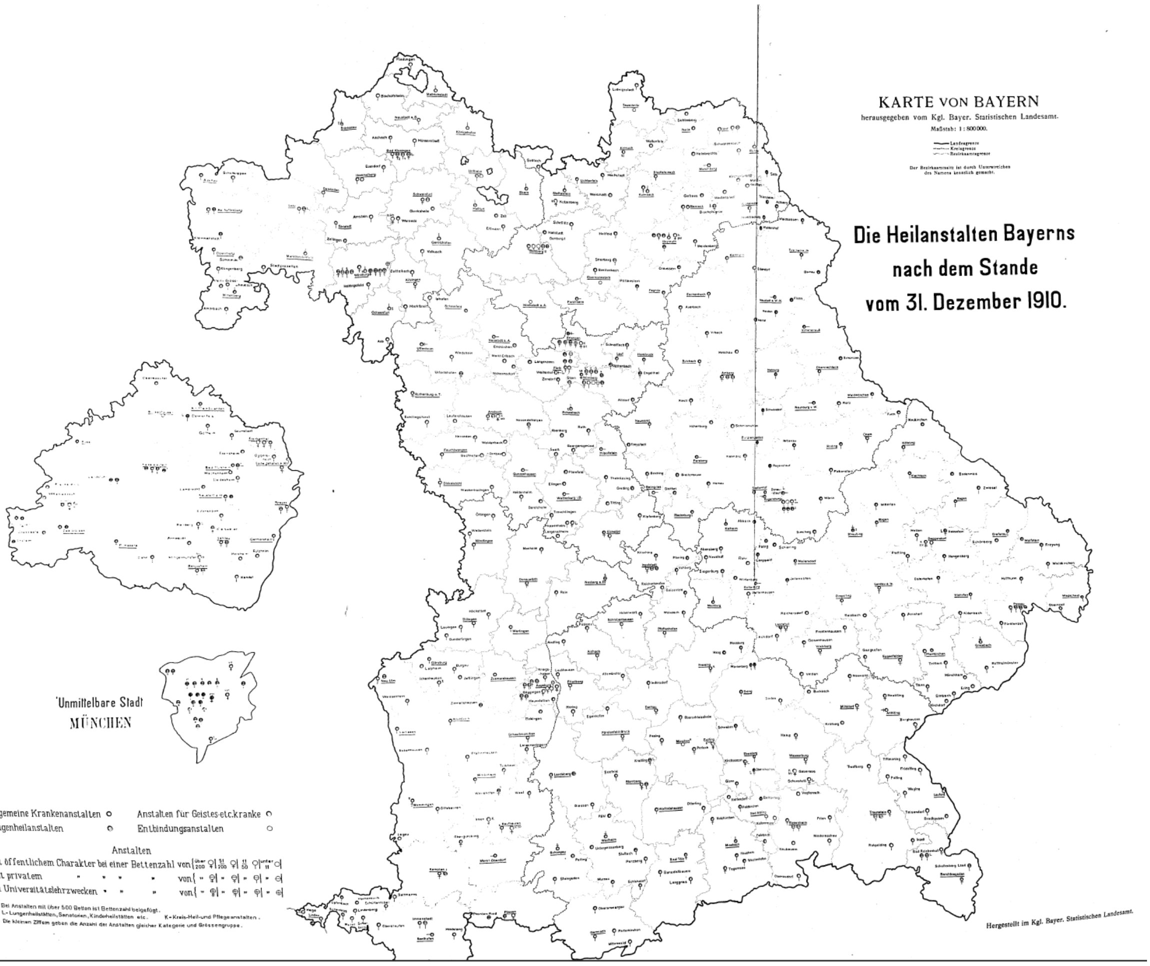
A Supplementary material

Figure A1: Hospital beds in Bavaria 1910 and 1918



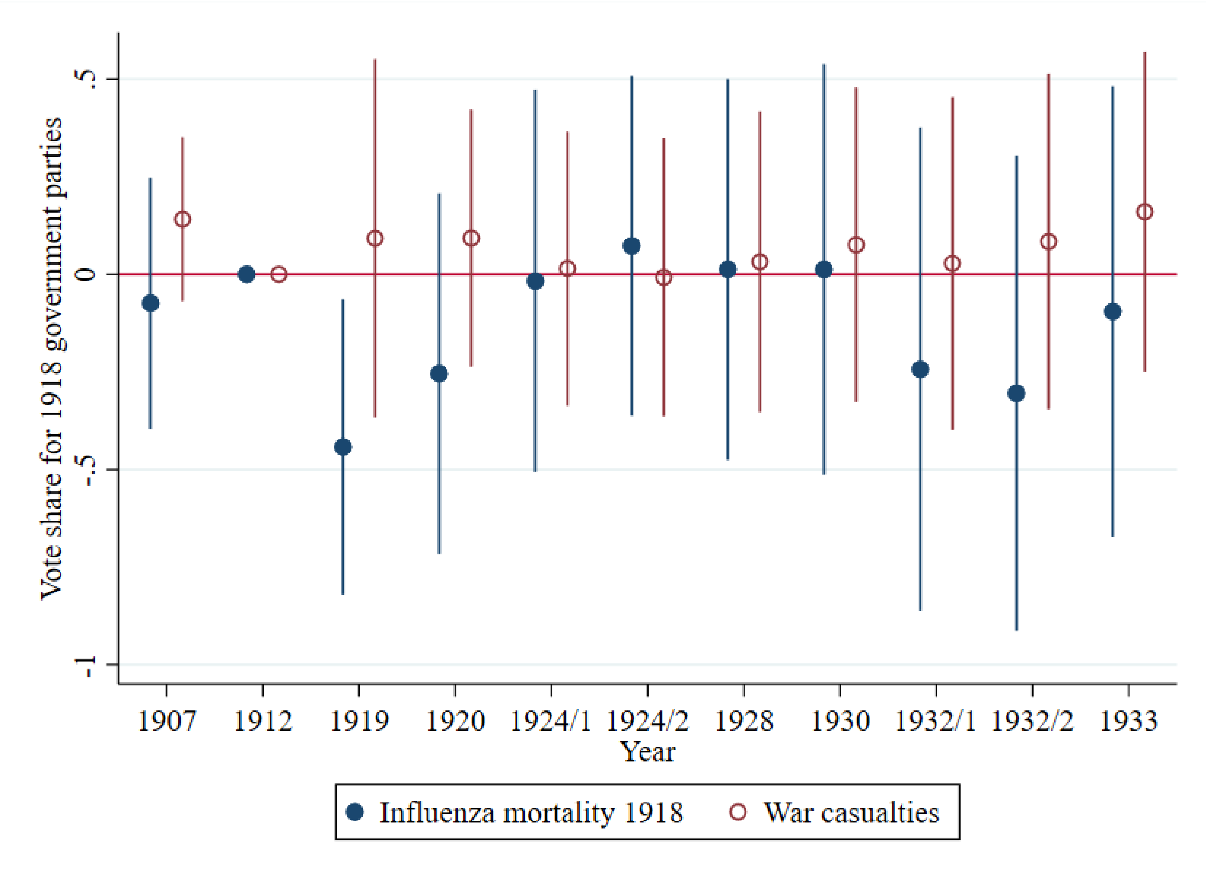
Notes: The figure shows the number of hospital beds per 1,000 inhabitants in Bavaria 1910 and 1918. Source: Bayerisches Statistisches Landesamt (1913). *Statistisches Jahrbuch für das Königreich Bayern.* München: J. Lindauersche Buchhandlung (Schöpping); Bayerisches Statistisches Landesamt (1921). *Statistisches Jahrbuch für den Freistaat Bayern.* München: J. Lindauersche Buchhandlung (Schöpping).

Figure A2: Hospitals in Bavaria 1910



Notes: The figure shows the regional distribution of hospitals in Bavaria 1910. Source: Bayerisches Statistisches Landesamt (1912). *Zeitschrift des K. Bayerischen Statistischen Landesamts.* München: J. Lindauersche Buchhandlung (Schöpping).

