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Controlling Tuberculosis? Evidence from the Mother of all Community-Wide Health Experiments*

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Abstract

This paper studies the immediate and long-run mortality effects of the first community-based health intervention in the world, which had a particular focus on controlling tuberculosis – the so-called Framingham Health and Tuberculosis Demonstration. Comparing death and TB-mortality rates between Framingham and seven (pre-selected) control towns during the Demonstration period between 1917 and 1923, the contemporary official evaluation committee concluded that the Demonstration was highly successful in controlling TB and reducing mortality The Framingham Demonstration subsequently became a health example for the world. The findings in our paper question this very positive assessment. We collected and digitized causes-of-death data for towns/cities in Massachusetts and the United States for the period 1901-1934, allowing us to extend the number of control towns (or cities) and study whether the Demonstration reduced mortality in the long run. Compared to the official seven controls towns, we find that TB mortality in Framingham was on average lower between 1917 and 1923. In the extended control samples, these immediate TB mortality differences are smaller and often more than reversed by 1934. However, we do find robust evidence that the Demonstration reduced infant mortality, and these improvements persisted even after the Demonstration ended.

Key Words: Public Health; Health Demonstration; Tuberculosis Mortality; Infant Mortality

JEL: I15; I18; N32

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1 Introduction

In the United States, the tuberculosis (TB) mortality rate fell from above 200 in the beginning of the 20th century to circa 60 per 100,000 in the mid-1930s (Cutler and Meara, 2004). Was this decline mainly due to public health policies? So far, research has provided different answers to this question. In his classic work, McKeown (1976) argued that public policy played a limited role in reducing TB mortality prior to antibiotics.[1] By contrast, Preston (1975), Szreter (1988), Cutler et al. (2006), and others highlight the important role of various public health interventions that were set in motion by the germ theory of disease in the 1880s.[2]

In this paper, we contribute to the debate on the success of public health policies in the pre-antibiotic era by evaluating the first public health demonstration in the world known as the Framingham Community Health and Tuberculosis Demonstration.[3] Funded by the Metropolitan Life Insurance Company, the (Framingham) Demonstration was carried out by the National Tuberculosis Association (NTA) and has ever since then been widely regarded as successful in combating TB at the time. Shryock (1957: p.167) mentions that the earlier work of the NTA can hardly be said to have proven the validity of its program; an observation that Anderson et al. (2017) confirm empirically. Even in the 1910s, there were doubts about the degree to which the efforts of the NTA had played any role in the decline in the TB death rate, and the situation therefore seemed to call for some demonstration of what a concerted public-health program actually could achieve under controlled conditions. The town of Framingham was ultimately chosen for such a demonstration. The NTA subsequently used the Demonstration for justifying its general philosophy and program (Shryock, 1957: p.169). In fact, it is still believed to have been successful: Kannel and Levy (2005), for example, conclude that the Demonstration not only showed that TB could be controlled but that the approach taken by the Demonstration could be a foundation for the investigation of the causes and control of other

[1] McKeown, along with Fogel (1994, 1997), emphasize the role of nutritional improvements as a main factor behind the mortality decline. Egedesø (2018) reports evidence on this based on data for US prisons. He finds that increases in spending on provisions per prisoner can explain about 26 percent of the prison mortality decline. Moreover, recent research by Anderson et al. (2017) partly supports McKeown's conclusion regarding public health policy, and finds that the first campaign against TB had limited success prior to 1918 in the United States.

[2] Empirical work supporting that clean water and sanitation mattered includes Cutler and Miller (2005), Ferrie and Troesken (2008), Clay et al. (2014), and Alsan and Goldin (forthcoming). Regarding TB, research by Hollingsworth (2014) and Egedesø et al. (2017) suggests that interventions targeted at TB were, in fact, successful in the pre-antibiotic era.

[3] An article in the Boston Globe from March 18, 2016 states that, according to Framingham History Center executive director Anne Murphy, the Framingham Demonstration was the first community-based participatory health study in the world.

chronic diseases that impact the population. If so, this would suggest that public health policies targeted at TB had the potential to be more widely successful. Yet, there is little systematic research on the Demonstration and other historical health demonstration projects that tested new models of health care delivery in selected urban and rural communities in the United States, as also pointed out by D'Antonio (2017). Further, as a part of modern US health policy, the Center for Medicare and Medicaid Services (CMS) Innovation Center launches health innovation demonstration projects.[4]

The Demonstration was made possible by a donation of 200,000 US dollars (about 4.5 million dollars in present day terms) made by the Metropolitan Life Insurance Company to the National Association for the Study and Prevention of Tuberculosis in 1916. The insurance company was motivated by the fact that a large number of policy holders died of TB. In late 1916, Framingham, Massachusetts, was chosen as a typical American community, and the Demonstration was carried out from 1917 to 1923 with increased efforts to control TB through a consultation service, among other initiatives. The Demonstration also expanded infant welfare services with nurses making home visits. Immediately after conclusion of the Demonstration in 1923 an official evaluation concluded that the numbers of TB deaths and infant mortality decreased more in Framingham compared to similar communities during the Demonstration period 1917-1923. Shryock (1957: p.168) summarizes the results and reports that infant mortality fell from 76 per 1,000 live births in 1916-1917 to 49 in 1922-1923. The TB mortality rate fell from 121 per 100,000 (for 1907-1916) to 38 in 1923, which constitutes a fall of 69 percent. This was compared with that of seven control communities in which the fall was 32 percent (Monograph No. 10, 1924: p.40).[5] Shryock (1957: p.169) interprets this as "evidence that a planned application of medical principles, both general and specific, could indeed hasten the decline of the disease". Given its historical nature, the evaluation made after the Demonstration, which in spirit is similar to a difference-in-differences (DD) type estimation, did not take into account statistical uncertainty and, therefore, did not consider the possibility that the outcome could have been a statistical artifact.

[4]D'Antonio (2017) gives some details on the the Center for Medicare and Medicaid Services (CMS) Innovation Center. Its $10 billion budget has given rise to demonstration projects to increase the access to high-quality, cost-effective, and coordinated healthcare for beneficiaries of Medicare, Medicaid, and state-based children's health insurance programs. The objective of the CMS Innovation Center is to rigorously and rapidly assess the progress of these demonstrations and to replicate those with a "high return on investment" in communities across the country.

[5]The NTA published 10 Monographs on Framingham. In the text, we refer to these volumes as, for example, Monograph No. 1 for the first volume, and so on.

Thus, the official evaluation (Monograph No. 10, 1924) used seven pre-selected control communities in Massachusetts to measure whether the Demonstration reduced TB mortality in Framingham during the Demonstration period (1917-1923). Digitizing official vital statistics for Massachusetts towns and cities for the period 1901-1934, we extend the number of control towns (or cities) and study whether the Demonstration reduced TB mortality during the Demonstration period and in the long run. We supplement these data by collecting city level total mortality rates and pulmonary TB deaths for cities throughout the United States for the same period. These mortality data sets allow us to study the Demonstration more systematically and to apply methods that take into account that we have only one treated unit. This means that we do not only apply DD estimation as in the spirit of the original study, but that we also use the method for inference with few treated units of Conley and Taber (2011) and the synthetic control method pioneered by Abadie and Gardeazabal (2003) and Abadie et al. (2010). The two latter methods are designed to deal with setups with few or only one treated unit, as in our study (i.e., Framingham).

Overall, our findings generally question the very positive conclusions in Monograph No. 10 (1924) and Shryock (1957). In particular, our simple DD strategy suggests that while TB mortality decreased significantly during the Demonstration period, these improvements were more than reversed in the 10 years following the Demonstration, so we do not find any evidence of sustained reductions in TB mortality as a result of the Demonstration. For example, in the baseline sample of 89 towns and cities in Massachusetts, we estimate that the pulmonary TB mortality rate on average declined by 13 percent during the Demonstration period and subsequently increased by 18 percent from 1924 to 1934 in Framingham.[6] The estimates are even more dismal when compared to cities across the United States. Yet, when we take into account that only one unit was treated, most of our evidence suggests that there is no discernible effect on TB mortality. Our findings therefore have at least two plausible interpretations: First, the Demonstration might have had only temporary positive effects (during the Demonstration period), which were subsequently completely reversed. Second, the pattern in the data is also consistent with the Demonstration having no significant effect on TB mortality. Importantly, both interpretations imply that the original conclusion regarding the effect of the Demonstration on TB was incorrect. However, our analysis does confirm the observation that the Demonstration

[6] We obtain similar findings when including 192 towns and cities in Massachusetts for which we have data on TB mortality throughout the period from 1901 to 1934.

had a negative on infant mortality during the Demonstration. We find that this negative effect is unlikely to be observed by chance and that it even persisted after the Demonstration ended, from 1924 to 1934.[7]

Apart from studying whether the Framingham Demonstration was in fact effective, and thereby contributing to the literature on the causes of the historical mortality decline in the United States, the paper also speaks to whether the approach taken in Framingham could have value in combating TB (and other diseases) in today's developing countries. After all, TB is a major global health problem ranking alongside HIV as a leading cause of death, and consequently reductions in TB mortality as well as infant and child mortality are part of the UN's third sustainable development goal.[8]

The rest of the paper is organized as follows. Section 2 provides historical background on the Framingham Demonstration explaining the intervention in detail. Section 3 describes the data collected. Section 4 presents the empirical strategy. Sections 5 and 6 report the results. Section 7 concludes.

2 Historical background

This section provides more details on the Framingham Community Health and Tuberculosis Demonstration as well as other background material. We first describe the background for the donation to the National Association and why Framingham was chosen as the location for the Demonstration. Second, we describe the key elements of the Demonstration. Third, we discuss other demonstrations that followed after the Framingham Demonstration. Finally, we take an initial look at the differences between Framingham and other towns and cities in the United States in terms of pulmonary TB.

2.1 The donation and the choice of location

In May 1916, the Metropolitan Life Insurance Company donated USD 100,000 to the National Association for the Study and Prevention of Tuberculosis (NTA). The gift was given for the

[7] We also do not find any evidence of spill-over effects of the Demonstration to nearby communities as measured by distance to Framingham.

[8] Besides the fact that reducing mortality is obviously important for human welfare in itself (e.g., Becker et al., 2005; Jones and Klenow, 2016), several papers have documented that health (or mortality) is an important impetus for economic productivity and human-capital production (e.g., Bleakley, 2007; Hansen 2013; Bütikofer and Salvanes, 2015). Nevertheless, Acemoglu and Johnson (2007) document that the mortality improvements observed from 1940 onwards in developing countries were not associated with increasing income.

purpose of carrying out a community health and TB demonstration. The insurance company had an interest in the demonstration, as 16 percent of the deaths in its industrial department were due to TB. In 1915, the company paid claims of over 4 million dollars on the lives of 14,325 policy holders dying from the disease (Monograph No. 1, 1918: p.9). The purpose of the investigation was to demonstrate what may be possible with a united action of prevention and control of TB (Monograph No. 1 1918: p.12). Soon after the Demonstration had begun, it was deemed impossible to fight TB without carrying out a program for improving the general health of the community. By mid-1919, all Demonstration activities were under way, and it was too soon to judge their effects (Shryock, 1957: p.168). To allow activities to continue, the insurance company increased the appropriation to 200,000 US dollars and the Demonstration was therefore able to run for a period of seven years (Social Work Handbook, 1933: p.204).

Initially, the location of the Demonstration had not been determined. In November 1916, the choice fell on Framingham, a town located 21 miles west of Boston (D'Antonio, 2017; Monograph No. 1, 1918); see also the town/city map of Massachusetts and the United States in Figure 1. It was a "typical community" of second and third generation white Irish Americans, whose immigrant population of 27 percent mirrored that of the United States as a whole (d'Antonio, 2017: p.22). Monograph No. 1 (1918: p.13) describes Framingham as a community with mixed industries, varied racial groups, a good health organization linked with an excellent State Department of Health, a normal amount of disease – particularly tuberculosis, well trained physicians, and good hospitals. Moreover, Monograph No. 10 (1924: p.16) adds that the town was an autonomous, economically independent, and essentially non-commuting settlement. Framingham is also described as an average town with the properties mentioned above and "a sufficient promise of cooperation from medical, industrial, commercial and social organizations to give reasonable assurance of success" (Monograph No. 10, 1924: p.17).

[Figure 1 *about here]*

2.2 The elements of the Demonstration

As mentioned above, the Demonstration ran from 1917 to 1923. It included several elements that may be grouped under primary research activities and health services. We also provide a description of the evolution of health services based on the Board of Health Reports.

2.2.1 Primary research activities

The first year of the Demonstration was mainly devoted to primary research activities. As detailed in the Monographs No. 2, 5, and 6, these research activities included a sickness survey,[9] the Von Pirquet Tuberculin Survey of children, and studies of the sanitary conditions in schools and factories. In 1918, a tuberculin survey of cattle was carried out. Research and investigation constituted roughly 52 percent of the costs incurred as part of the Demonstration in 1917, which had decreased to 17 percent by 1922 (Monograph No. 10, 1924: p.46).

Shryok (1957: p.169) notes that the research activities produced a number of by-products. They not only resulted in a medical survey of the population in the course of which many children were tuberculin tested, but also in the systematic use of X-ray as a diagnostic aid.

2.2.2 Establishment and expansion of services

Consultation service During the first year of the of the Demonstration, a consultation service was established (Monograph No. 10, 1924: p.51). Dr. P.C. Bartlett was the chief medical examiner and expert consultant. His job included helping local Framingham physicians with diagnosing TB. This helped to increase the number of known TB cases from 27 to 185 as well as the number of active cases from 13 to 59 (Monograph No. 10, 1924: p.10). Related to diagnosis, Comstock (2005: p.1189) points out that the use of methods such as "fluoroscopy was almost routine and chest radiographs were made when indicated. Both were rarely available in small towns at that time". In line with this, Shryok (1957: p.169) emphasizes that Framingham was the earliest instance in which expert consultation services were made available to local practitioners for the diagnosis of pulmonary and cardiac conditions. The consultation service also acted as a connecting link between "physicians and patients, between the patients and treatment, and between physicians and scientific knowledge and methods" (Monograph No. 10, 1924: p.10). Matson (1924) believed that the consultation service was the most valuable of the services set up by the Demonstration. He described the service as "an expert consultation service, offering consultations to local physicians, factory medical and nursing staffs on cases of suspected tuberculosis, or respiratory infections". He also emphasizes the importance of the expert consultant Dr. Bartlett for the success of the consultation service.[10]

[9] Shryock (1957) notes that the sickness survey covered 38.7 percent of the Framingham population.

[10] Regarding what he deems to be the success of the consultation service, Matson (1924: p.8) writes that "this has been largely due to the highly efficient consultation service in charge of Dr. P.C. Bartlett, who with scientific skill and exceptional tact and judgment, has made the service one of the most valuable features of the

Infant welfare work Initially, infant welfare work was carried out and expanded by a private organization called the Civic League, which itself was established in 1917 (Monograph No. 10, 1924: p.33). From 1920, this work was taken over and expanded by the board of health, which established infant welfare clinics. According to the 1921 Framingham Board of Health report, the work of the infant welfare department consisted in ensuring that 1) prospective mothers received adequate care; 2) mothers were taught the value of fresh milk for their babies and were instructed not to wean them too soon; 3) mothers who were not fortunate enough to have mothers' milk, obtained good cow's milk for their babies; and 4) mothers were taught when and how to begin to give their children foods other than milk. The 1920 Framingham Board of Health report explains that babies attending the clinic would be weighed and examined by a clinic physician and that directions would be given to see the family physician when necessary. Other activities after 1919 included hiring one visiting TB nurse, two infant and pre-school nurses, and three part-time infant welfare physicians as well as establishing an infantile paralysis clinic and one venereal disease clinic (Monograph No. 10, 1924: p.32).

Existing services The Demonstration also implied an expansion of existing services. The budget for health work in the Framingham schools quadrupled from USD 1,500 to USD 6,000. The health department was also more active in TB work and work on sanitary conditions. The leading industry in Framingham increased its nursing and clinical work. Moreover, there was also increased coordination among voluntary health agencies (Monograph No. 10, 1924: p.30). Other changes to health services included provision of dental services in the industries and the increased fraction of pasteurized milk available in the community. In addition, the Demonstration published "Health Letters", which provided health education and ran five children summer camps (Monograph No. 10, 1924: p.62).

Spending on health services The spending on health services increased from USD 6,400 in 1916 to USD 50,000 in 1923, with both Demonstration spending and the spending by private and public agencies contributing to the increase. In per capita terms, this was an increase from USD 0.40 per capita in 1916 to USD 2.75 in 1923 (Monograph No. 10, 1924: p.47).[11]

demonstration, and utilised by nearly all local physicians".

[11] Shryock (1957) notes that the spending levels per capita at the end of the Demonstration became desirable public health expenditure levels for other communities.

2.2.3 Services provided by the Board of Health

To obtain information on which services were publicly provided before, during, and after the Demonstration, we have read through the annual reports of the Framingham Board of Health for the years 1910-1930. The annual reports of the Board of Health reveal how health spending was distributed within one of the central units in the Framingham Demonstration. Moreover, they contain information on some of the services provided by the Board of Health.

The spending in the years 1913-1916 reveals that there were some developments taking place prior to the Demonstration. In the years 1913-1914, about a quarter of the budget went towards care of "contagious cases". Other significant spending was on inspections of slaughtering and on plumbing. In 1915, a small amount was spent on a TB dispensary, which was founded in that year. This appears to have been the main new activity of the Board of Health prior to the Demonstration. There is no budget printed in 1917, but from 1918 expenses on laboratory equipment and management are added. From 1920, spending on the Infant Welfare department is included along with the names of two infant welfare nurses and the reports from 1920-1930 all contain descriptions of or references to infant welfare clinics. In line with the narrative above, the 1920 report mentions that the Board of Health took over the infant welfare work from the Civic League.

The 1924 report (p.255) states that the death of Dr. Bartlett had left Framingham without an expert on TB. His death had led to the suspension of the consultation service (p.259). The 1925 report further states that the consultation service, which focused on TB and was established as a vital part of the Demonstration, had been replaced by a weekly clinic. Moreover, a monthly clinic was operated by the State Board of Health, which also provided services for 13 surrounding towns.[12] For the subsequent years, there are only references to one consultation service in the Framingham Board of Health reports. Interestingly, the 1924 report associates an increase in TB cases and deaths with Dr. Bartlett's death: "The reported cases of tuberculosis as well as the deaths from the disease showed a considerable increase. In our opinion this increase is directly due to the suspension of consultant service as a result of the death of Dr. Bartlett" (Board of Health Report, 1924: p.259). It also seems that the new clinic examined fewer cases. Bartlett (1918, annual meeting) reported that the consultation service examined about 15 patients per month. By contrast, the annual Board of Health Reports mention a number of about 5 to 6 per

[12] The annual report of the State Board of Health also mentions this clinic in 1925, but there is no reference to it in later volumes.

month (1927 and 1928 reports).

2.3 Other health demonstrations

According to Monograph No. 10 (1924: p.9), the Demonstration was a frontrunner of many demonstrations of similar character. Monograph No. 10 (1924) contains the following list of demonstrations: the Hagerstown, Maryland, health demonstration; the Mansfield child health demonstration; the child health demonstrations by the American Child Health Association in Fargo, North Dakota, in Athens, Georgia, in Rutherford County, Tennessee, and on the Pacific Coast; the Detroit Tuberculosis Demonstration; the Metropolitan Life Insurance Company infant welfare demonstration in Thetford Mines, Quebec; and the tuberculosis and health demonstration in Montreal. The list illustrates that demonstrations were carried out in different parts of the United States and also spread to Canada.[13]

To consider an example of the similarities to the Framingham Demonstration, we focus on the Milbank Memorial Fund health demonstrations carried out in selected communities in New York State. The fund chose a rural county, a medium-sized city, and a district in New York City for its demonstrations. The Health Demonstration was carried out in Syracuse from 1923 to 1930, which saw an increase in health spending from USD 175,000 to USD 350,000 (see, e.g., Social Work Yearbook, 1933: p.205). Unlike the Framingham Demonstration, this health demonstration was funded by a general purpose fund.[14] The Syracuse demonstration saw "the appointment of the first full-time health commissioner, the development of a generalized public health nursing service, the improvement of tuberculosis services and of measures for communicable disease control, the centering of a complete child welfare program, under the direction of a Bureau of Child Hygiene, the immunization in the years 1923-1929 of 27,320 children against diphtheria [...]" (Anonymous, 1930: p.51). As can be seen, the focus on TB and infant welfare is similar to the one in Framingham, which underlines the fact that the Framingham Demonstration was the source of inspiration.

2.4 Tuberculosis in Massachusetts and the United States, 1901-1934

As the Demonstration had a strong focus on TB, we provide a brief description of the disease and how it evolved in Framingham, Massachusetts, and the whole of the United States. As

[13]Health demonstrations were also carried out in France by the Rockefeller Foundation.
[14]https://www.milbank.org/about/history/

for TB itself, the disease is caused by the bacteria of the Mycobacterium tuberculosis complex (discovered by Robert Koch in 1882). The most common type of TB is pulmonary TB, but TB can also affect other organs.[15]

As shown in Figure 2, pulmonary TB mortality was high in the early 20th century but was then in decline throughout the period when we consider the mortality rate for Framingham and other towns and cities in Massachusetts from 1901 to 1934 (Panel B).[16] The level for Framingham is mostly seen to be lower than the one for other towns and cities. There is no clear break during the period of the Demonstration. In Panel A of Figure 2, we compare Framingham to the seven control communities in Massachusetts chosen prior to the Demonstration: Chicopee, Clinton, Fitchburg, Gardner, Marlboro, Milford, and North Adams (Monograph No. 10, 1924: p.39). The Framingham monographs are silent on why these cities and towns were chosen, but they do mention that the control communities were chosen with the advice of the Massachusetts State Health Department.[17] Relatively lower pulmonary TB rates become visible a few years prior to 1917 and remain during the Demonstration in Framingham, but then at the end of the 1920s, Framingham looks like the control communities. In the 1930s, Framingham saw some reductions in pulmonary TB mortality, but at the of the period the rate was on the rise again. Thus, the visual impression is that Framingham had lower pulmonary TB mortality rates than other Massachusetts towns and cities, but compared to the control cities, the differences are only clearly visible during the Demonstration as well as a few years before.

[Figure 2 about here]

Monograph No. 10 (1924: p.40) also indicates that Framingham saw a large reduction in TB mortality in comparison to US cities outside Massachusetts. To get some initial impressions on this, we plot TB mortality in US cities outside of Massachusetts in Appendix Figure A.1. The overall impression is that Framingham had lower pulmonary TB mortality than other US

[15]Transmission of TB occurs by inhalation of infectious droplet nuclei containing viable bacilli, known as aerosol spread. Mycobacteria-laden droplet nuclei are formed when a patient with active pulmonary TB coughs or sneezes, and they can remain suspended in the air for several hours. After the initial infection with Mycobacterium tuberculosis, the individual either clears the infection, contains the infection without symptoms but with the bacilli remaining (i.e., latent TB infection), or develops active TB (Hemskerk et al., 2015).

[16]We use towns and cities with populations from 5,000 inhabitants up to 50,000 inhabitants.

[17]In the empirical analysis, we calculate the DD estimate implied by these rates and compare them to place-based mortality rates and find little differences. We also compare the control communities with Framingham on observable characteristics and find that Framingham was a much smaller community than the control communities. This warrants a closer look at how successful the Demonstration really was.

cities, and that the development is similar until the demonstration. During the Demonstration, pulmonary TB mortality does seem to decline more sharply than in US cities, but then after, it is on the rise again. Both figures indicate some reduction in Pulmonary TB mortality during the Demonstration period, yet do not reveal if this is something that could simply have happened by chance.

3 Data

Our data come from three principal sources. First, the "Annual report on the vital statistics of Massachusetts" published by the Division of Vital Statistics for the Commonwealth contain cause of death statistics and infant mortality for the period 1901-1934. Second, we obtain pulmonary TB mortality and total mortality for a balanced panel of US cities from the publication "Mortality Statistics" published by the US census bureau covering the same years as for Massachusetts. We have digitized both these datasets. Third, the following control variables (at the town/city level) are obtained from the full-count US Census microdata (IPUMS) in 1910 (Ruggles et al., 2015): Share of infants; Share aged 15-44; Share aged 60+; Share of foreign-born; and average Earnings score. We use MCD codes in order to aggregate and merge these data to the town/city level.

For the Massachusetts data set, we obtain a balanced panel of 192 towns and cities for pulmonary TB death and 89 towns and cities when restricting to cities with a population between 5,000 inhabitants and 50,000 inhabitants as we do in the baseline analysis. We refer the reader to Figure 1 and Appendix Tables A.1 and A.2 for an overview of which towns and cities are included. For infant mortality rates, the data are only available from 1915 and only for 38 cities. The US city dataset cover a balanced panel of 324 cities for the period 1901-1934 and 217 cities when restricting to cities with a population between 5,000 inhabitants and 50,000 inhabitants. Appendix Figure A.2 shows what cities and states are included in the database. We also obtained the total mortality rate for 36 Massachusetts towns and cities from the mortality statistics published by the census bureau.[18] We generally use log rates and interpolate when deaths are equal to zero to obtain a balanced panel.[19]

Regarding the quality of cause of death statistics for Massachusetts, Shryock (1957: p.62) observes that "Massachusetts led the way in the United States when, about 1870, it inaugurated

[18] Appendix Figure A.3 plots the total mortality rate for Framingham and the Massachusetts cities for comparison.

[19] The estimation results are robust to dropping missing values due to log transformations of zero deaths instead of interpolating.

the first reliable registration of deaths and their causes". The main features of an adequate system had been adopted and put into operation by 1890 (Gutman, 1959: p.411). Only one or two percent of the births and deaths that occurred in the state were not registered. Moreover, the returns of the causes of death had attained a high degree of accuracy and reliability according to Gutman (1959). Even so, this does not mean that the data contained no errors. During the period of the Demonstration, some cases of death from bronchitis were mistaken for deaths from pulmonary tuberculosis (Framingham Monograph 3, 1918: p.15): "It is unquestionable that the work of the demonstration will lead to better diagnosis of tuberculosis, and an increase in the registered mortality from the disease reasonably might be expected if this factor alone were operative".[20]

Regarding the data on TB deaths across US cities, Doege (1965) takes a skeptical view and notes that there is wide variation in quality and quantity in the evidence used to make death certificates. A more detailed discussion is in Jacobs (1912), who examined local, state, and census bureau statistics for TB mortality for cities above 30,000 inhabitants for the period 1900-1909. He argues that there are different sources of error for this period. First, he mentions that in a few cases the errors are simply typographical errors, which accounts for a number of minor differences in the data he examined. More importantly, he stresses that the classification of the cause of death may be a problem. For TB a source of error is that local and state registrars might have to face what he calls indefinite terms used by physicians in stating causes of death. For example, "bad cold" may have been bronchitis or pulmonary TB. Also, the census bureau believed that "chronic bronchitis" often meant "pulmonary TB". Similarly, local physicians might write "lung trouble" for pulmonary TB. He writes that some effort was being made by the census bureau to correct the mistakes by engaging in detailed correspondence with the registrar, but lack of funds prevented this from happening on a large scale. A final source of error is that local and state statistics sometimes compute deaths by residence rather than place, and Jacobs (1912: p.189) reports that this happened for some cities in New York State. Yet, Jacobs stresses that the census bureau is doing everything it can to correct the mortality statistics.[21]

[20]For the case of Denmark, Egedesø et al. (2018) emphasize that methods of diagnosis, such as X-rays and tuberculin tests, were in existence by 1910. The problem of misclassifying TB as bronchitis is mentioned but was mainly an issue in the 1890s according to these authors. In the case of Framingham, the use of X-rays was not common prior to the Demonstration, and as noted above this was uncommon for smaller towns. Also, tuberculin testing does not seem to have been common.

[21]While Jacobs assesses the statistics published by the census to be of better quality, the discussion in his article indicates that the census rates are based on the transcripts of the original returns of local or state officials, and so error in those will translate into error in the ones compiled by the census bureau.

The census bureau provides a section in "Mortality Statistics" on the accuracy of the data and in 1911, for example, evidence suggests that active pulmonary TB deaths were diagnosed correctly in 60 percent of the cases. By 1920, this is no longer highlighted and the statistics provided for that year suggest that the queries made to physicians by the census bureau about pulmonary TB diagnoses only increased the total number of TB deaths by 0.2 percent with a similar number for, e.g., 1922. By 1930, pulmonary TB deaths are no longer mentioned among the diseases affected by the queries to physicians regarding death certificates, though this is not true for other types of TB.

This discussion implies that while we do not claim that our data are error free, they are of high quality by historical standards. This is especially true for Massachusetts as discussed above. It is arguably also the case that data quality was improving over time as diagnoses got better, though they might not be of the same quality from all over the United States.

4 Empirical strategy

This section outlines our two empirical strategies, which aim at isolating the effects of the Framingham Demonstration on TB mortality and other causes of death.

The first strategy is a simple difference-in-differences (DD) framework, comparing TB mortality in Framingham to other towns and cities before and after the Demonstration started its work. Therefore, the estimation equation takes on the following form:

$$\log COD_{ct} = \sum_{j \in T} \beta_j \times Demo_{ct}^{\tau+j} + \phi_c + \phi_t + x'_{ct}\gamma + \varepsilon_{ct}, \tag{1}$$

where COD_{ct} is the pulmonary TB mortality rate (and later other causes of death) in town/city c in year t,[22] $\sum_{j \in T} Demo_{ct}^{\tau+j}$ is a set of lead/lag intervention dummies, such that $Demo_{c,t}^{\tau-10}$ is equal to one during the years 1901-1906 for Framingham (and zero otherwise), $Demo_{ct}^{\tau}$ is equal to one in 1917, $Demo_{c,t}^{\tau+1}$ is equal to one in 1918, .., $Demo_{c,t}^{\tau+6}$ is equal to one in 1923, and $Demonstration_{c,t}^{\tau+7}$ is equal to one in the following 10 years. So the estimated $\beta'_j s$ trace out the annual effect during the Demonstration period from 1917 to 1923 and the average "long-run effect" from 1924 to 1934, relative to the omitted pre-Demonstration years 1907-1916. We use exactly those comparison years since Monograph No 10. (1924) evaluated the effect on

[22] We use the pulmonary TB mortality rate instead of all forms of TB (as in the official evaluation) because this variable is present during all the years in the vital statistics, whereas more forms of TB are being added throughout the years. However, similar results are obtained if we use all forms of TB.

TB mortality of the Demonstration using the average TB mortality rate during those years for comparison. We also estimate variants of equation (1), where the annual intervention dummies for the period 1917-1923 are collapsed into just one (Demonstration) indicator, which then quantifies the average effect on TB mortality of the Demonstration during the active Demonstration period. Town/city and year fixed effects are given by ϕ_c and ϕ_t, respectively, and x'_{ct} denotes a set of town/city-level controls in 1910 (i.e., an occupational based measure of income, city-population size, share of foreign born, and measures of the age distribution), derived from the full-count US census microdata in 1910 (IPUMS), and interacted with an indicator taking the value one after 1916.[23]

In order to take into account possible serial correlation, we cluster the standard errors at the town/city level as a starting point. However, this approach is problematic as our framework only includes *one* treatment unit (i.e., Framingham); see, e.g., Conley and Taber (2011). For this reason, we also report results from a specification where data are collapsed into the two periods (before/after the Demonstration) as an alternative way of dealing with serial correlation without clustering. In addition, we show the distributions of coefficients from permutation of the treatment and control units (i.e., placebo-inference test method), akin to Abadie et al. (2010) and Conley and Taber (2011), from which so-called "empirical p-values" can be inferred.

Following Abadie et al. (2010), the second empirical strategy uses the synthetic control method (SCM). Compared to the DD strategy outlined above, the SCM approach is more data driven in selecting the control units. In particular, our DD design includes all towns/cities with a population of 5,000 to 50,000 in 1915 and then adds controls for differences in pre-Demonstration demographic/economic characteristics. The SCM assigns weights to the pool of control units in order to construct a so-called synthetic Framingham, which, after the Demonstration started in 1917, provides us with an idea of the counterfactual path for Framingham, and the gap between the observed path and the synthetic path is then the effect of the Demonstration on TB mortality. Our predictors of the (log) TB mortality rate in the pre-Demonstration period (1900-1916) are: the (log) TB mortality rate from 1911 to 1916, population size, (log) occupational earnings score per worker in 1910, share of foreign-born in 1910, share of the population in the age interval 15 to 44, and share of the population older than 60 (both measured in 1910). The pool of donors include the same towns and cities as in the DD strategy. To evaluate the significance of

[23]The reason why these cross-sectional measures are interacted with an indicator is that they would otherwise be absorbed by the town/city fixed effects. The main idea is that these pre-Demonstration characteristics could matter for the development of TB after the Demonstration started.

these SCM estimates, we follow Abadie et al. (2010) and use a placebo test based on the SCM approach. The logic is the same as when applying the placebo test within the DD framework: For each control town/city in the donor pool, a synthetic path is generated leveraging the SCM, which can be compared to the observed path for the TB mortality rate. If these false gaps are similar to the gap for Framingham, then the interpretation is that the Demonstration did not have any significant effects in reducing TB mortality in Framingham.

5 Towns and cities in Massachusetts

5.1 TB mortality

The final publication in the Framingham series of monographs (Monograph No. 10, 1924) provides an overview of the most important findings of the Demonstration. This includes an evaluation of (TB) mortality in Framingham, compared to the official Massachusetts control towns (i.e., Chicopee, Clinton, Fitchburg, Gardner, Marlborough, Milford, and North Adams), before and after the Demonstration was carried out, making it possible to calculate DD estimates. The official (log) TB mortality rates in Framingham and the MA control towns are repeated in columns 1 and 2 of Table 1.[24] Comparing the (log) TB mortality rates between Framingham and the control towns for the years 1917, 1918, . . . , 1923 relative to the average (log) TB mortality rate during the pre-Demonstration (1906-1917), we derive the DD estimates reported in column 3 of Table 1. Taken at face value, they show that the Demonstration reduced the TB mortality rate throughout the entire Demonstration period; from a reduction of 24 percent during the first year to a 91-percent reduction in 1921, and a 75-percent reduction in the final Demonstration year. Accordingly, the average reduction throughout the Demonstration period was around 60 percent (not reported). It is therefore not at all surprising that Monograph No. 10 (1924) viewed the Demonstration as being very successful in terms of reducing TB mortality, and the results from this first community-wide Demonstration in fact stimulated the expansion of the tuberculosis programs throughout the United States as well as other similar types of interventions, as also discussed in Section 2.

[24] It is worthwhile to notice that the TB death rates for Framingham, reported in the summary report, are based on whether the deceased had any contact with the town of Framingham within a certain time period, which then includes both residents and non-residents. It was not possible to do a similar detailed correction for the control towns, although an effort was made to correct the mortality on a residence basis (see Monograph No. 10, 1924). Our analysis is based on city/town tabulated mortality data, and such adjustments are, therefore, impossible.

[Table 1 about here]

We now first leverage our Massachusetts town/city mortality data set to study if these official findings can be replicated broadly. Hereafter, we ask additional questions: i) What happens to this conclusion when the set of controls towns/cities is extended to include all towns/cities larger/smaller than 5,000/50,000 in 1915?[25], ii) Were there any long-run improvements in the TB mortality rate because of the Demonstration?, and iii) How did other causes of death respond to the intervention? The latter question is addressed in the next subsection.

However, before attempting to replicate the results for Framingham and its control towns, we study if the research design is reasonable as it was basically argued in the Monographs No. 1-10, by conducting simple balancing tests (using data in 1910) and showing the development of the TB mortality rate between Framingham and the control towns/cities during the pre-Demonstration period (1901-1916). First, Table 2 reports the results from balancing tests using the TB mortality rate, population size, share of infants, share of people in the age group 15-44 (or age 60 plus), share of foreign-born, and income per worker (i.e., earnings score). These variables are all measured in 1910, as most are derived using Census data in 1910. Panel A reports the findings for Framingham and its official control towns. Besides population size, which was on average larger among the controls towns, we find that treatment and controls are well-balanced along these particular characteristics. Panel B compares Framingham to towns/cities in the extended control sample. Here the balancing works out even better: for example, the average population size among the control towns/cities is 12,963, whereas the Framingham population is 12,948.

Second, we study the pre-Demonstration trends in TB: Panel A of Figure 3 graphs annual event-study estimates for the (log) TB mortality rate between 1901 and 1916, using the seven control cities for comparison, while Panel B uses the extended control sample, but otherwise reports the same type of estimates.[26] While there are clear year-to-year differences in both panels, we do not see any clearly decreasing or increasing pre-Demonstration trend in Framingham's TB mortality rate relative to the control towns/cities, indicating that Framingham was not chosen

[25] These population thresholds are not as such crucial for our findings. For example, similar results are obtained when including all 192 towns and cities in Massachusetts (available upon request). However, we apply these thresholds in the baseline model in order to compare Framingham to towns and cities that relatively similar in size.

[26] As 1916 is the omitted year, all estimates are relative to this particular year.

as the Demonstration town because TB mortality was developing more/less favorably than in other places.[27] Overall, we conclude for both samples that the research design seems reasonable, as also argued to be the case for the seven control towns by the official evaluation.