Figure A3: Influenza mortality 1918 and war casualties 1914–1918



Notes: The graph shows the results of fixed effects OLS estimations using the vote shares in German national elections for the 1918 government parties as dependent variable. Coefficients of mortality variables and the respective election year between 1907 and 1933 are shown. Solid circles (blue) represent coefficients of influenza mortality. Hollow circles (red) represent the coefficients of war casualties 1914-1918. Bavarian counties are the unit of observation. Standard errors are clustered at the county level and 95% confidence intervals are shown.

Table A1: Mortality

	Mortality		
	All	Cities	Rural
	(1)	(2)	(3)
Hospital beds × Year 1915	-0.050	0.097	0.086
	(0.099)	(0.106)	(0.079)
Hospital beds × Year 1916	-0.067	0.007	-0.082
	(0.056)	(0.056)	(0.067)
Hospital beds × Year 1917			
Hospital beds × Year 1918	-0.139*	-0.039	-0.173**
	(0.073)	(0.074)	(0.069)
Hospital beds × Year 1919	0.026	0.048	0.058
	(0.056)	(0.079)	(0.068)
Hospital beds × Year 1920	-0.030	0.034	-0.021
	(0.086)	(0.117)	(0.069)
Hospital beds × Year 1921	-0.050	0.041	-0.106
	(0.068)	(0.066)	(0.081)
Mean dep. var.	16.727	17.102	16.624
Counties	205	44	161
Obs.	1,429	308	1,121
County fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Within R^2	0.492	0.364	0.566

Notes: The table shows the results of fixed effects OLS regressions using the (female) mortality rates as dependent variable. Column (1) refers to the full sample, columns (2) to (3) are subsamples. Hospital beds are per 1,000 inhabitants and refer to the year 1910. Significance levels (standard errors clustered at the county level in brackets): *** 0.01, ** 0.05, * 0.1.

Table A2: Robustness tests

	Vote share for 1918 government parties						
	Baseline	w/o war census	SPD	Mortality 1915-1917	Controls	Time trends	War casualties
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Influenza mortality 1918	-0.346	-0.389	-0.351	-0.053	-0.179	-0.390	-0.479
	(0.355)	(0.360)	(0.347)	(0.341)	(0.343)	(0.364)	(0.370)
Influenza mortality 1918 × Year 1919	-0.441**	-0.422**	-0.707**	-0.341*	-0.384*	-0.353*	-0.429**
	(0.191)	(0.185)	(0.328)	(0.175)	(0.205)	(0.187)	(0.188)
War casualties							-1.054***
							(0.320)
War casualties × Year 1919							0.092
							(0.235)
Mean dep. var.	25.896	25.896	24.740	25.896	25.896	25.896	25.896
Counties	205	205	205	205	205	205	205
Obs.	410	410	410	410	410	410	410
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.316	0.369	0.303	0.364	0.636	0.378	0.393

Notes: The table shows the results of OLS regressions using the vote shares in German national elections for the 1918 government parties as dependent variable. The main explanatory variable is the influenza mortality 1918, which we interact with a dummy for the 1919 election. Districts fixed effects refer to the eight Bavarian districts as of 1919. Bavarian counties are the unit of observation. Column (1) reproduces our baseline findings in column (3) in Table 3. Column (2) excludes the war census of 1916 and 1917 from population interpolations. In column (3), we use only the vote share for the SPD as dependent variable. We use different reference years (1915, 1916, and 1917) in column (4) to calculate the influenza mortality 1918. We include controls in column (5) and time trends in column (6). In column (7), we also control for war casualties. Significance levels (standard errors clustered at the county level in brackets): *** 0.01, ** 0.05, * 0.1.

Table A3: Influenza mortality 1918 and nazi party vote shares

	NSDAP vote share			
	1928	1932/1	1932/2	1933
	(1)	(2)	(3)	(4)
Influenza mortality 1918	-0.195	-0.112	0.060	0.058
	(0.161)	(0.282)	(0.264)	(0.319)
Mean dep. var.	5.364	31.963	29.744	44.433
Counties	205	198	198	198
Obs.	205	198	198	198
District fixed effects	Yes	Yes	Yes	Yes
R^2	0.286	0.575	0.595	0.365

Notes: The table shows the results of OLS regressions using the Nazi party (NSDAP) vote share in German national elections as dependent variable. The main explanatory variable is the influenza mortality 1918. Districts fixed effects refer to the eight Bavarian districts as of 1919. Bavarian counties are the unit of observation. Significance levels (standard errors clustered at the county level in brackets): *** 0.01, ** 0.05, * 0.1.