[Table 2 about here]

[Figure 3 about here]

Panel A of Figure 4 depicts event-study estimates for the post-Demonstrations period (i.e., after 1916) for Framingham and the seven control cities. In order to make the results comparable to the official estimates, reported in Table 1, the (omitted) pre-Demonstration comparison years are 1907-1916. Annual estimates are depicted during the Demonstration period (1917-1923), and the long-run effect is given by $\beta_{>7+}$, which is basically a dummy equal to one after 1923 for Framingham. While one should not put too much weight on the statistical (in-)significance, a clear downward trend in the point estimates is visible during the Demonstration period. Except for 1919, we obtain results that are quite similar to the official estimates. This discrepancy could have the following explanations: i) our outcome is pulmonary TB, whereas the official evaluation uses all forms of TB;[28] or ii) our TB mortality rate is place-based, while the official evaluation uses a residence-based measure. Nevertheless, the time-varying pattern of our estimates follows the official ones. We find an average decline in the TB mortality rate during the Demonstration period of around 33 percent (see also Table 3). Interestingly, our long-run estimate reveals an *increase* of similar magnitude from 1924 to 1934, so that the initial relative improvements were completely erased 10 years after the Demonstration ended. In terms of dynamics, the results for the extended control sample are somewhat similar (Panel B of Figure 4).

Table 3 summarizes the findings of Figure 4. In particular, to create a better overview, the annual post-Demonstration estimates from 1917 to 1923 have been collapsed into one Demonstration-period indicator, which then quantifies the average effect on TB mortality during the Demonstration period, and the long-run variable remains unchanged, so it still gives us the average effect for the 10 years following the end of the Demonstration period. As mentioned

[27] The confidence bands in Panel A of Figure 3, which are based on standard errors clustered at the town level, should taken with a grain of salt, as these use only eight towns in the sample, which are observed over a period of 16 years.

[28] This seems not to be the main reason as when we use all forms of TB, we obtain a similar estimate (with the caveat that we do not have a consistent measure of all forms of TB throughout the years).

above, the improvements in TB mortality during the Demonstration are reversed throughout the years 1924-1934 when Framingham is compared to its official controls towns (column 1). Next, we estimate that the TB mortality rate was lowered by 12 percent during the Demonstration period and increased by 18 percent in the following 10 years in the extended control sample. Therefore, we again do not see any evidence of sustained TB mortality improvements in Framingham. This seems not to be a matter of a simple convergence story, in which Framingham start out (in 1924) with a lower TB mortality rate (due to the Demonstration) and the other towns/cities subsequently catch up due to forces of convergence in TB.[29] Column 3 adds controls for different demographic and economic characteristics, which we described above, to the extended sample. Column 4 also adds the lags of the log TB mortality rate (1-5 year lags). If anything, these estimates leave the impression that the possible benefits of the Demonstration for Framingham were more than outweighed by 1934.[30]

Next, we address the issue that inference is made difficult in a setup with only one treatment unit (e.g., Bertrand et al., 2004; Conley and Taber, 2011). Up to now, standard errors have been clustered at the town/city level in order to take into account possible serial correlation. However, even if the extended sample contains 89 towns/cities, clustered standard errors might be misleading as only one unit is treated (Conley and Taber, 2011). In our first approach to deal with this matter, we collapse our data into two periods by averaging. In order to make the findings comparable, the first period is 1906-1916 and the second period is either 1917-1923 (the Demonstration period) or 1924-1934 ("the long-run period"). According to Bertrand et al. (2004), the two-period approach lowers the issue of serial correlation, allowing us to compute simple robust standard errors. The DD estimates, reported in Table 4, are very similar in magnitude and statistical significance to the ones in the previous table.

Our second approach constructs placebo test as, for example, suggested by Conley and Taber (2011). We re-assign treatment to each control town/city in our extended sample and reestimate Table 3, column (3) for each town/city. This gives us a distribution of coefficients plotted in Figure 5. We see that the true estimates are basically placed in the middle of the distributions, which one can interpret as there were no significant effects during the Demonstration period (1917-1923, Panel A) or afterwards (1924-1934, Panel B). Therefore, regarding statistical significance

[29]We checked this by controlling for the log TB mortality rate in 1923 interacted with an indicator taking on the value one after 1923 (results are available upon request).

[30]The estimation results are similar when running the regressions with no restrictions on the population size of the cities in the Massachusetts sample.

we end up with mixed evidence from these tests. Yet, in both cases, our overall criticism, which simply questions the very positive contemporary assessment in Monograph No. 10 (1924)—in terms of reducing TB deaths—of the Demonstration, remains intact.[31]

[Tables 3 and 4 about here]

[Figures 4 and 5 about here]

Figure 6 depicts the findings for the SCM strategy. Before commenting on these plots, we note that the weights assigned to towns/cities in the donor pool are reported in Appendix Table A.2, and Table A.3 reports the balance between the synthetic control and the treated. Interestingly, we see that the official control cities are given relatively small weights (around one percent or below). The cities with the most weight are: Concord (23 percent), Brookline (13 percent), Orange (11 percent), and Norwood (7 percent); the remaining 84 towns/cities are assigned (positive) weights below 6 percent. Now, comparing the observed path of Framingham's (log) TB mortality rate to its (counterfactual) synthetic path after the Demonstration started in 1917, we reach a conclusion similar to the above one: during the Demonstration period the TB mortality seems lower, while afterwards the opposite pattern emerges (see Panel A).[32]

The in-place placebo effects, along with the "true" Demonstration effect, and the resulting (empirical) p-values are displayed in Panels B and C of Figure 6. We get the same impression when evaluating the DD results using placebo-inference test in that the effects of the Demonstration on TB mortality, both during the period of Demonstration and afterwards, are likely to have been observed by chance (i.e., statistically insignificant).

[Figure 6 about here]

5.2 Other causes of death

While the Demonstration had a particular focus on controlling TB, the public health activities carried out by the Demonstration might have influenced other health/mortality conditions in

[31] A third interpretation could be that if there indeed were effects on TB during the Demonstration, they may best be thought of as a "Dr. Bartlett effect". The Framingham Board of Health reports indicate that after Bartlett's death, the new consultancy service did not meet the standards set by Dr. Bartlett.

[32] After the Demonstration ended, the TB mortality rate in Framingham is only lower in 1933 and 1934.

Framingham as well (both intentionally and unintentionally). Moreover, as discussed in Section 2, the Demonstration also came with other services. Table 5 shows the DD estimates for the (log) crude death rate, the (log) infant mortality, the (log) pneumonia rate, the (log) stroke rate, and the (log) external causes rate. Before commenting on them, a couple of remarks should be mentioned, however. First, the crude death rate are taken from the US-city mortality dataset for towns/cities in Massachusetts, reducing the sample to 36 towns/cities (column 1). Second, we were only able to obtain data on infant mortality for Framingham from 1915 onwards (from the Vital statistics) and only for a subset of towns/cities in Massachusetts. Regardless of these limitations, we believe it is important to study these "causes" as well, since Monograph No. 10 (1924, p. 8) highlighted that the crude death rate was down by 9 percent the last two years of the program (compared to 1907 to 1916) and the infant mortality rate by 40 percent (compared to 1916).

According to the point estimates in column 1, we find that the crude death rate increased by 4 percent during the Demonstration period and decreased 0.06 percent subsequently. Yet, these effects are statistically highly insignificant, so we cannot reject that the Demonstration had no effects on the crude death rate between 1917 and 1934, which is rather different than the conclusion in Monograph No. 10 (1924). The placebo-inference test method likewise suggests that the effects are insignificant (see Figure 7). In addition, Figure 8, which shows the output from the SCM, also supports the notion that there are no significant effects on the crude death rate. In particular, the (log) crude mortality rate for synthetic Framingham is only smaller than the actual one the last couple of years of the Demonstration, which then reverses from 1924 to 1933 (Panel A). But again, these effects are likely to be by chance (Panel C).[33]

Using 1915 and 1916 as the pre-Demonstration comparison years, column 2 of Table 5 finds that the infant mortality rate reduced by 65 percent during the Demonstration period and these reductions persisted until 1934, where our investigation ends. Therefore, for the infant mortality rate, we actually find evidence of sustained improvements of the Demonstration. The estimates are statistically significant at the 1-percent level, and using the two alternative inference methods (from the previous subsection), provides a similar impression regarding statistically significance (placebo test is depicted in Figure 9). While the infant-mortality findings are inferred using a subset of towns/cities from the extended TB sample, we do not think that it is the sample

[33] It is important to bear in mind that the DD and SCM, among other things, take into account possible pre-Demonstration differences in the age distribution which are obviously important for the development of the crude death rate.

composition driving these different long-run findings between TB and infant mortality. For example, restricting the sample to the 38 towns/cities in column 2 of Table 5, and using 1915 and 1916 for comparison years, give rise to an even more pessimistic view of the (relative) development of TB in Framingham (not reported). As seen in Figure 10, the SCM yields to a largely similar conclusion. As mentioned in Section 2, the Demonstration also established infant welfare clinics, which remained in place after 1923. Thus, this evidence suggests that they were effective in reducing infant mortality.

Next, we find some evidence that the Demonstration was associated with persistent reductions in the pneumonia mortality rate, albeit these effects are small in magnitude (a circa 10-percent decline) and only borderline statistically significant (column 3 of Table 5). Both alternative inference methods, however, indicate that the long-run improvements are not statistically significant (see the placebo-inference test method in Appendix Figure A.5).[34]

The remaining two columns of Table 5 report the findings for strokes (column 4) and external causes (column 5). For strokes, we find a relative small decrease after the Demonstration ended. Using cluster robust standard errors as in Table 5, this effect is statistically significant at the 5-percent level, which remains to be the case when collapsing to two periods and using robust standard errors instead, whereas the placebo-test inference method indicates the opposite (see Appendix Figure A.7).[35]

The main idea of studying external causes (suicides, homicides, and accidents) is that they should not (in theory) be directly affected by the Demonstration. Therefore, finding that external causes of death changed differently in Framingham compared to its control towns/cities could be evidence of i) an indirect effect, working through more/less human activities because of the Demonstration; ii) misspecification (e.g., coincidence). According to the point estimates, reported in column 5, external causes increased by 13 percent during the Demonstration and decreased by 39 percent the subsequent 10 years, both of which are statistically significant at the 1-percent level. On the one hand, this could (in theory) be explained by further human activities related to the Demonstration. On the other hand, unreported estimates reveal a similar pattern for suicide alone, and our placebo-test inference method indicates that the estimates (in column 5) are not significant at any conventional levels, so such differences could have been observed by

[34]Appendix Figure A.6 report the SCM output for the (log) pneumonia mortality rate. This evidence does, however, not lead to any changed conclusions.

[35]Similar, Appendix Figure A.8 report the SCM output for the (log) mortality by strokes rate. This evidence does not lead to any changed conclusions.

chance (see Appendix Figure A.8).[36] The latter explanation suggests that we should insist on letting the placebo-test inference method determine whether the effects are significant or not. One implication of this, however, is that we should view our results for TB as being statistically insignificant.

[Table 5 about here]

[Figures 7-10 about here]

6 Comparing to other cities in the United States

According to Monograph No. 10 (1924) Framingham was a typical semi-industrial community with 17,000 people at the time of its selection for the Demonstration, providing the (future) findings of the Demonstration some external validity in an US context. In fact, the Monograph No. 10 compared Framingham's TB mortality before (1907-1916) and during the Demonstration years 1919-1921 to two groups of control cities across the US: i) 45 cities over 100,000 people; and ii) 50 cities with 10 to 25,0000 people. The reported figures in Monograph No. 10 (1924, p.40) leave the impression that Framingham experienced relative declines in TB mortality for the years 1919-1921. Accordingly, compared to cities throughout the US, the Demonstration seemed also successful in reducing TB mortality. This section provides a follow-up to this positive contemporary assessment of the Demonstration.

Table 6 starts by presenting the DD estimates for the baseline population thresholds, which then includes cities between 5,000 and 50,000 people that are observed in our US-city mortality dataset: Columns 1-3 include all these 217 cities, whereas columns 4-6 exclude cities in Massachusetts in order to take into account possible local spillover effects of the Demonstration.[37] First, Table 6 documents small negative (or statistically insignificant) effects during the Demonstration period. Second, across the different specifications, we find that the 10 years following the Demonstration period, TB mortality increased significantly more in Framingham relative to its control cities (or decreased less). For example, controlling for

[36] Appendix Figure A.9 report the SCM output for the (log) external cause of death rate. This evidence does not lead to any changed conclusions.

[37] We have investigated whether there were any spill-over effects related to (physical) distance to Framingham. However, as shown in Appendix Table A.17, this seems *not* to be the case.

pre-Demonstration economic and demographic characteristics (in column 2), we find that the TB mortality increased by around 56 percent more in Framingham from 1924 to 1934. This effect cuts in half when including the 5 lags of the TB mortality rate (column 3).[38] A similar pattern emerges if all cities in Massachusetts (besides Framingham) are excluded from the sample; see columns 5 and 6. For a specification similar to the one reported in column 2, Figure 11 shows the SCM output. Here we also find that Framingham's TB mortality rate is higher than its synthetic path after the Demonstration ended in 1923 (Panel A), albeit only a subset of these gaps are significant (Panel C).

Table 7 reports results for alternative samples of cities. Columns 1-6 use the same sample definitions as in Monograph No. 10 (1924, p.40), including in our case 130 cities between 10 to 25,000 people (in 1915) and 59 cities over 100,000 people (in 1915).[39] As an additional specification test, columns 7-9 include all cities in our US-city mortality dataset. Table 8 report the (main) results for all cities by Census Divisions (Northeast, Midwest, South, and West). The estimates, reported in both tables, demonstrate a similar pattern to once reported in Table 6. Overall, these findings support the idea that the TB mortality improvements in Framingham during the Demonstration period were very limited when comparing to the development of TB mortality across cities in the US, and afterwards Framingham even experienced a less rapid decline in TB mortality compared to these cities.

[Tables 6-8 about here]

[Figure 11 about here]

7 Conclusion

This research has challenged the conventional view that the Framingham Demonstration succeeded in reducing TB mortality. Contrary, to the beliefs of the National Tuberculosis Association and historical accounts, the systematic evidence we offer in this paper suggests that the Demonstration cannot be leveraged as unequivocal evidence for the success of pre-antibiotic era health policies. Some of our results suggest that there was an effect during the Demonstration, but that

[38]A placebo-inference test is depicted in Appendix Figure A.10 confirming the results.

[39]We note that Monograph No. 10 (1924) includes fewer cities for these population thresholds. However, it was not possible to determine exactly which cities they included.

this was met by a period of higher TB mortality in Framingham compared to other places. This is consistent with the historical narrative, which suggests that Dr. Bartlett was important as a TB expert in Framingham and once he died, similar expert knowledge was not maintained. Yet, the results that takes into account that we only have one treated unit fails to find significant effects for TB in the treatment period, so it is possible that the apparent fall in TB in the Demonstration period happened by a fluke. Even if there was a decline in the Demonstration period and this can be attributed to the expert knowledge of Dr. Bartlett, the general lessons for whether TB could be reduced remain unclear. Yet, the Demonstration was successful in reducing infant mortality by expanding services focused on infant health.

The implication of these findings is that the Framingham Demonstration was not as successful as believed by the NTA and would tend to support McKeown's (1976) contention that public health policy was not a decisive factor in the reduction of TB mortality. Yet, Hollingsworth (2014) presents evidence that sanatoria may have played some role for TB mortality in North Carolina through health education and isolation, and Egedesø et al. (2017) show that personalized information on how to avoid spreading TB reduced mortality in Danish cities. What is true about the Framingham Demonstration is that it relied very much on general health education through the health letters and none of the monographs emphasize a role for more personalized information for the TB patients. This could be one reason that the Demonstration was not as effective as hitherto believed.

The bottomline for our knowledge on the effectiveness of efforts to reduce TB in the past is that this seems to have depended on the intervention. We leave it for future research to expand our knowledge on what other past interventions were effective.

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Tables

Table 1: The official results of the Framingham Demonstration 1917-1923, and DD estimates

	Framingham TB rate	Control Towns TB rate	DD estimates
	(1)	(2)	(3)
Pre-Demo. decade, 1907-1916	121.0	125.9	
1917	97.50	129.4	-27.00
1918	84.70	146.7	-57.10
1919	90.20	128.8	-33.70
1920	64.50	133.7	-64.30
1921	40.10	103.8	-58.80
1922	67.20	92.30	-20.20
1923	38.20	84.60	-41.50

Note: This table reports the official findings from the final Framingham series of mongraphs (No. 10), with the TB mortality rate of Framingsham in column (1), the TB mortality rate of the Massachusetts control towns in column (2), and DD estimate based on the numbers in columns (1) and (2) in column (3), by our calcualtions.

Table 2: Balancing tests

	A. Framingham and the official control cities				
	Official control cities			Framingham	
	Obs.	Mean	Std. Dev.	Obs.	Mean
TB mortality rate	7	0.911	0.0951	1	1.004
Population	7	20,093	9,171	1	12,948
Share of infants	7	0.0208	0.00912	1	0.0195
Share aged 15-44	7	0.493	0.0477	1	0.565
Share aged 60-	7	0.0804	0.0345	1	0.0843
Share of foreign-born	7	0.306	0.0576	1	0.300
Earnings score	7	667.2	68.59	1	686.4
	B. Framingham and the extended MA control panel				
	Extended MA city panel			Framingham	
	Obs.	Mean	Std. Dev.	Obs.	Mean
TB mortality rate	88	1.022	0.514	1	1.004
Population	88	12,963	10,535	1	12,948
Share of infants	88	0.0210	0.0161	1	0.0195
Share aged 15-44	88	0.505	0.0601	1	0.565
Share aged 60-	88	0.0797	0.0438	1	0.0843
Share of foreign-born	88	0.285	0.117	1	0.300
Earnings score	88	674.5	155.6	1	686.4

Note: This table reports balancing tests. In part A of the table, we compare the official control cities to Framingham, and in part B we compare the Massachusetts cities with a population between 5,000 and 50,000 inhabitants to Framingham. The variables compared across are: the TB moratlity rate; population size; share of infants; share of people in the age group 15-44; share of people in the age group 60 or above; share of foreign-born; and income per worker using earnignscore. All varaibles are measured in 1910.

Table 3: DD estimation results on log TB rate

Dep. variable:	log TB rate			
	(1)	(2)	(3)	(4)
Pre 11 years Demo.	0.181**	0.00684	0.00684	0.576***
	(0.0702)	(0.0262)	(0.0262)	(0.0481)
Demonstration period	-0.332**	-0.128***	-0.0815*	-0.0575**
	(0.0976)	(0.0390)	(0.0481)	(0.0276)
Post Demonstration	0.351	0.184***	0.230***	0.140***
	(0.244)	(0.0558)	(0.0626)	(0.0392)
Avg. dep. var.	-0.416	-0.510	-0.510	-0.638
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Demographic controls	No	No	Yes	Yes
Economic controls	No	No	Yes	Yes
Lags of the dependent var.	No	No	No	Yes
Cities	8	89	89	89
Time period	1901-1934	1901-1934	1901-1934	1906-1934
Observations	279	3,026	3,026	2,581
R-squared	0.678	0.637	0.641	0.659

Note: The table reports least squares estimates. In column (1) the panel consists of Framingham and the official controls cities, in columns (2) to (4) the panel is the Massachusetts cities with a population between 5,000 and 50,000 inhabitants. In columns (1) to (4) the left-hand-side variable is the log TB mortality per 1,000. All regressions include city and year fixed effects. Pre 11 years Demo. is an indicator equal to one 11 years and prior to the Demonstration, in column (4) this only includes the year 1906; Demonstration period is an indicator equal to one during the Demonstration period, 1917 to 1923; Post Demonstration is an indicator equal to one after the Demonstration period. Columns (3) and (4) add demographic controls of log population size, share of infants, share aged 15-44, share aged 60 and above, share of foreign born, and the economic control of income per worker using earningsscore, all measured in 1910 and equal to zero before 1917, and column (4) additionally adds 1-5 year lags of the log TB mortality rate. Robust standard errors clustered at the city level are in parentheses. *, **, and *** determine significance levels of ten percent, five percent, and one percent, respectively.

Table 4: Two period inference of DD estimation on log TB rate

Dep. variable:	log TB rate			
	(1)	(2)	(3)	(4)
Demonstration period	-0.170***		-0.192***	
	(0.0427)		(0.0480)	
Post Demonstration		0.177***		0.165**
		(0.0587)		(0.0732)
Avg. dep. var.	-0.286	-0.629	-0.286	-0.629
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Demographic controls	No	No	Yes	Yes
Economic controls	No	No	Yes	Yes
Cities	89	89	89	89
Observations	178	178	178	178
R-squared	0.832	0.861	0.848	0.867

Note: The table reports least squares estimates. The panel is the Massachusetts cities with a population between 5,000 and 50,000 inhabitants. In columns (1) to (4) the left-hand-side variable is the log TB mortality per 1,000. All regressions include city and year fixed effects. The data are collapsed into two periods by averaging the left hand side variable, TB mortality per 1,000, and subsequently taking logs, where the first period being 1906-1916 in columns (1) to (4) and the second period being 1917-23 in columns (1) and (3), and 1924-34 in columns (2) and (4). Demonstration is an indicator equal to one when the second period is collapsed over 1917-23, and Post Demonstration is an indicator equal to one when the second period is collapsed over 1924-34. Columns (3) and (4) add demographic controls of log population size, share of infants, share aged 15-44, share aged 60 and above, share of foreign born, and the economic control of income per worker using earningsscore, all measured in 1910 and equal to zero in the first period. Robust standard errors are in parentheses. *, **, and *** determine significance levels of ten percent, five percent, and one percent, respectively.

Table 5: DD estimation on other causes of deaths

Dep. variable:	log mortality rate	log infant rate	log pneumonia rate	log strokes rate	log external rate
	(1)	(2)	(3)	(4)	(5)
Pre 11 years Demo.	-0.0996***		-0.204***	0.00990	-0.00571
	(0.0155)		(0.0298)	(0.0236)	(0.0389)
Demonstration period	0.0444	-0.654***	-0.114*	0.0488	0.134***
	(0.0407)	(0.0745)	(0.0580)	(0.0372)	(0.0454)
Post Demonstration	-0.00604	-0.538***	-0.103*	-0.0963**	-0.387***
	(0.0436)	(0.0775)	(0.0541)	(0.0409)	(0.0496)
Avg. dep. var.	2.528	4.172	-0.313	-0.0747	-0.453
City FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes
Cities	36	38	87	92	86
Time period	1901-1934	1915-1934	1901-1934	1901-1934	1901-1934
Observations	1,224	760	2,958	3,128	2,924
R-squared	0.827	0.725	0.679	0.415	0.289

Note: The table reports least squares estimates. In column (1) the data are from the Massachusetts cities with a population between 5,000 and 50,000 inhabitants available in the US sample, and in columns (2) to (5) the data are from the Massachusetts city sample for all cities in column(2) and for cities with a population between 5,000 and 50,000 in columns (3) to (5). In column (1) the left-hand-side variable is the log total mortality per 1,000, in column (2) the left-hand-side variable is the log infant mortality rate per 1,000, in column (3) the left-hand-side variable is the log pneumonia mortality rate per 1,000, in column (4) the left-hand-side variable is the log mortality by strokes per 1,000, and in column (5) the left-hand-side variable is the log deaths by external causes per 1,000. All regressions include city and year fixed effects and demographic controls of log population size, share of infants, share aged 15-44, share aged 60 and above, share of foreign born, and the economic control of income per worker using earningsscore, all measured in 1910 and equal to zero before 1917. Pre 11 years Demo. is an indicator equal to one 11 years and prior to the Demonstration; Demonstration period is an indicator equal to one during the Demonstration period, 1917 to 1923; Post Demonstration is an indicator equal to one after the Demonstration period. Robust standard errors clustered at the city level are in parentheses. *, **, and *** determine significance levels of ten percent, five percent, and one percent, respectively.

Table 6: DD estimation results on log TB rate using the US sample

	Incl. MA			Excl. MA		
Dep. variable:	log TB rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Pre 11 years Demo.	0.144***	0.144***	0.524***	0.169***	0.169***	0.533***
	(0.0179)	(0.0179)	(0.0218)	(0.0192)	(0.0193)	(0.0236)
Demonstration period	-0.0453**	0.0690	0.0367	-0.0464**	0.0361	0.0316
	(0.0203)	(0.0480)	(0.0232)	(0.0214)	(0.0588)	(0.0272)
Post Demonstration	0.452***	0.567***	0.271***	0.437***	0.519***	0.273***
	(0.0306)	(0.0572)	(0.0281)	(0.0301)	(0.0659)	(0.0312)
Avg. dep. var.	-0.296	-0.296	-0.399	-0.276	-0.276	-0.375
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	No	Yes	Yes	No	Yes	Yes
Economic controls	No	Yes	Yes	No	Yes	Yes
Lags of the dependent var.	No	No	Yes	No	No	Yes
Cities	217	217	217	176	176	176
Time period	1901-1934	1901-1934	1906-1934	1901-1934	1901-1934	1906-1934
Observations	7,378	7,378	6,293	5,984	5,984	5,104
R-squared	0.750	0.753	0.805	0.763	0.764	0.808

Note: The table reports least squares estimates. In columns (1) to (3) the panel consists of Framingham and the cities in the US sample with a population between 5,000 and 50,000 inhabitants, columns (4) to (6) exclude cities in Massachusetts besides Framingham. In columns (1) to (6) the left-hand-side variable is the log TB mortality per 1,000. All regressions include city and year fixed effects. Pre 11 years Demo. is an indicator equal to one 11 years and prior to the Demonstration, in columns (3) and (6) this only includes the year 1906; Demonstration period is an indicator equal to one during the Demonstration period, 1917 to 1923; Post Demonstration is an indicator equal to one after the Demonstration period. Columns (2), (3), (5) and (6) add demographic controls of log population size, share of infants, share aged 15-44, share aged 60 and above, share of foreign born, and the economic control of income per worker using earningsscore, all measured in 1910 and equal to zero before 1917, and columns (3) and (6) additionally add 1-5 year lags of the log TB mortality rate. Robust standard errors clustered at the city level are in parentheses. *, **, and *** determine significance levels of ten percent, five percent, and one percent, respectively.

Table 7: DD estimation results on log TB rate using the US sample split by population sizes

Dep. variable:	Control cities pop. 10,000 to 25,000			Control cities pop. above 100,000			Control cities independent of size		
				log TB rate					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pre 11 years Demo.	0.146***	0.146***	0.516***	0.178***	0.178***	0.604***	0.145***	0.145***	0.536***
	(0.0236)	(0.0236)	(0.0294)	(0.0206)	(0.0206)	(0.0296)	(0.0131)	(0.0131)	(0.0165)
Demonstration period	-0.0354	0.0369	0.00385	-0.0660***	0.0810	0.0512	-0.0428***	0.0583	0.0346*
	(0.0289)	(0.0587)	(0.0266)	(0.0193)	(0.101)	(0.0307)	(0.0147)	(0.0412)	(0.0188)
Post Demonstration	0.445***	0.517***	0.247***	0.323***	0.470***	0.173***	0.439***	0.540***	0.247***
	(0.0426)	(0.0684)	(0.0344)	(0.0356)	(0.102)	(0.0340)	(0.0227)	(0.0483)	(0.0223)
Avg. dep. var.	-0.325	-0.325	-0.427	-0.00904	-0.00904	-0.0999	-0.229	-0.229	-0.332
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Economic controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Lags of the dependent var.	No	No	Yes	No	No	Yes	No	No	Yes
Cities	130	130	130	59	59	59	324	324	324
Time period	1901-1934	1901-1934	1906-1934	1901-1934	1901-1934	1906-1934	1901-1934	1901-1934	1906-1934
Observations	4,420	4,420	3,770	2,006	2,006	1,711	11,016	11,016	9,396
R-squared	0.717	0.722	0.774	0.915	0.918	0.955	0.796	0.798	0.846

Note: The table reports least squares estimates. In columns (1) to (9) the panel consist of Framingham and the cities in the US sample. In columns (1) to (3) the control cities are restricted to cities with a population of 10,000 to 25,000 inhabitants. In columns (4) to (6) the control cities are restricted to cities with a population of above 100,000 inhabitants. Columns (7) to (9) present the results of all the cities in the US sample. In columns (1) to (9) the left-hand-side variable is the log TB mortality per 1,000. All regressions include city and year fixed effects. Pre 11 years Demo. is an indicator equal to one 11 years and prior to the Demonstration, in columns (3), (6), and (9) this only includes the year 1906; Demonstration period is an indicator equal to one during the Demonstration period, 1917 to 1923; Post Demonstration is an indicator equal to one after the Demonstration period. Columns (2), (3), (5), (6), (8), and (9) add demographic controls of log population size, share of infants, share aged 15-44, share aged 60 and above, share of foreign born, and the economic control of income per worker using earningsscore, all measured in 1910 and equal to zero before 1917, and columns (3), (6), and (9) additionally add 1-5 year lags of the log TB mortality rate. Robust standard errors clustered at the city level are in parentheses. *, **, and *** determine significance levels of ten percent, five percent, and one percent, respectively.

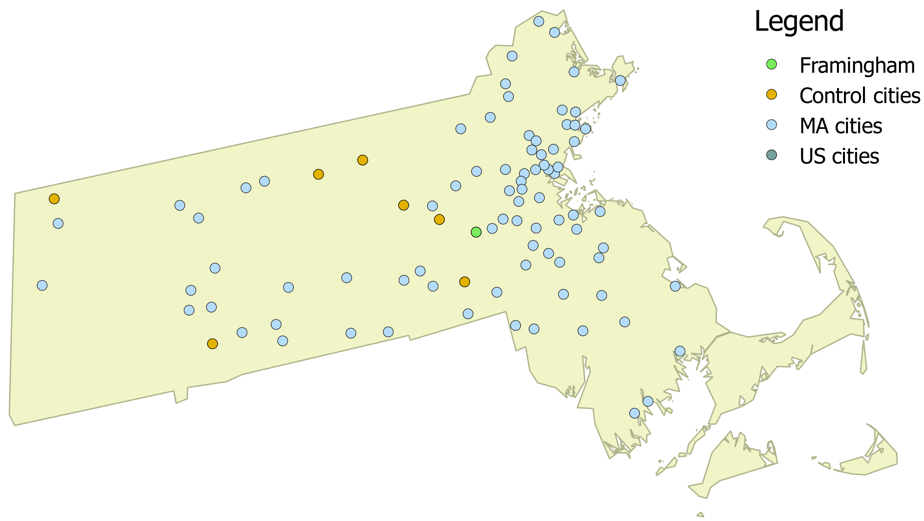
Table 8: DD estimation results on log TB rate using the US sample split by Census Region

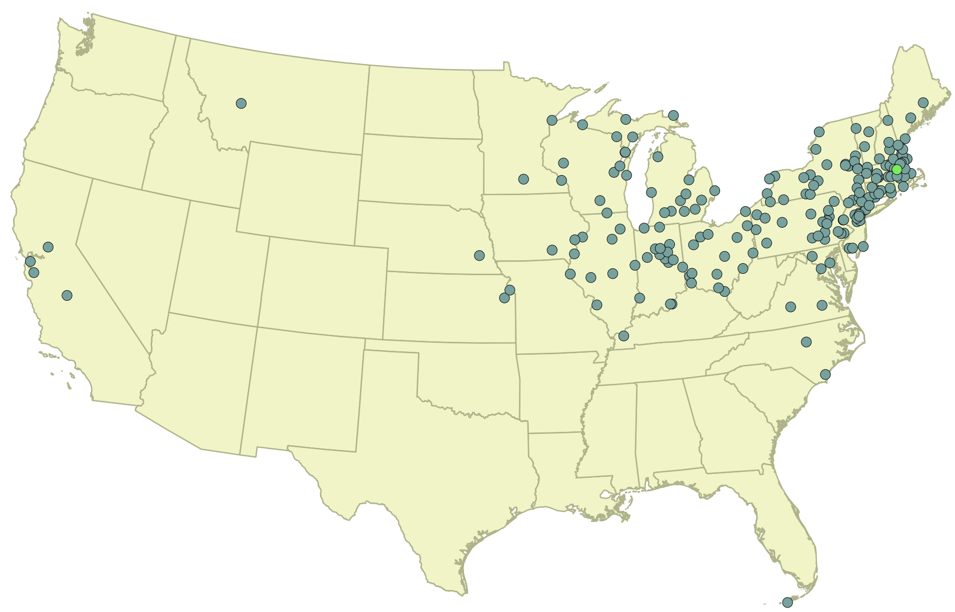
Census Region:	Northeast	Midwest	South	West
Dep. variable:	log TB rate			
	(1)	(2)	(3)	(4)
Pre 11 years Demo.	0.133***	0.199***	0.0879*	0.0501
	(0.0179)	(0.0228)	(0.0438)	(0.0431)
Demonstration period	0.0547	-0.0707	-0.0341	0.238
	(0.0491)	(0.0811)	(0.315)	(0.162)
Post Demonstration	0.584***	0.358***	0.345	0.685***
	(0.0590)	(0.0903)	(0.310)	(0.150)
Avg. dep. var.	-0.284	-0.310	0.343	-0.189
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes
Cities	182	100	28	17
Time period	1901-1934	1901-1934	1901-1934	1901-1934
Observations	6,188	3,400	952	578
R-squared	0.775	0.778	0.889	0.912

Note: The table reports least squares estimates. In columns (1) to (4) the panel consist of Framingham and the cities in the US sample. In column (1) the control cities are restricted to cities in the Northeast Census Region. In column (2) the control cities are restricted to cities in the Midwest Census region. In column (3) the control cities are restricted to cities in the South Census region. In column (4) the control cities are restricted to cities in the West Census region. In columns (1) to (4) the left-hand-side variable is the log TB mortality per 1,000. All regressions include city and year fixed effects, and demographic controls of log population size, share of infants, share aged 15-44, share aged 60 and above, share of foreign born, and the economic control of income per worker using earningsscore, all measured in 1910 and equal to zero before 1917. Pre 11 years Demo. is an indicator equal to one 11 years and prior to the Demonstration; Demonstration period is an indicator equal to one during the Demonstration period, 1917 to 1923; Post Demonstration is an indicator equal to one after the Demonstration period. Robust standard errors clustered at the city level are in parentheses. *, **, and *** determine significance levels of ten percent, five percent, and one percent, respectively.

Figures

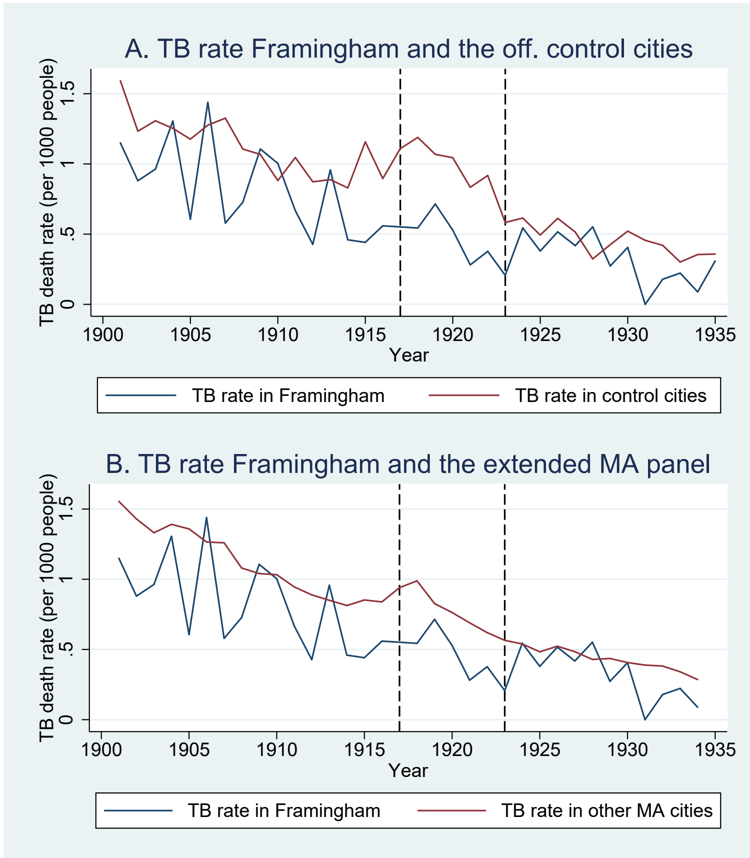
Figure 1: Maps of the cities in the Massachusetts and US sample





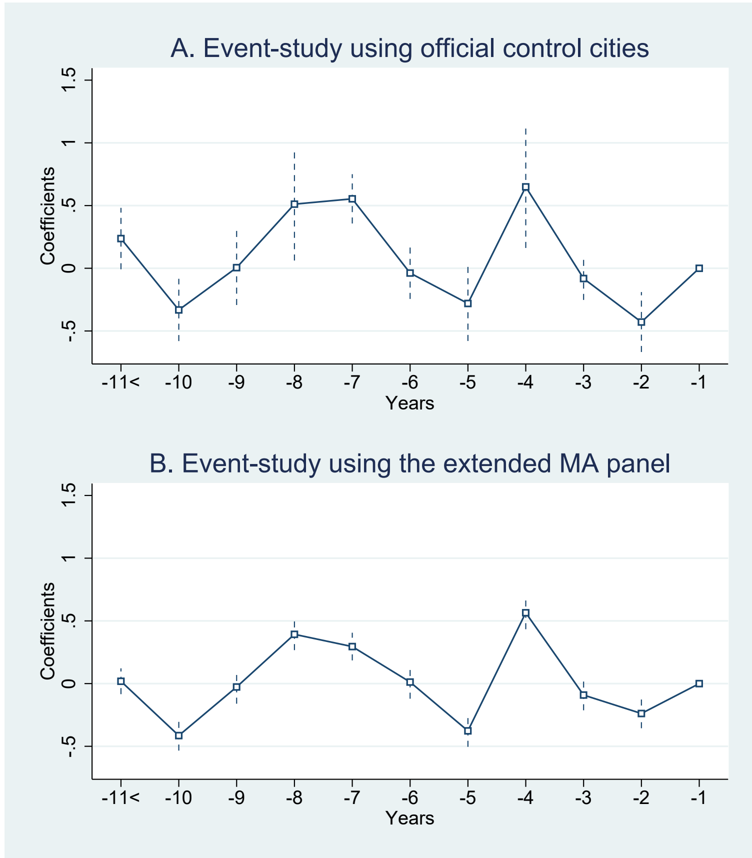
Note: The top map plots the position of Framingham; the official control cities; and the cities in Massachusetts with populations from 5,000 and up to 50,000 inhabitants. The map below plots the position of the cities in the US sample with 5,000 and up to 50,000 inhabitants.