B Data sources

We compile a dataset at the level of 205 Bavarian counties as of 1919. We track all boundary changes as best as possible for a consistent territorial status as of 1919 for all observations.

B.1 Election data

National elections 1907, 1912, 1919, 1920, 1924/1, 1924/2, 1928, 1930, 1933: National election data for the 1907, 1912 and 1919 elections are from the Bavarian State Statistical Office (Bayerisches Statistisches Landesamt (1912). *Zeitschrift des K. Bayerischen Statistischen Landesamts.* München: J. Lindauersche Buchhandlung (Schöpping); Bayerisches Statistisches Landesamt (1919). *Zeitschrift des Bayerischen Statistischen Landesamts.* München: J. Lindauersche Universitäts-Buchhandlung (Schöpping)). Data for national elections from 1920 to 1933 are retrieved from Falter, J. W. and Hänisch, D. (1990). Wahl- und Sozialdaten der Kreise und Gemeinden des Deutschen Reiches von 1920 bis 1933. GESIS Datenarchiv, Köln. ZA8013 Datenfile Version 1.0.0, https://doi.org/10.4232/1.8013.

B.2 Mortality data

Influenza mortality: We compute female influenza mortality per 1,000 female inhabitants as described in the paper. We retrieve data on the deaths by gender for the years 1915 to 1921 from the Bavarian State Statistical Office (Bayerisches Statistisches Landesamt (1919, 1920, 1921, 1922, 1923). *Zeitschrift des Bayerischen Statistischen Landesamts.* München: J. Lindauersche Universitäts-Buchhandlung (Schöpping)).

War mortality: We calculate the sum of all war causalities 1915-1918 per 1,000 inhabitants. Data on war causalities from 1914 to 1918 are from the Bavarian State Statistical Office (Bayerisches Statistisches Landesamt (1919, 1920, 1921). *Zeitschrift des Bayerischen Statistischen Landesamts.* München: J. Lindauersche Universitäts-Buchhandlung (Schöpping)).

B.3 Infrastructure data

Hospitals and hospital beds: We use the number of hospitals per 1,000 capita and the number of hospital beds per 1,000 capita in the year 1910. Data on hospitals and hospital beds are obtained from the Bavarian State Statistical Office (Bayerisches Statistisches Landesamt (1912). *Zeitschrift des K. Bayerischen Statistischen Landesamts*. München: J. Lindauersche Buchhandlung (Schöpping)).

B.4 Other data

Population: We use population data from the 1910 (Bayerisches Statistisches Landesamt (1919). *Zeitschrift des Bayerischen Statistischen Landesamts*. München: J. Lindauersche Universitäts-Buchhandlung (Schöpping)), 1919 (Bayerisches Statistisches Landesamt (1920). *Zeitschrift des Bayerischen Statistischen Landesamts*. München: J. Lindauersche Universitäts-Buchhandlung (Schöpping)), and 1925 census (Bayerisches Statistisches Landesamt (19126). *Zeitschrift des Bayerischen Statistischen Landesamts*. München: J. Lindauersche Universitäts-Buchhandlung (Schöpping)) and from the 1916 and 1917 war censuses (Bayerisches Statistisches Landesamt (1919). *Die Kriegs-Volkszählungen vom Jahre 1916 und 1917 in Bayern, Beiträge zur Statistik Bayerns*, vol. 89. München.).

Share of Catholics 1910: We compute the population share of Catholics. We retrieve the number of Catholics per county from the 1910 census (Bayerisches Statistisches Landesamt (1919). *Zeitschrift des Bayerischen Statistischen Landesamts*. München: J. Lindauersche Universitäts-Buchhandlung (Schöpping)).

Cities 1919: We use the classification into cities (*Kreisunmittelbare Städte*) and rural counties (*Bezirksämter*) according to the 1919 administrative status (Bayerisches Statistisches Landesamt (1920). *Zeitschrift des Bayerischen Statistischen Landesamts*. München: J. Lindauersche Universitäts-Buchhandlung (Schöpping)).