Figure 2: TB mortality per 1,000 in Framingham, the official control cities, and the extended MA panel



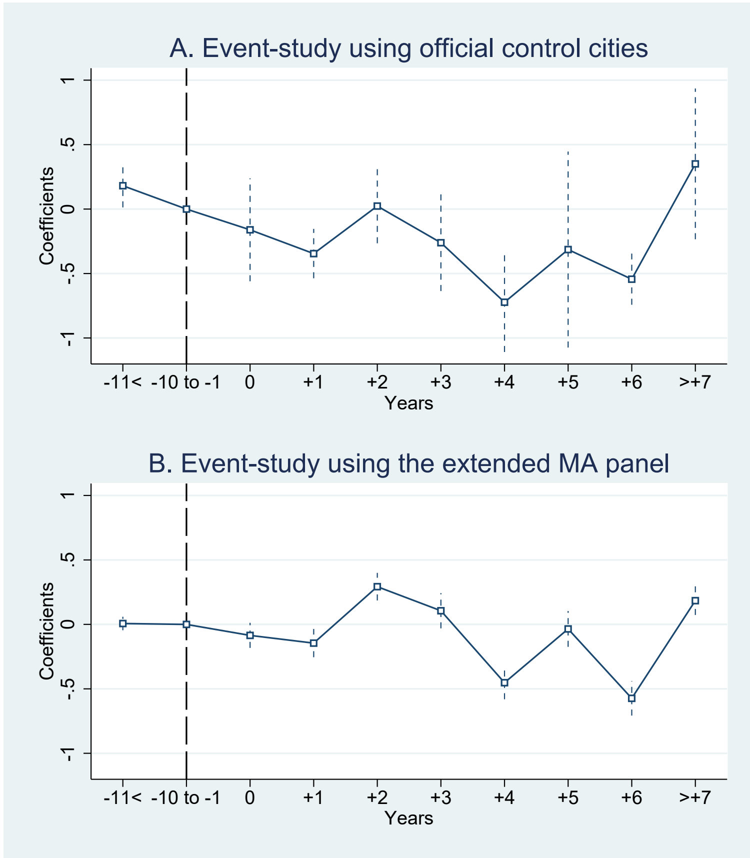
Note: The graph plots the development of the aggregate TB mortality per 1,000 in Framingham compared to the TB rate in the official control cities in panel A, and compared to the TB rate of the cities in Massachusetts with populations from 5,000 and up to 50,000 inhabitants in panel B. The vertical doted lines enclose the Demonstration period from 1917 to 1923.

Figure 3: Event-study of pre-trends



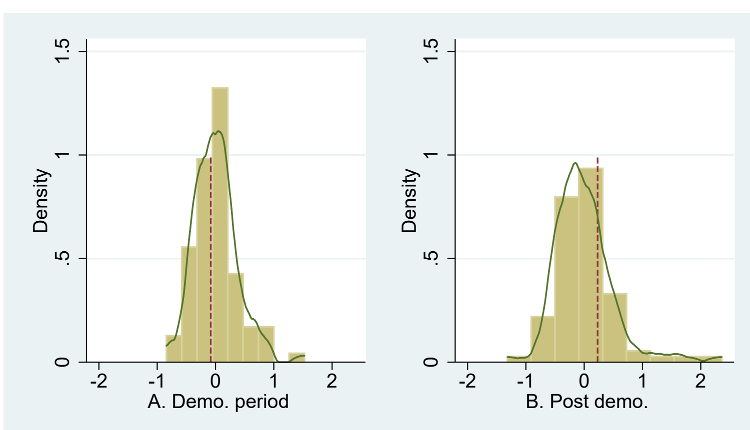
Note: In panel A and B the graph show the $\hat{\beta}_j$ coefficients and their 95 percent confidence interval pre intervention (1917), from estimating event-studies of the Framingham Demonstration with 1916 as the base year, using the official control cities in part A, and using Massachusetts cities with populations from 5,000 and up to 50,000 inhabitants in part B.

Figure 4: Event-study results



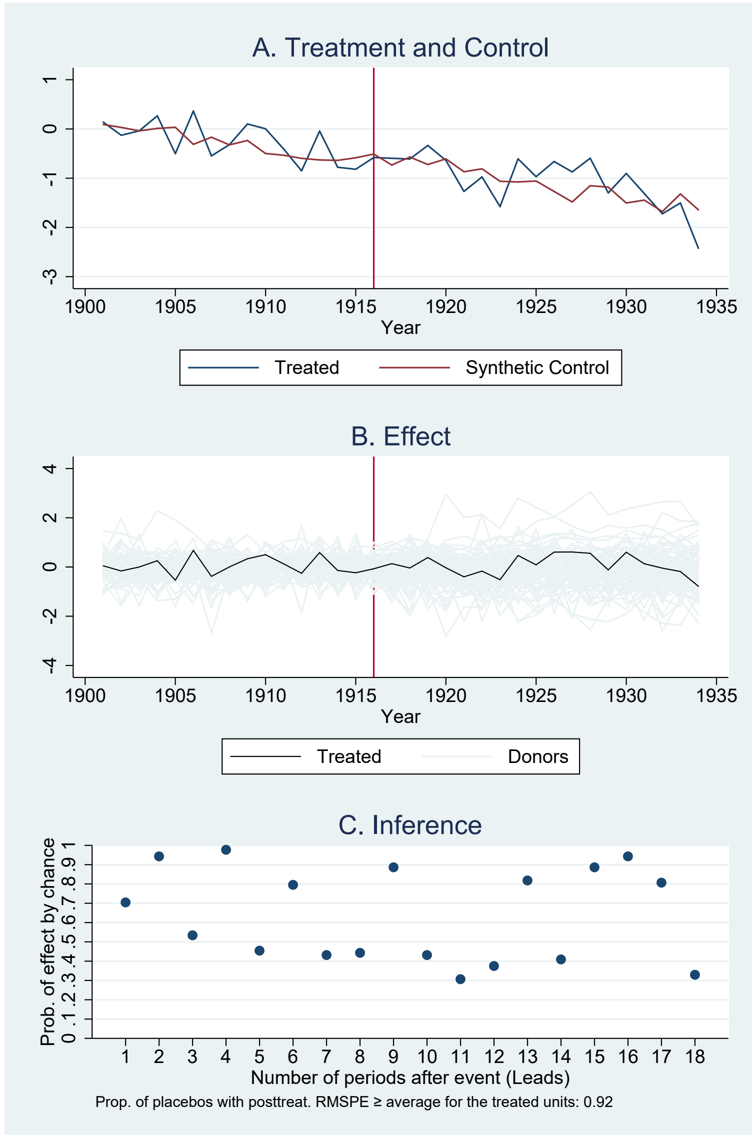
Note: In panel A and B the graph shows the $\hat{\beta}_j$ coefficients and their 95 percent confidence interval of estimating equation (1) with the comparison period being 1907 to 1916 (marked by the vertical long-dashed line), using the official control cities in part A, and using Massachusetts cities with populations from 5,000 and up to 50,000 inhabitants in part B.

Figure 5: Permutation inference on log TB mortality per 1,000



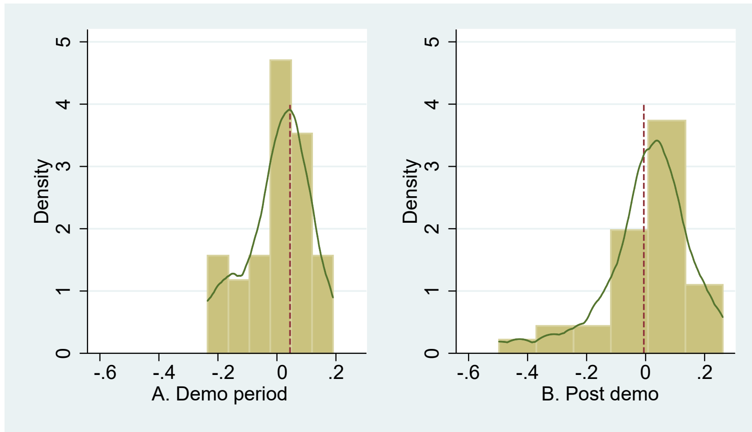
Note: In panel A and B the distribution of the coefficients on the Demonstration period variable and the Post 7 years Demo. variable are plotted respectively, from re-assigning treatment to each control city in the sample and reestimating the regression of Table 3, column (3), along with kernel densisty plots with the true estimates indicated by vertical dotted lines.

Figure 6: Synthetic control results on log TB mortality per 1,000



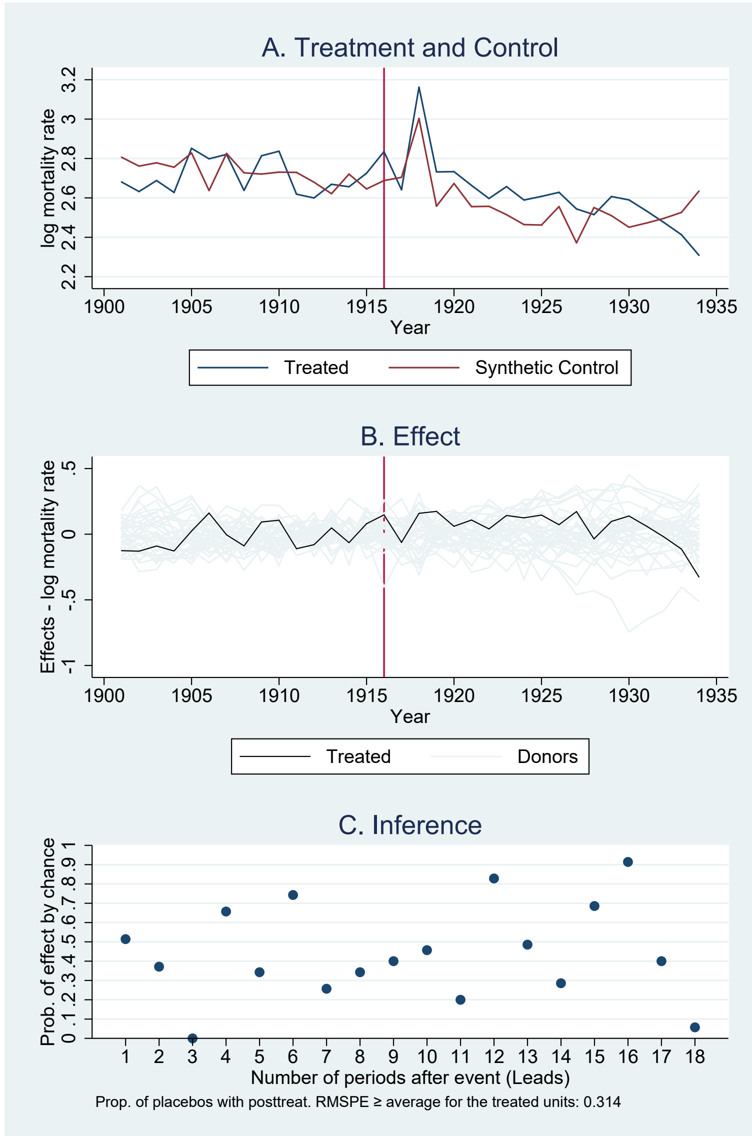
Note: This figure shows the results of the SCM on log TB mortality per 1,000, where the predictors of the log TB rate in the pre-Demonstration period (1901-1916) are: the log TB mortality rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910). The synthetic control is constructed from the cities in Massachusetts with populations from 5,000 and up to 50,000 inhabitants. Panel A shows the path of Framingsham's log TB mortality rate, along with the (counterfactual) synthetic path. The in-place placebo effects, along with the "true" Demonstration effect, and the resulting (empirical) p-values are displayed in Panels B and C respectively. The vertical red line indicate the start of the Demonstration in 1917. See Appendix Table A.3 and A.4 for the weights assigned to the cities forming the synthetic control, and the balance between the synthetic control and the treated before 1917, respectively.

Figure 7: Permutation inference on log total mortality per 1,000



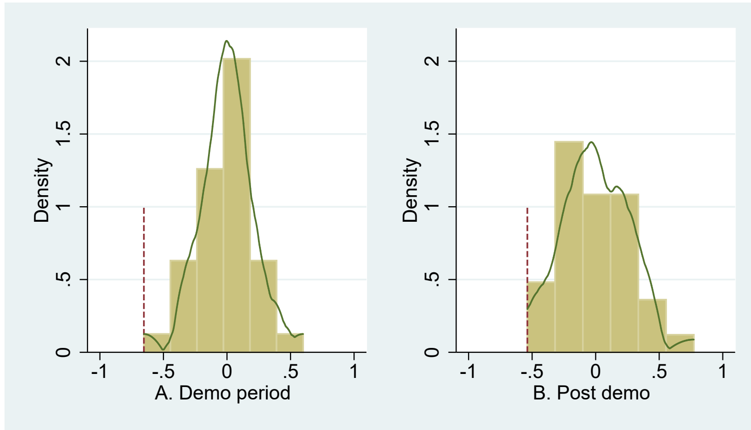
Note: In panel A and B the distribution of the coefficients on the Demonstration period variable and the Post 7 years Demo. variable are plotted respectively, from re-assigning treatment to each control city in the sample and reestimating the regression of Table 5, column (1), along with kernel densisty plots with the true estimates indicated by vertical dotted lines.

Figure 8: Synthetic control results on log total mortality per 1,000



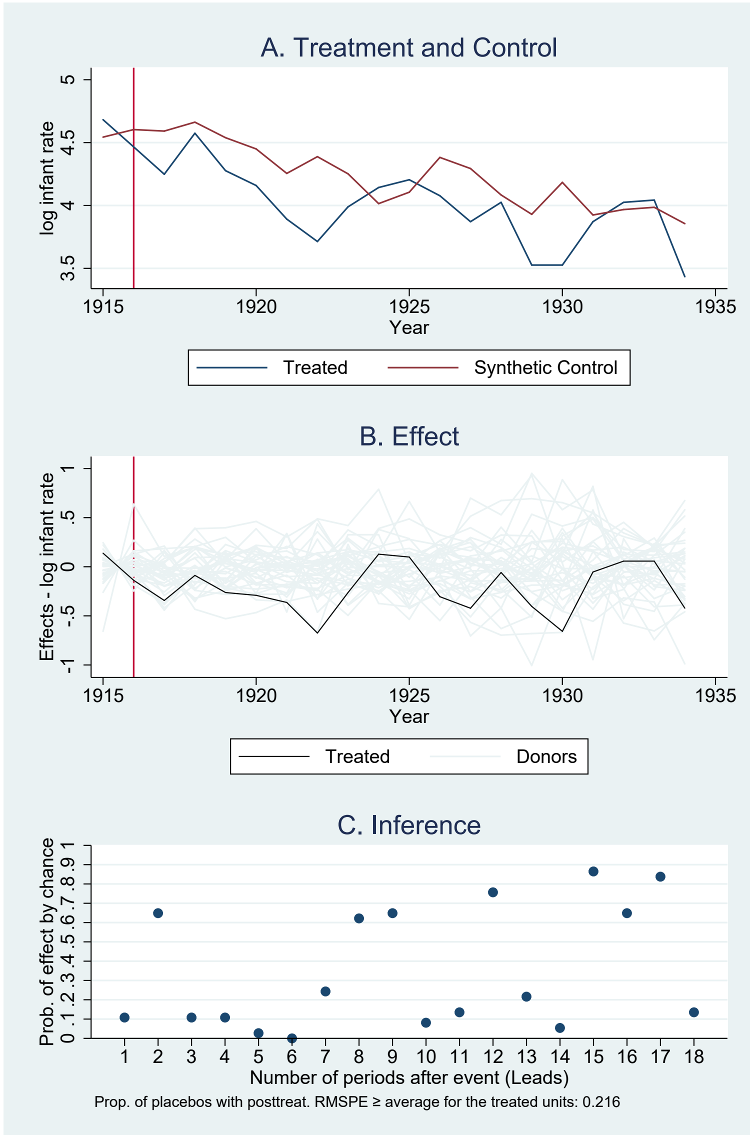
Note: This figure shows the results of the SCM on log total mortality per 1,000, where the predictors of the log mortality rate in the pre-Demonstration period (1901-1916) are: the log mortality rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910). The synthetic control is constructed from the cities in Massachusetts in the US city sample with populations from 5,000 and up to 50,000 inhabitants. Panel A shows the path of Framingsham's log mortality rate, along with the (counterfactual) synthetic path. The in-place placebo effects, along with the "true" Demonstration effect, and the resulting (empirical) p-values are displayed in Panels B and C respectively. The vertical red line indicate the start of the Demonstration in 1917. See Appendix Table A.5 and A.6 for the weights assigned to the cities forming the synthetic control, and the balance between the synthetic control and the treated before 1917, respectively.

Figure 9: Permutation inference on log infant mortality per 1,000



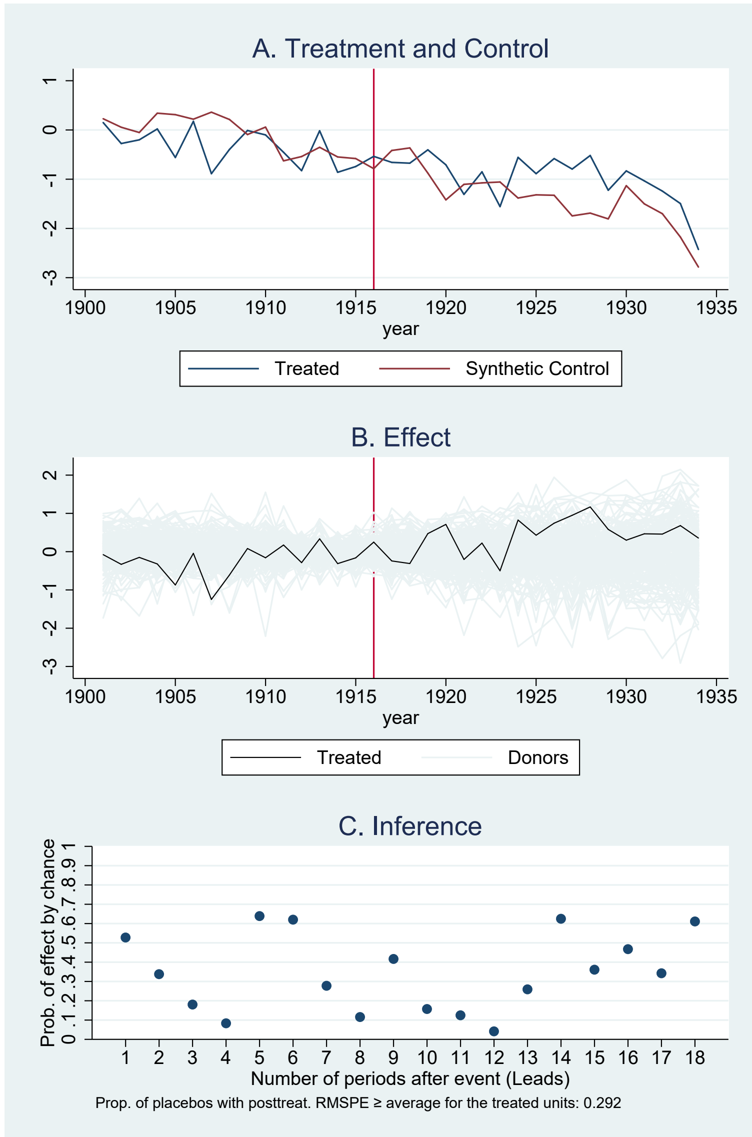
Note: In panel A and B the distribution of the coefficients on the Demonstration period variable and the Post 7 years Demo. variable are plotted respectively, from re-assigning treatment to each control city in the sample and reestimating the regression of Table 5, column (2), along with kernel densisty plots with the true estimates indicated by vertical dotted lines.

Figure 10: Synthetic control results on log infant mortality per 1,000



Note: This figure shows the results of the SCM on log infant mortality per 1,000, where the predictors of the log infant mortality rate in the pre-Demonstration period (1915-1916) are: the log infant mortality rate (1915-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910). The synthetic control is constructed from all the cities in Massachusetts in the US city sample. Panel A shows the path of Framingsham's log infant mortality rate, along with the (counterfactual) synthetic path. The in-place placebo effects, along with the "true" Demonstration effect, and the resulting (empirical) p-values are displayed in Panels B and C respectively. The vertical red line indicate the start of the Demonstration in 1917. See Appendix Table A.7 and A.8 for the weights assigned to the cities forming the synthetic control, and the balance between the synthetic control and the treated before 1917, respectively.

Figure 11: Synthetic control results on log TB mortality per 1,000, using US cities as control



Note: This figure shows the results of the SCM on log TB mortality per 1,000, where the predictors of the log TB rate in the pre-Demonstration period (1901-1916) are: the log TB mortality rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910). The synthetic control is constructed from the cities in US sample with populations from 5,000 and up to 50,000 inhabitants. Panel A shows the path of Framingsham's log TB mortality rate, along with the (counterfactual) synthetic path. The in-place placebo effects, along with the "true" Demonstration effect, and the resulting (empirical) p-values are displayed in Panels B and C respectively. The vertical red line indicate the start of the Demonstration in 1917. See Appendix Table A.15 and A.16 for the weights assigned to the cities forming the synthetic control, and the balance between the synthetic control and the treated before 1917, respectively.

A Appendix tables

Table A.1: Cities in the official control sample and the MA sample

MA city	Control city
framingham	1
chicopee	1
clinton	1
fitchburg	1
gardner	1
marlborough	1
milford	1
north adams	1
abington	0
adams	0
amesbury	0
amherst	0
andover	0
arlington	0
athol	0
attleboro	0
belmont	0
beverly	0
blackstone	0
braintree	0
bridgewater	0
brookline	0
canton	0
chelmsford	0
chelsea	0
concord	0
danvers	0
dartmouth	0
dedham	0
easthampton	0
easton	0
everett	0
fairhaven	0
franklin	0
gloucester	0
grafton	0
greenfield	0
haverhill	0
hingham	0
hudson	0
ipswich	0
lexington	0
ludlow	0
malden	0
marblehead	0
maynard	0
medford	0
melrose	0
middleborough	0
millbury	0
milton	0
monson	0
montague	0
natick	0
needham	0
newburyport	0
newton	0
north andover	0
north attleborough	0
northampton	0
northbridge	0
norwood	0
orange	0
palmer	0
peabody	0
pittsfield	0
plymouth	0
quincy	0
reading	0
revere	0
rockland	0
salem	0
saugus	0
south hadley	0
southbridge	0
spencer	0
stoneham	0
stoughton	0
swampscott	0
taunton	0
tewksbury	0
wakefield	0
walpole	0
waltham	0
ware	0
wareham	0
watertown	0
webster	0
wellesley	0

Note: This table lists the official control cities, and the cities in Massachusetts with populations from 5,000 to 50,000 inhabitants.

Table A.2: Cities in the US sample

City, State ID	State Name	City, State ID	State Name
Framingham, MA	Massachusetts	Torrington, CT	Connecticut
Adams, MA	Massachusetts	Wallingford, CT	Connecticut
Amesbury, MA	Massachusetts	Key West, FL	Florida
Arlington, MA	Massachusetts	Aurora, IL	Illinois
Attleboro, MA	Massachusetts	Belleville, IL	Illinois
Beverly, MA	Massachusetts	Danville, IL	Illinois
Brookline, MA	Massachusetts	Decatur, IL	Illinois
Chelsea, MA	Massachusetts	Jacksonville, IL	Illinois
Chicopee, MA	Massachusetts	Ottawa, IL	Illinois
Clinton, MA	Massachusetts	Quincy, IL	Illinois
Danvers, MA	Massachusetts	Anderson, IN	Indiana
Everett, MA	Massachusetts	Elkhart, IN	Indiana
Fitchburg, MA	Massachusetts	Elwood, IN	Indiana
Gardner, MA	Massachusetts	Huntington, IN	Indiana
Gloucester, MA	Massachusetts	Jeffersonville, IN	Indiana
Holyoke, MA	Massachusetts	Kokomo, IN	Indiana
Leominster, MA	Massachusetts	Lafayette, IN	Indiana
Malden, MA	Massachusetts	Logansport, IN	Indiana
Marlborough, MA	Massachusetts	Marion, IN	Indiana
Medford, MA	Massachusetts	Michigan City, IN	Indiana
Melrose, MA	Massachusetts	Muncie, IN	Indiana
Milford, MA	Massachusetts	New Albany, IN	Indiana
Natick, MA	Massachusetts	Peru, IN	Indiana
Newburyport, MA	Massachusetts	Richmond, IN	Indiana
Newton, MA	Massachusetts	Vincennes, IN	Indiana
North Adams, MA	Massachusetts	Burlington, IA	Iowa
Northampton, MA	Massachusetts	Davenport, IA	Iowa
Peabody, MA	Massachusetts	Muscatine, IA	Iowa
Pittsfield, MA	Massachusetts	Ottumwa, IA	Iowa
Plymouth, MA	Massachusetts	Lawrence, KS	Kansas
Quincy, MA	Massachusetts	Leavenworth, KS	Kansas
Revere, MA	Massachusetts	Newport, KY	Kentucky
Salem, MA	Massachusetts	Paducah, KY	Kentucky
Southbridge, MA	Massachusetts	Augusta, ME	Maine
Taunton, MA	Massachusetts	Bangor, ME	Maine
Wakefield, MA	Massachusetts	Biddeford, ME	Maine
Waltham, MA	Massachusetts	Annapolis, MD	Maryland
Watertown, MA	Massachusetts	Frederick, MD	Maryland
Webster, MA	Massachusetts	Ann Arbor, MI	Michigan
Westfield, MA	Massachusetts	Battle Creek, MI	Michigan
Weymouth, MA	Massachusetts	Bay City, MI	Michigan
Woburn, MA	Massachusetts	Escanaba, MI	Michigan
Alameda, CA	California	Iron Mountain, MI	Michigan
Fresno, CA	California	Ironwood, MI	Michigan
Sacramento, CA	California	Jackson, MI	Michigan
San Jose, CA	California	Kalamazoo, MI	Michigan
Ansonia, CT	Connecticut	Lansing, MI	Michigan
Bristol, CT	Connecticut	Marquette, MI	Michigan
Danbury, CT	Connecticut	Menominee, MI	Michigan
Meriden, CT	Connecticut	Muskegon, MI	Michigan
Middletown, CT	Connecticut	Owosso, MI	Michigan
Naugatuck, CT	Connecticut	Pontiac, MI	Michigan
New London, CT	Connecticut	Port Huron, MI	Michigan
Norwich, CT	Connecticut	Sault Ste. Marie, MI	Michigan
Stamford, CT	Connecticut	Traverse City, MI	Michigan

Note: Table continued on next page.

Table A.2 (Cont'd): Cities in the US panel

City, State ID	State Name
Mankato, MN	Minnesota
Winona, MN	Minnesota
Helena, MT	Montana
Lincoln, NE	Nebraska
Berlin, NH	New Hampshire
Concord, NH	New Hampshire
Dover, NH	New Hampshire
Keene, NH	New Hampshire
Laconia, NH	New Hampshire
Nashua, NH	New Hampshire
Portsmouth, NH	New Hampshire
Rochester, NH	New Hampshire
Atlantic City, NJ	New Jersey
Bridgeton, NJ	New Jersey
Harrison, NJ	New Jersey
Millville, NJ	New Jersey
Montclair, NJ	New Jersey
Morristown, NJ	New Jersey
New Brunswick, NJ	New Jersey
Orange, NJ	New Jersey
Perth Amboy, NJ	New Jersey
Phillipsburg, NJ	New Jersey
Plainfield, NJ	New Jersey
Union City, NJ	New Jersey
Amsterdam, NY	New York
Auburn, NY	New York
Cohoes, NY	New York
Corning, NY	New York
Cortland, NY	New York
Dunkirk, NY	New York
Elmira, NY	New York
Geneva, NY	New York
Glens Falls, NY	New York
Gloversville, NY	New York
Hudson, NY	New York
Ithaca, NY	New York
Jamestown, NY	New York
Johnstown, NY	New York
Kingston, NY	New York
Lockport, NY	New York
Middletown, NY	New York
Mount Vernon, NY	New York
New Rochelle, NY	New York
Newburgh, NY	New York
Niagara Falls, NY	New York
Ogdensburg, NY	New York
Olean, NY	New York
Peekskill, NY	New York
Port Jervis, NY	New York
Poughkeepsie, NY	New York
Rome, NY	New York
Saratoga Springs, NY	New York
Watertown, NY	New York
Watervliet, NY	New York
Raleigh, NC	North Carolina
Wilmington, NC	North Carolina
Ashtabula, OH	Ohio
Bellaire, OH	Ohio
Chillicothe, OH	Ohio
Findlay, OH	Ohio
Hamilton, OH	Ohio
Ironton, OH	Ohio
Lima, OH	Ohio
Marietta, OH	Ohio
Massillon, OH	Ohio
Middletown, OH	Ohio
Newark, OH	Ohio
Portsmouth, OH	Ohio
Tiffin, OH	Ohio
Warren, OH	Ohio
Carbondale, PA	Pennsylvania
Carlisle, PA	Pennsylvania
Columbia, PA	Pennsylvania
Du Bois, PA	Pennsylvania
Easton, PA	Pennsylvania
Hazleton, PA	Pennsylvania
Lebanon, PA	Pennsylvania
Mahanoy City, PA	Pennsylvania
McKeesport, PA	Pennsylvania
Meadville, PA	Pennsylvania
Mount Carmel, PA	Pennsylvania
New Castle, PA	Pennsylvania
Norristown, PA	Pennsylvania
Oil City, PA	Pennsylvania
Phoenixville, PA	Pennsylvania
Plymouth, PA	Pennsylvania
Pottstown, PA	Pennsylvania
Pottsville, PA	Pennsylvania
Steelton, PA	Pennsylvania
Williamsport, PA	Pennsylvania
Central Falls, RI	Rhode Island
Newport, RI	Rhode Island
Woonsocket, RI	Rhode Island
Barre, VT	Vermont
Burlington, VT	Vermont
Rutland, VT	Vermont
Alexandria, VA	Virginia
Lynchburg, VA	Virginia
Petersburg, VA	Virginia
Appleton, WI	Wisconsin
Beloit, WI	Wisconsin
Eau Claire, WI	Wisconsin
Green Bay, WI	Wisconsin
Madison, WI	Wisconsin
Manitowoc, WI	Wisconsin
Marinette, WI	Wisconsin
Superior, WI	Wisconsin

Note: This table lists the cities in the US panel with populations from 5,000 to 50,000 inhabitants.

Table A.3: Synthetic control weights for the synthetic control results on log TB mortality per 1,000

City	Weight
abington	.004
adams	.002
amesbury	.002
amherst	.003
andover	.004
arlington	.002
athol	.004
attleboro	.003
belmont	.008
beverly	.004
blackstone	.002
braintree	.003
bridgewater	.001
brookline	.127
canton	.002
chelmsford	.002
chelsea	.005
chicopee	.002
clinton	.003
concord	.225
danvers	.002
dartmouth	.003
dedham	.004
easthampton	.027
easton	.002
everett	.004
fairhaven	.004
fitchburg	.006
franklin	.012
gardner	.004
gloucester	.003
grafton	.001
greenfield	.006
haverhill	.005
hingham	.003
hudson	.007
ipswich	.005
lexington	.003
ludlow	.014
malden	.008
marblehead	.005
marlborough	.002
maynard	.005
medford	.004
melrose	.003
middleborough	.003
milford	.002
millbury	.002
milton	.013
monson	.002
montague	.005
natick	.009
needham	.002
newburyport	.003
newton	.059
north adams	.003
north andover	.004
north attleborough	.003
northampton	.002
northbridge	.003
norwood	.073
orange	.111
palmer	.002
peabody	.004
pittsfield	.005
plymouth	.006
quincy	.005
reading	.003
revere	.004
rockland	.002
salem	.004
saugus	.002
south hadley	.003
southbridge	.011
spencer	.002
stoneham	.003
stoughton	.003
swampscott	.004
taunton	.002
tewksbury	.014
wakefield	.005
walpole	.003
waltham	.004
ware	.005
wareham	.002
watertown	.012
webster	.006
wellesley	.041

Note: This table lists the weights assigned to cities in the donor pool of cities in the extended Massachusetts panel from the SCM results on log TB mortality per 1,000 shown in Figure 6, where the predictors of the log TB mortality rate in the pre-Demonstration period (1901-1916) are: the log TB mortality rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910).

Table A.4: Balance of treated versus the synthetic control for the synthetic control results on log TB mortality per 1,000

	Treated	Synthetic
log TB rate (1911-1916)	-.5790446	-.5819229
Population size	13020.44	13068.06
log income(1910)	6.531471	6.570505
Share of foreign born (1910)	.2995993	.3014688
Share aged 15-44 (1910)	.5651415	.567995
Share age 60- (1910)	.084335	.0847915

Note: This table lists the average value of the predictors of the log TB mortality rate in the pre-Demonstration period (1901-1916) for the treated unit (Framingham), and the sythetic control, using the weights assigned in Table A.3.

Table A.5: Synthetic control weights for the synthetic control results on log total mortality per 1,000

City	Weight
adams	0
arlington	0
attleboro	0
beverly	0
brookline	0
chelsea	0
chicopee	0
clinton	.227
everett	0
fitchburg	0
gardner	.016
gloucester	0
haverhill	0
leominster	0
malden	0
marlborough	0
medford	0
melrose	0
milford	0
newburyport	0
newton	0
north adams	0
northampton	0
peabody	0
pittsfield	0
plymouth	.342
quincy	0
revere	0
salem	0
southbridge	.157
taunton	.228
wakefield	0
waltham	0
watertown	0
webster	.029

Note: This table lists the weights assigned to cities in the donor pool of Massachusetts cities in the US sample from the SCM results on log total mortality per 1,000 shown in Figure 8, where the predictors of the log mortality rate in the pre-Demonstration period (1901-1916) are: the log mortality rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910).

Table A.6: Balance of treated versus the synthetic control for the synthetic control results on log total mortality per 1,000

	Treated	Synthetic
log mortality rate (1911-1916)	2.684095	2.680831
Population size	13020.44	17015.74
log income(1910)	6.531471	6.506506
Share of foreign born (1910)	.2995993	.2978357
Share aged 15-44 (1910)	.5651415	.5413785
Share age 60- (1910)	.084335	.0763084

Note: This table lists the average value of the predictors of the log mortality rate in the pre-Demonstration period (1901-1916) for the treated unit (Framingham), and the sythetic control, using the weights assigned in Table A.5.

Table A.7: Synthetic control weights for the synthetic control results on log infant mortality per 1,000

City	Weight		
attleboro	0	malden	0
beverly	0	marlborough	0
boston	0	medford	0
brockton	0	melrose	0
brookline	0	new bedford	0
cambridge	0	newton	0
chelsea	0	north adams	0
chicopee	0	northampton	0
everett	0	peabody	0
fall river	0	pittsfield	0
fitchburg	0	quincy	0
gardner	0	revere	0
gloucester	0	salem	0
haverhill	0	somerville	0
holyoke	.175	springfield	0
lawrence	0	taunton	.321
leominster	0	waltham	.168
lowell	0	watertown	.336
lynn	0		

Note: This table lists the weights assigned to cities in the donor pool of cities in the extended Massachusetts panel from the SCM results on log infant mortality per 1,000 shown in Figure 10, where the predictors of the log infant mortality rate in the pre-Demonstration period (1915-1916) are: the log infant mortality rate (1915-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910).

Table A.8: Balance of treated versus the synthetic control for the synthetic control results on log infant mortality per 1,000

	Treated	Synthetic
log infant mortality rate (1915-1916)	4.57402	4.573781
Population size	15973.98	33047.4
log income(1910)	6.531471	6.513304
Share of foreign born (1910)	.2995993	.3134716
Share aged 15-44 (1910)	.5651415	.5274899
Share age 60- (1910)	.084335	.0823679

Note: This table lists the average value of the predictors of the log infant mortality rate in the pre-Demonstration period (1915-1916) for the treated unit (Framingham), and the sythetic control, using the weights assigned in Table A.7.

Table A.9: Synthetic control weights for the synthetic control results on log pneumonia mortality per 1,000

City	Weight
abington	0
adams	.001
amesbury	.004
amherst	.002
andover	.005
arlington	.002
athol	.003
attleboro	.002
belmont	.006
beverly	.001
blackstone	.002
braintree	.001
bridgewater	.003
brookline	.154
canton	.001
chelsea	.007
chicopee	.004
clinton	.01
concord	.058
danvers	.182
dartmouth	.003
dedham	.003
easthampton	.004
easton	.002
everett	.003
fairhaven	.007
fitchburg	.005
franklin	.002
gardner	.002
gloucester	.003
grafton	.002
great barrington	.002
greenfield	.003
haverhill	.011
hingham	.001
ipswich	.003
leominster	.003
lexington	.003
ludlow	.102
malden	.003
marlborough	.002
maynard	.002
medford	.007
melrose	.002
middleborough	.001
milford	.003
millbury	.001
milton	.01
monson	.032
montague	.014
natick	.009
needham	.002
newburyport	.003
newton	.005
north adams	.003
north andover	.002
north attleborough	.001
northampton	.003
northbridge	.002
norwood	.003
orange	.072
palmer	.001
peabody	.002
pittsfield	.024
plymouth	.004
quincy	0
reading	.004
revere	.002
rockland	.001
salem	.005
saugus	.002
southbridge	.005
spencer	.002
stoneham	.003
stoughton	.008
swampscott	.001
taunton	.006
tewksbury	0
wakefield	.004
walpole	.001
waltham	.006
ware	.103
wareham	.001
watertown	.007
webster	.007
wellesley	.001

Note: This table lists the weights assigned to cities in the donor pool of cities in the extended Massachusetts panel from the SCM results on log pneumonia mortality per 1,000 shown in Figure A.5, where the predictors of the log pneumonia mortality rate in the pre-Demonstration period (1901-1916) are: the log pneumonia mortality rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910).

Table A.10: Balance of treated versus the synthetic control for the synthetic control results on log pneumonia mortality per 1,000

	Treated	Synthetic
log pneumonia mortality rate (1911-1916)	.4729174	.4712107
Population size	13020.44	12952.94
log income(1910)	6.531471	6.492478
Share of foreign born (1910)	.2995993	.2974995
Share aged 15-44 (1910)	.5651415	.5621322
Share age 60- (1910)	.084335	.0837625

Note: This table lists the average value of the predictors of the log pneumonia mortality rate in the pre-Demonstration period (1901-1916) for the treated unit (Framingham), and the sythetic control, using the weights assigned in Table A.9.

Table A.11: Synthetic control weights for the synthetic control results on log mortality by strokes per 1,000

City	Weight	City	Weight	City	Weight
abington	.004	grafton	.003	northbridge	.006
adams	.004	great barrington	.003	norwood	.017
amesbury	.003	greenfield	.006	orange	.151
amherst	.003	haverhill	.026	palmer	.004
andover	.01	hingham	.002	peabody	.005
arlington	.004	hudson	.006	pittsfield	.01
athol	.006	ipswich	.03	plymouth	.007
attleboro	.004	leominster	.006	quincy	.009
belmont	.006	lexington	.005	reading	.005
beverly	.006	ludlow	.026	revere	.005
blackstone	.003	malden	.007	rockland	.004
braintree	.004	mansfield	.003	salem	.008
bridgewater	.004	marblehead	.005	saugus	.005
brookline	.113	marlborough	.004	south hadley	.004
canton	.004	maynard	.009	southbridge	.012
chelmsford	.004	medford	.005	spencer	.003
chelsea	.007	melrose	.003	stoneham	.005
chicopee	.006	middleborough	.003	stoughton	.005
clinton	.007	milford	.003	swampscott	.004
concord	.151	millbury	.003	taunton	.005
danvers	.005	milton	.008	tewksbury	.007
dartmouth	.004	monson	.007	wakefield	.006
dedham	.006	montague	.007	walpole	.003
easthampton	.006	natick	.005	waltham	.01
easton	.003	needham	.004	ware	.034
everett	.008	newburyport	.004	wareham	.002
fairhaven	.006	newton	.009	watertown	.012
fitchburg	.01	north adams	.005	webster	.012
franklin	.006	north andover	.006	wellesley	.003
gardner	.005	north attleborough	.005		
gloucester	.005	northampton	.004		

Note: This table lists the weights assigned to cities in the donor pool of cities in the extended Massachusetts panel from the SCM results on log mortality by strokes per 1,000 shown in Figure A.5, where the predictors of the log mortality by strokes rate in the pre-Demonstration period (1901-1916) are: the log mortality by strokes rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910).

Table A.12: Balance of treated versus the synthetic control for the synthetic control results on log mortality by strokes per 1,000

	Treated	Synthetic
log deaths by strokes rate (1911-1916)	-.0784592	-.0791999
Population size	13020.44	13045.52
log income(1910)	6.531471	6.543586
Share of foreign born (1910)	.2995993	.2999649
Share aged 15-44 (1910)	.5651415	.5661419
Share age 60- (1910)	.084335	.0844452

Note: This table lists the average value of the predictors of the log mortality by strokes rate in the pre-Demonstration period (1901-1916) for the treated unit (Framingham), and the sythetic control, using the weights assigned in Table A.11.

Table A.13: Synthetic control weights for the synthetic control results on log external causes of death per 1,000

City	Weight
abington	0
adams	0
amesbury	0
andover	0
arlington	0
athol	0
attleboro	0
beverly	0
blackstone	0
braintree	0
bridgewater	0
brookline	0
canton	0
chelmsford	0
chelsea	.182
chicopee	0
clinton	0
concord	.243
danvers	0
dartmouth	0
dedham	0
easton	0
everett	0
fitchburg	0
franklin	0
gardner	0
gloucester	0
grafton	0
great barrington	0
greenfield	.254
haverhill	0
hingham	0
hudson	0
ipswich	.049
leominster	0
lexington	0
ludlow	0
malden	0
mansfield	0
marblehead	0
marlborough	0
maynard	0
medford	0
melrose	0
middleborough	0
milford	0
millbury	0
milton	0
monson	0
montague	.259
natick	0
needham	0
newburyport	0
newton	0
north adams	0
north andover	0
north attleborough	0
northampton	0
northbridge	0
norwood	0
orange	.013
palmer	0
peabody	0
pittsfield	0
plymouth	0
quincy	0
reading	0
revere	0
rockland	0
salem	0
saugus	0
south hadley	0
southbridge	0
spencer	0
stoneham	0
swampscott	0
taunton	0
tewksbury	0
wakefield	0
walpole	0
waltham	0
ware	0
watertown	0
webster	0
wellesley	0

Note: This table lists the weights assigned to cities in the donor pool of cities in the extended Massachusetts panel from the SCM results on log external causes of death per 1,000 shown in Figure A.5, where the predictors of the log external causes of death rate in the pre-Demonstration period (1901-1916) are: the log external causes of death rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910).

Table A.14: Balance of treated versus the synthetic control for the synthetic control results on log external causes of death per 1,000

	Treated	Synthetic
log deaths by external causes rate (1911-1916)	.1743594	.1743087
Population size	13020.44	12927.47
log income(1910)	6.531471	6.531945
Share of foreign born (1910)	.2995993	.2994392
Share aged 15-44 (1910)	.5651415	.5637111
Share age 60- (1910)	.084335	.0836093

Note: This table lists the average value of the predictors of the log external causes of death rate in the pre-Demonstration period (1901-1916) for the treated unit (Framingham), and the sythetic control, using the weights assigned in Table A.13.

Table A.15: Synthetic control weights for the synthetic control results on log TB mortality per 1,000 using US cities as control

City	Weight
Adams, MA	0
Alameda, CA	0
Alexandria, VA	0
Amesbury, MA	0
Amsterdam, NY	0
Anderson, IN	0
Ann Arbor, MI	0
Annapolis, MD	0
Ansonia, CT	0
Appleton, WI	0
Arlington, MA	0
Ashtabula, OH	0
Atlantic City, NJ	0
Attleboro, MA	0
Auburn, NY	0
Augusta, ME	0
Aurora, IL	0
Bangor, ME	0
Barre, VT	0
Battle Creek, MI	0
Bay City, MI	0
Bellaire, OH	0
Belleville, IL	0
Beloit, WI	0
Berlin, NH	0
Beverly, MA	0
Biddeford, ME	0
Bridgeton, NJ	0
Bristol, CT	0
Brookline, MA	.035
Burlington, IA	0
Burlington, VT	0
Carbondale, PA	0
Carlisle, PA	0
Central Falls, RI	0
Chelsea, MA	0
Chicopee, MA	0
Chillicothe, OH	0
Clinton, MA	0
Cohoes, NY	0
Columbia, PA	0
Concord, NH	0
Corning, NY	0
Cortland, NY	0
Danbury, CT	0
Danvers, MA	0
Danville, IL	0
Davenport, IA	0
Decatur, IL	0
Dover, NH	0
Du Bois, PA	0
Dunkirk, NY	0
Easton, PA	0
Eau Claire, WI	0
Elkhart, IN	0
Elmira, NY	0
Elwood, IN	0
Escanaba, MI	0
Everett, MA	0
Findlay, OH	0
Fitchburg, MA	0
Frederick, MD	0
Fresno, CA	0
Gardner, MA	0
Geneva, NY	0
Glens Falls, NY	0
Gloucester, MA	0
Gloversville, NY	0
Green Bay, WI	0
Hamilton, OH	0
Harrison, NJ	0
Hazleton, PA	0
Helena, MT	0
Holyoke, MA	0
Hudson, NY	0
Huntington, IN	0
Iron Mountain, MI	0
Ironton, OH	0
Ironwood, MI	0
Ithaca, NY	0
Jackson, MI	0
Jacksonville, IL	0
Jamestown, NY	0
Jeffersonville, IN	0
Johnstown, NY	0
Kalamazoo, MI	0
Keene, NH	0
Key West, FL	0
Kingston, NY	0
Kokomo, IN	0
Laconia, NH	0
Lafayette, IN	0
Lansing, MI	.135
Lawrence, KS	0
Leavenworth, KS	0
Lebanon, PA	0
Leominster, MA	0
Lima, OH	0
Lincoln, NE	0
Lockport, NY	0
Logansport, IN	0
Lynchburg, VA	0
Madison, WI	0
Mahanoy City, PA	0
Malden, MA	0
Manitowoc, WI	0
Mankato, MN	0
Marietta, OH	0
Marinette, WI	0
Marion, IN	0
Marlborough, MA	0
Marquette, MI	0
Massillon, OH	0
McKeesport, PA	0
Meadville, PA	0
Medford, MA	0
Melrose, MA	0
Menominee, MI	0
Meriden, CT	0
Michigan City, IN	0
Middletown, CT	0
Middletown, NY	0
Middletown, OH	0
Milford, MA	0
Millville, NJ	0
Montclair, NJ	0
Morristown, NJ	0
Mount Carmel, PA	0
Mount Vernon, NY	0
Muncie, IN	0
Muscatine, IA	0
Muskegon, MI	0
Nashua, NH	0
Natick, MA	0
Naugatuck, CT	0
New Albany, IN	0
New Brunswick, NJ	0
New Castle, PA	0
New London, CT	0
New Rochelle, NY	0
Newark, OH	0
Newburgh, NY	0
Newburyport, MA	0
Newport, KY	0
Newport, RI	0
Newton, MA	0
Niagara Falls, NY	0
Norristown, PA	0
North Adams, MA	0
Northampton, MA	0
Norwich, CT	0
Ogdensburg, NY	0
Oil City, PA	0
Olean, NY	0
Orange, NJ	0
Ottawa, IL	0
Ottumwa, IA	0
Owosso, MI	0
Paducah, KY	0
Peabody, MA	0
Peekskill, NY	0
Perth Amboy, NJ	0
Peru, IN	0
Petersburg, VA	0
Phillipsburg, NJ	0
Phoenixville, PA	0
Pittsfield, MA	0
Plainfield, NJ	0
Plymouth, MA	0
Plymouth, PA	0
Pontiac, MI	0
Port Huron, MI	0
Port Jervis, NY	0
Portsmouth, NH	0
Portsmouth, OH	0
Pottstown, PA	0
Pottsville, PA	0
Poughkeepsie, NY	0
Quincy, IL	0
Quincy, MA	0
Raleigh, NC	0
Revere, MA	0
Richmond, IN	0
Rochester, NH	0
Rome, NY	0
Rutland, VT	0
Sacramento, CA	0
Salem, MA	0
San Jose, CA	0
Saratoga Springs, NY	0
Sault Ste. Marie, MI	0
Southbridge, MA	.444
Stamford, CT	0
Steelton, PA	0
Superior, WI	0
Taunton, MA	0
Tiffin, OH	0
Torrington, CT	0
Traverse City, MI	0
Union City, NJ	0
Vincennes, IN	0
Wakefield, MA	0
Wallingford, CT	0
Waltham, MA	0
Warren, OH	0
Watertown, MA	.117
Watertown, NY	0
Watervliet, NY	0
Webster, MA	0
Westfield, MA	0
Weymouth, MA	.269
Williamsport, PA	0
Wilmington, NC	0
Winona, MN	0
Woburn, MA	0
Woonsocket, RI	0

Note: This table lists the weights assigned to cities in the donor pool of cities in the US city sample from the SCM results on log TB mortality per 1,000 shown in Figure 11, where the predictors of the log TB mortality rate in the pre-Demonstration period (1901-1916) are: the log TB mortality rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910).

Table A.16: Balance of treated versus the synthetic control for the synthetic control results on log TB mortality per 1,000 using US cities as control

	Treated	Synthetic
log TB rate (1911-1916)	-.5724008	-.5721859
Population size	15001.09	14925.3
log income(1910)	6.53147	6.527371
Share of foreign born (1910)	.2995994	.2960001
Share aged 15-44 (1910)	.5651417	.557884
Share age 60- (1910)	.084335	.0820419

Note: This table lists the average value of the predictors of the log TB mortality rate in the pre-Demonstration period (1901-1916) for the treated unit (Framingham), and the sythetic control, using the weights assigned in Table A.15.

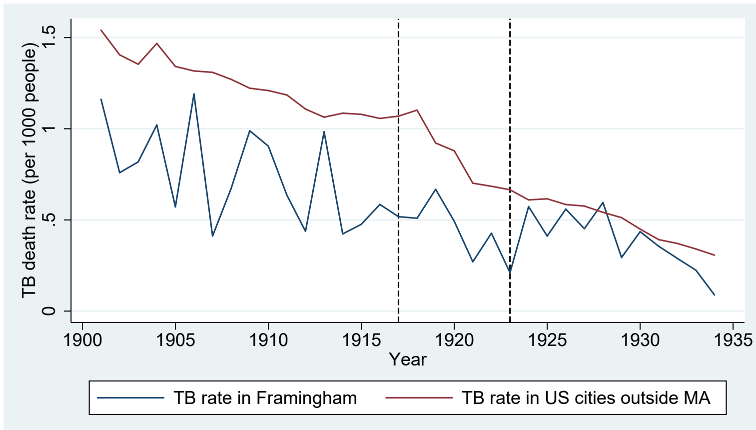
Table A.17: Spillover effects

Dep. variable:	Control cities	Massachusetts cites			US control cities		
	log TB rate						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pre 11 years Demo. × dist.	0.0344	-0.0146	-0.0154	0.0247	-0.0214	-0.0199	-0.0232
	(0.0320)	(0.0294)	(0.0294)	(0.0346)	(0.0165)	(0.0166)	(0.0173)
Demonstration period × dist.	0.0144	0.00913	0.0181	0.00101	-0.00438	-0.0201	-0.0113
	(0.0508)	(0.0315)	(0.0312)	(0.0233)	(0.0159)	(0.0172)	(0.00994)
Post Demonstration × dist.	-0.0278	-0.00786	0.00175	0.00411	0.0193	0.00247	-0.00136
	(0.0975)	(0.0458)	(0.0469)	(0.0277)	(0.0285)	(0.0275)	(0.0115)
Avg. dep. var.	-0.399	-0.510	-0.510	-0.638	-0.296	-0.296	-0.399
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	No	No	Yes	Yes	No	Yes	Yes
Economic controls	No	No	Yes	Yes	No	Yes	Yes
Lags of the dependent var.	No	No	No	Yes	No	No	Yes
Cities	8	89	89	89	217	217	217
Time period	1901-1934	1901-1934	1901-1934	1906-1934	1901-1934	1901-1934	1906-1934
Observations	272	3,026	3,026	2,581	7,378	7,378	6,293
R-squared	0.663	0.637	0.641	0.659	0.750	0.753	0.805

Note: The table reports least squares estimates. In column (1) the panel consist of Framingham and the official controls cities, in columns (2) to (4) the panel is the extended Massachusetts panel, in columns (5) to (7) the panel is the cities in the US sample. In columns (1) to (7) the left-hand-side variable is the log TB mortality per 1,000. All regressions include city and year fixed effects. Pre 11 years Demo.×dist. is the standardized distance to Framingham 11 years and prior to the Demonstration and zero afterwards, in columns (4) and (7) this only includes the year 1906; Demonstration period×dist. is the standardized distance to Framingham during the Demonstration period, 1917 to 1923, else zero; Post Demonstration×dist. is the standardized distance to Framingham after the Demonstration period, and zero before. Columns (3), (4), (6), and (7) add demographic controls of log population size, share of infants, share aged 15-44, share aged 60 and above, share of foreign born, and the economic control of income per worker using earningsscore, all measured in 1910 and equal to zero before 1917, and columns (4) and (7) additionally add 1-5 year lags of the log TB mortality rate. Robust standard errors clustered at the city level are in parentheses. *, **, and *** determine significance levels of ten percent, five percent, and one percent, respectively.

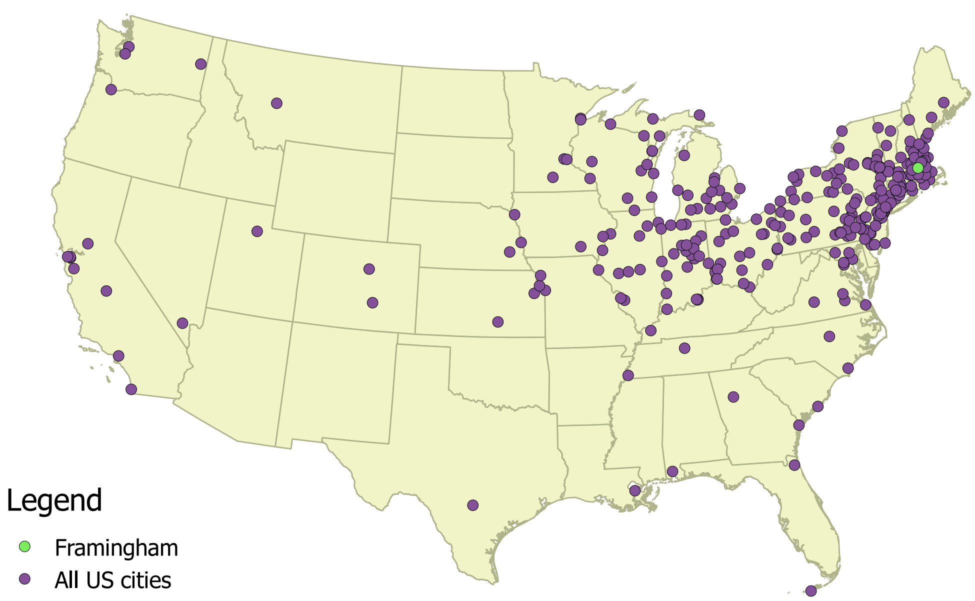
A Appendix figures

Figure A.1: TB deaths per 1,000 in Framingham and the US cities outside MA



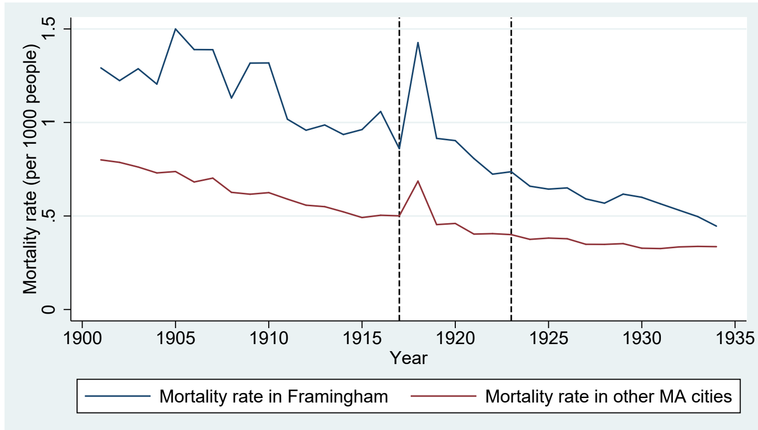
Note: The graph plots the development of the aggregate mortality per 1,000 in Framingham and the US cities outside Massachusetts. The vertical doted lines enclose the Demonstration period from 1917 to 1923.

Figure A.2: Map of the cities in the US sample



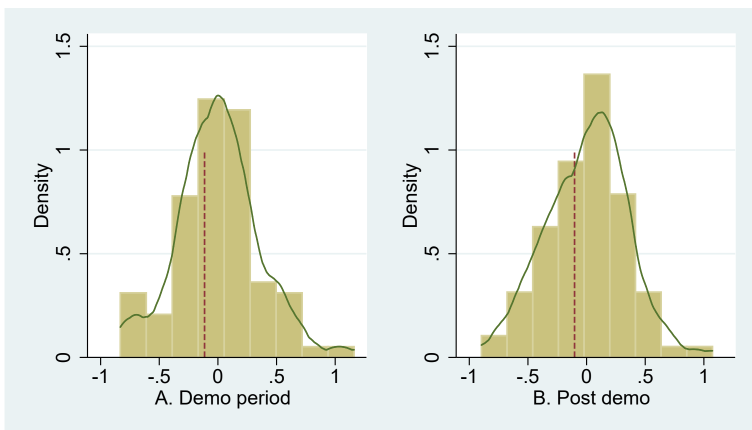
Note: The map plots the position of Framingham and the cities in the US sample with no restition on population size.

Figure A.3: Mortality per 1,000 in Framingham and in MA



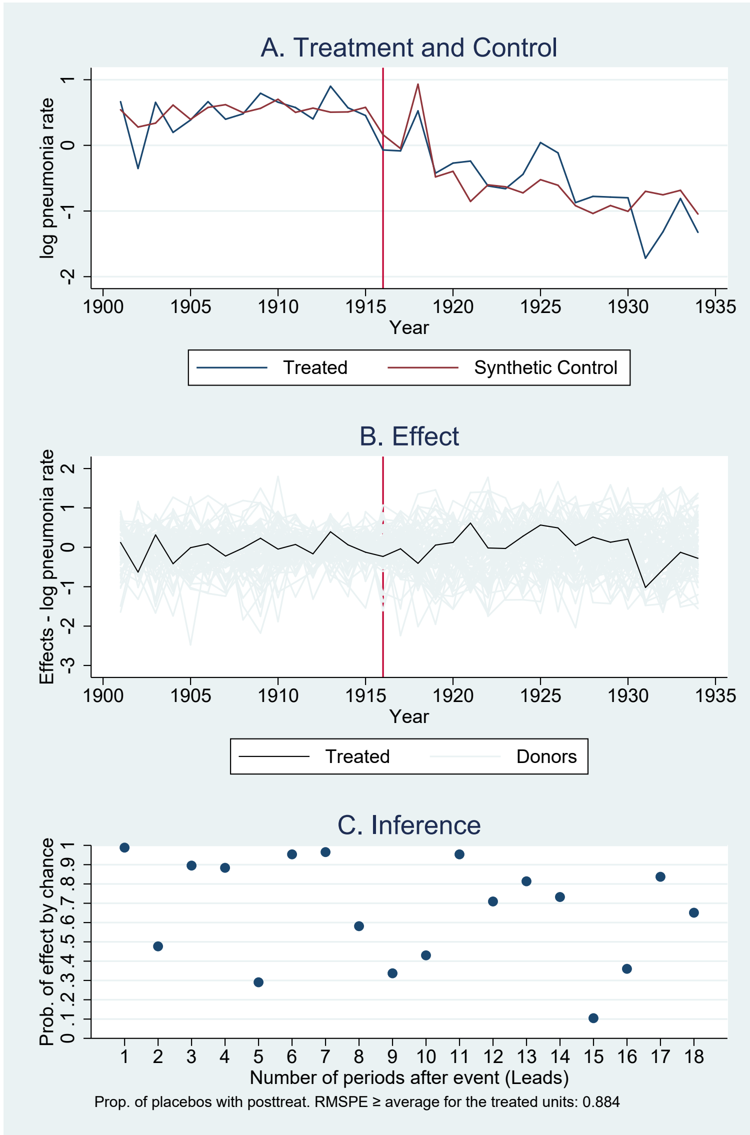
Note: The graph plots the development of the aggregate mortality per 1,000 in Framingham and the MA cities available in the US panel. The vertical doted lines enclose the Demonstration period from 1917 to 1923.

Figure A.4: Permutation inference on log pneumonia mortality per 1,000



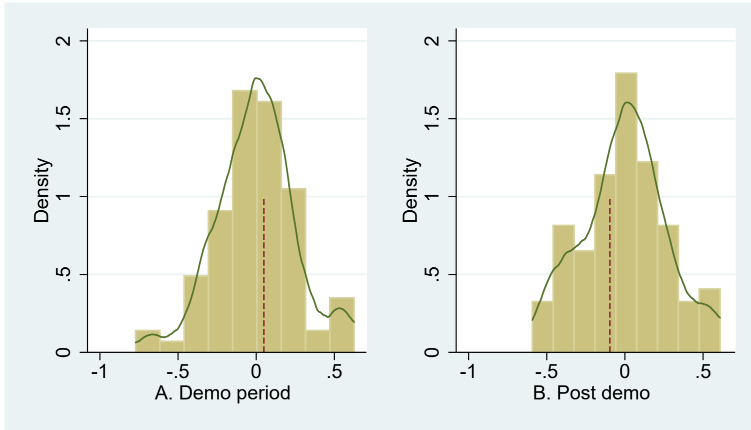
Note: In panel A and B the distribution of the coefficients on the Demonstration period variable and the Post 7 years Demo. variable are plotted respectively, from re-assigning treatment to each control city in the sample and reestimating the regression of Table 5, column (3), along with kernel densisty plots with the true estimates indicated by vertical dotted lines.

Figure A.5: Synthetic control results on log pneumonia mortality per 1,000



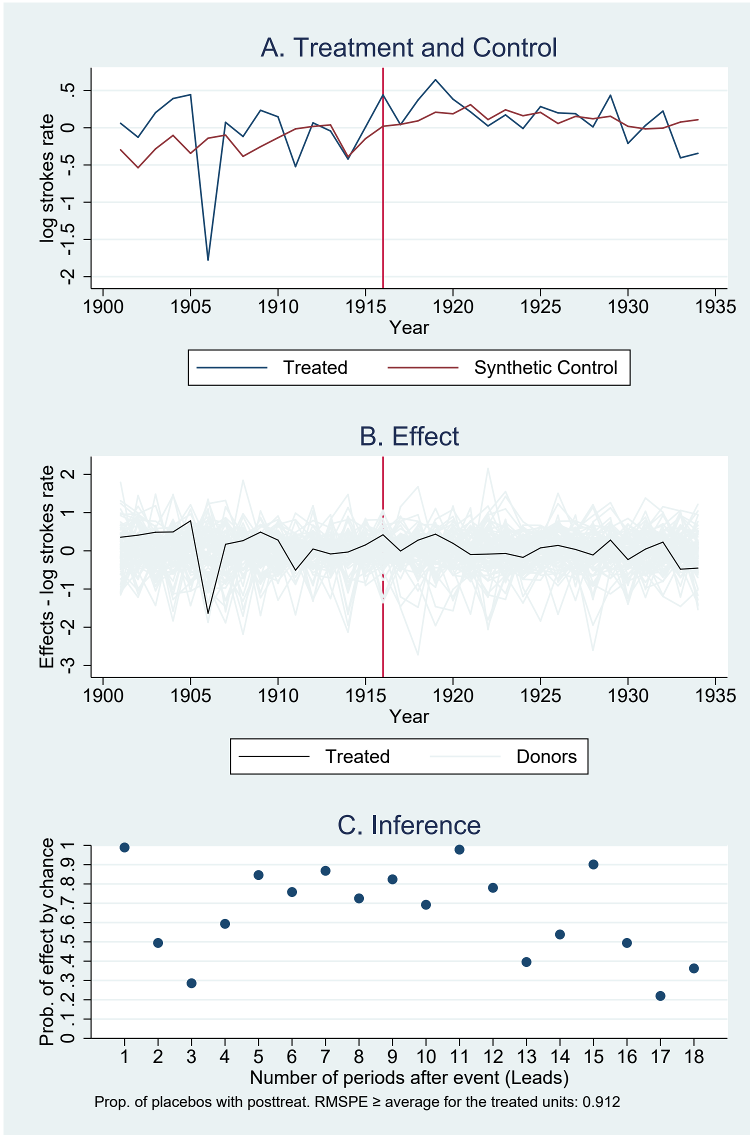
Note: This figure shows the results of the SCM on log pneumonia mortality per 1,000, where the predictors of the log pneumonia rate in the pre-Demonstration period (1900-1916) are: the pneumonia TB mortality rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910). The synthetic control is constructed from the cities in the extended Massachusetts panel. Panel A shows the path of Framingsham's log pneumonia mortality rate, along with the (counterfactual) synthetic path. The in-place placebo effects, along with the "true" Demonstration effect, and the resulting (empirical) p-values are displayed in Panels B and C respectively. The vertical red line indicate the start of the Demonstration in 1917. See Appendix Table A.9 and A.10 for the weights assigned to the cities forming the synthetic control, and the balance between the synthetic control and the treated before 1917, respectively.

Figure A.6: Permutation inference on log mortality by strokes per 1,000



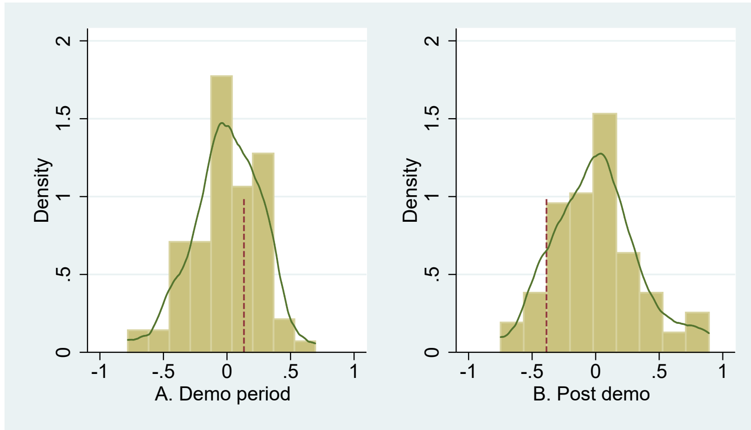
Note: In panel A and B the distribution of the coefficients on the Demonstration period variable and the Post 7 years Demo. variable are plotted respectively, from re-assigning treatment to each control city in the sample and reestimating the regression of Table 5, column (4), along with kernel densisty plots with the true estimates indicated by vertical dotted lines.

Figure A.7: Synthetic control results on log mortality by strokes per 1,000



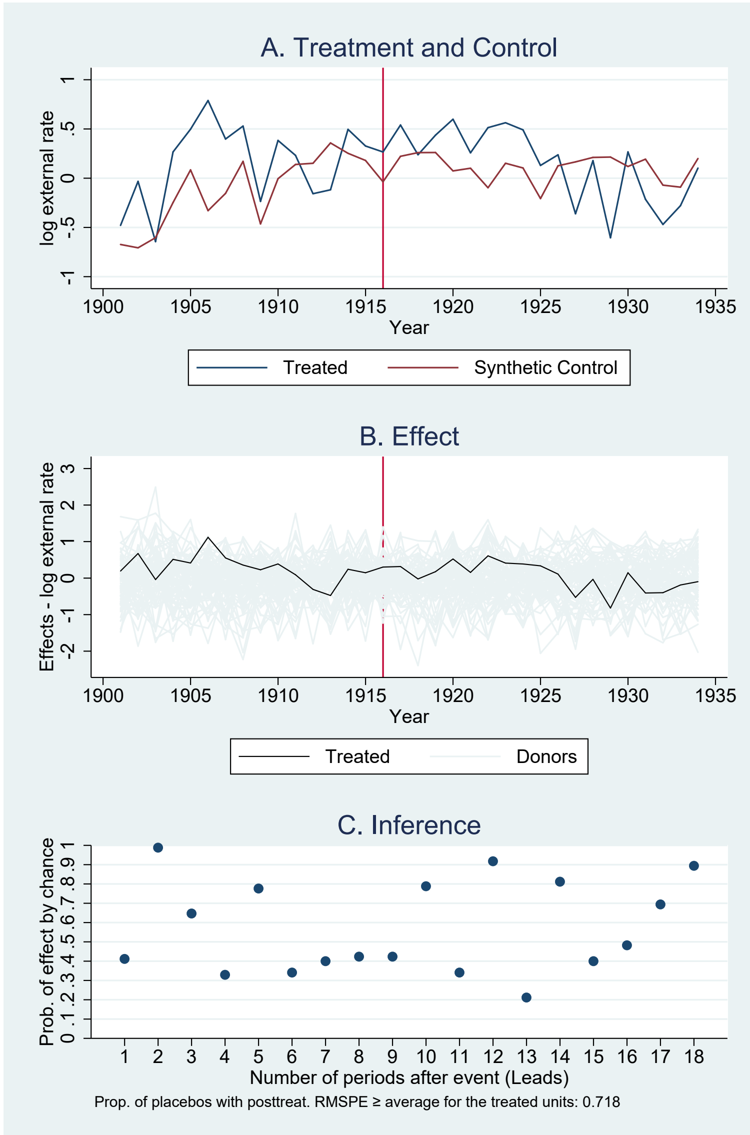
Note: This figure shows the results of the SCM on log mortality by strokes per 1,000, where the predictors of the log mortality by strokes rate in the pre-Demonstration period (1900-1916) are: the mortality by strokes rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910). The synthetic control is constructed from the cities in the extended Massachusetts panel. Panel A shows the path of Framingsham's log mortality by strokes rate, along with the (counterfactual) synthetic path. The in-place placebo effects, along with the "true" Demonstration effect, and the resulting (empirical) p-values are displayed in Panels B and C respectively. The vertical red line indicate the start of the Demonstration in 1917. See Appendix Table A.11 and A.12 for the weights assigned to the cities forming the synthetic control, and the balance between the synthetic control and the treated before 1917, respectively.

Figure A.8: Permutation inference on log external causes of death per 1,000



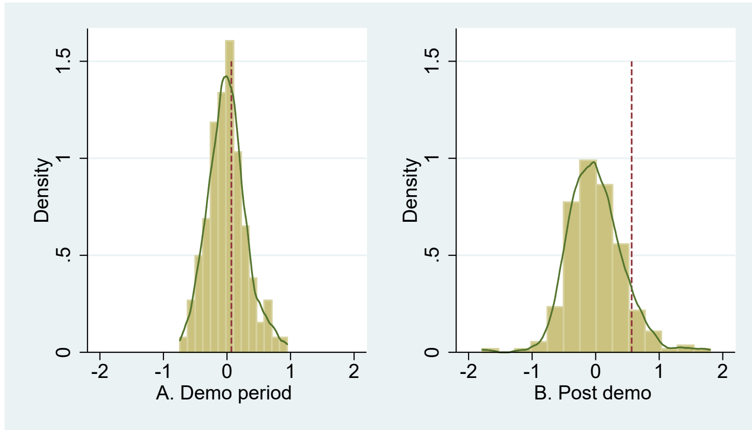
Note: In panel A and B the distribution of the coefficients on the Demonstration period variable and the Post 7 years Demo. variable are plotted respectively, from re-assigning treatment to each control city in the sample and reestimating the regression of Table 5, column (5), along with kernel densisty plots with the true estimates indicated by vertical dotted lines.

Figure A.9: Synthetic control results on log external causes of death per 1,000



Note: This figure shows the results of the SCM on log external causes of death per 1,000, where the predictors of the log external causes of death rate in the pre-Demonstration period (1900-1916) are: the external causes of death rate (1911-1916); population size; log occupational earnings score per worker in 1910; share of foreign born in 1910; share of population in the age interval 15-44; and share of population older than 60 (both measured in 1910). The synthetic control is constructed from the cities in the extended Massachusetts panel. Panel A shows the path of Framingsham's log external causes of death rate, along with the (counterfactual) synthetic path. The in-place placebo effects, along with the "true" Demonstration effect, and the resulting (empirical) p-values are displayed in Panels B and C respectively. The vertical red line indicate the start of the Demonstration in 1917. See Appendix Table A.13 and A.14 for the weights assigned to the cities forming the synthetic control, and the balance between the synthetic control and the treated before 1917, respectively.

Figure A.10: Permutation inference TB, US control cities



Note: In panel A and B the distribution of the coefficients on the Demonstration period variable and the Post 7 years Demo. variable are plotted respectively, from re-assigning treatment to each control city in the sample and reestimating the regression of Table 6, column (2), along with kernel densisty plots with the true estimates indicated by vertical dotted lines.