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WAS THE FIRST PUBLIC HEALTH CAMPAIGN A FAILURE?

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Abstract

The U.S. tuberculosis movement pioneered many of the strategies of modern public health campaigns. Dedicated to eradicating a specific disease, it was spearheaded by voluntary associations and supported by the sale of Christmas seals. Although remarkable in its scope and intensity, the effectiveness of the tuberculosis (TB) movement has not been studied in a systematic fashion. Using newly digitized mortality data at the municipal level for the period 1900-1917, we explore the effectiveness of the measures championed by the TB movement. Our results suggest that the adoption of a municipal reporting requirement was associated with a 6 percent decrease in pulmonary TB mortality, while the opening of a state-run sanatorium was associated with an almost 4 percent decrease in pulmonary TB mortality. However, these and other anti-TB measures can explain, at most, only a small portion of the overall decline in pulmonary TB mortality observed during the period under study.

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1. INTRODUCTION

In 1900, 194 out of every 100,000 Americans died of tuberculosis (TB), making it the second-leading cause of death, behind only pneumonia and influenza (Jones et al. 2012). Although an effective treatment would not be introduced until after the Second World War (Daniel 2006), the TB mortality rate fell dramatically over the next three decades. By 1920, it had fallen to 113 per 100,000 persons; by 1930 it had fallen to 71 per 100,000 persons (Jones et al. 2012).

How was TB vanquished, or at least controlled, in the United States and other developed countries? Scholars have proposed several explanations, including better living conditions, herd immunity due to natural selection, reduced virulence, and improved nutrition (Smith 2003; Daniel 2006; Kunitz 2007, pp. 196-197; Lönnroth et al. 2009; Mercer 2014, pp. 127-129). The introduction of basic public health measures (e.g., isolating patients in sanatoriums and TB hospitals) is another potential explanation (Wilson 1990; Fairchild and Oppenheimer 1998), but scholars have questioned whether such measures contributed meaningfully to the decline in TB mortality (McKeown 1976; Coker 2003; Daniel 2006).[1]

Drawing on newly digitized data from a variety of primary sources, the current study explores whether the TB movement contributed to the decline in TB mortality in the United States. The movement began with the establishment of the Pennsylvania Society for the Prevention of Tuberculosis in 1892 and gained momentum with the establishment of National Association for the Study of the Prevention and of Tuberculosis (NASPT) in 1904 (Shryock 1957, p. 52; Teller 1988, p. 30). Spearheaded by voluntary associations composed of both laypersons and physicians, dedicated

[1] See also Tomes (1989), Bates (1989; 1992), Vynnycky and Fine (1999), and Wilson (2005). Bates (1989, p. 349) wrote that, "in the absence of controlled studies", we may never know "whether or to what degree the tuberculosis movement contributed to the declining death rate in the United States or improved the health of tuberculosis patients." Tomes (1989, p. 477), although also skeptical, argued that "[h]istorians may fairly question the wisdom of spending money on sanatoria instead of on housing subsidies, but they cannot conclusively prove that the tuberculosis movement as a whole played no role in the 'retreat' of the disease."

to eradicating a specific disease and supported by the sale of Christmas seals, the U.S. TB movement pioneered many of the strategies of modern public health campaigns (Teller 1988 p. 1 and pp. 121-126; Jones and Greene 2013; Rosen 2015, pp. 226-231).

Between 1900 and 1917, hundreds of state and local TB associations sprung up across the United States (NASPT 1916; Knopf 1922). These associations distributed educational materials and provided financial support to sanatoriums and TB hospitals, where patients with active TB were isolated from the general population and, if lucky, could recover. In addition, these associations advocated, often successfully, for the passage of legislation designed to curb the transmission of TB, including requirements that doctors notify local public health officials about TB cases.

Reporting requirements were a key feature of the campaign against TB (Knopf 1922, p. 149; Teller 1988, p. 22; Rothman 1995, p. 187). These requirements prevented physicians from concealing a diagnosis of TB from their patients and allowed local health officials to monitor TB patients, ensuring that they were taking precautions not to infect others (Teller 1988, p. 22). In several states, "careless consumptives" could be forcibly committed to TB hospitals or sanatoriums, where they were not a threat to the health of their family and co-workers (Teller 1988, pp. 93-94; Roberts 2009, p. 186). When a TB patient died, municipalities and states often required that his or her premises be thoroughly disinfected.

Although remarkable in its scope and intensity, the effectiveness of the U.S. TB movement has, to date, not been studied in a systematic fashion.[2] Using municipal-level data for the period

[2] Two recent papers by economists have examined the effects of specific anti-TB public health measures undertaken before an effective treatment was available. Hollingsworth (2014) estimated the relationship between sanatoriums and pulmonary TB mortality using data from North Carolina for the period 1932-1940. He found that an additional sanitaria bed reduced the pulmonary TB mortality rate among whites by .695 per 100,000 population, but had no effect on the black residents. Hansen et al. (2017) estimated the relationship between TB dispensaries and TB mortality at the municipal level using data from Denmark for the period 1890-1939. These authors found that the opening of a TB dispensary was associated with a 16 percent reduction in the TB mortality rate, an effect they attributed to dispensaries "facilitating a local diffusion of (hygiene) knowledge about the disease." Hansen et al. (2017) also found that the opening of a sanatorium was associated with a (statistically insignificant) increase in the local TB mortality rate, but noted that, because Denmark is not a large, TB patients "had the liberty of choosing the sanatorium across the country

1900-1917 from *Mortality Statistics*, which was published on an annual basis by the U.S. Census Bureau, we estimate the relationship between pulmonary TB mortality and the introduction of public health measures designed to curb the spread of the disease. Such measures included the establishment of sanatoriums, TB hospitals and open-air camps, prohibitions on spitting and the use of common drinking cups, requirements that local health officials be notified about TB cases, and requirements that the premises of deceased TB patients be disinfected.

Our estimates, which control flexibly for common shocks and municipal-level heterogeneity, suggest that most anti-TB measures had no discernable impact on pulmonary TB mortality. Two exceptions to this general result stands out: requiring TB cases to be reported to local health officials is associated with a 6 percent reduction in pulmonary TB mortality, and the opening of a state-run sanatorium is associated with an almost 4 percent reduction in pulmonary TB mortality. These estimated effects are robust across a variety of specifications, but can explain, at most, only a small portion of the overall decline in pulmonary TB mortality observed during the period 1900-1917. We conclude that the TB movement, although pioneering, was ineffectual.

2. BACKGROUND

The United States experienced a dramatic decline in mortality from infectious diseases, including TB, in the first three decades of the 20th century (Jones et al. 2012). In an oft-cited review, Cutler et al. (2006, p. 106) attributed this decline to basic public health measures, including the building of sewage systems, the delivery of clean water, and educational campaigns designed to change personal health practices.

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that they liked the most." By contrast, all but the wealthiest TB patients in the United States would have viewed out-of-state sanatoriums as too expensive (Rothman (1995, pp. 207-210). Moreover, in the United States, state and local sanatoriums represented a substantial portion of total capacity (Teller 1988, p. 82), making much easier to identify their effect on TB mortality.

The evidence that sewers and the chlorination/filtration of water contributed to the decline in mortality due to diarrhea, dysentery, enteritis, typhoid and other waterborne diseases is quite strong (Troesken 2001; Cutler and Miller 2005; Ferrie and Troesken 2008; Alsan and Goldin 2015).[3] However, several prominent scholars have suggested that public health measures did not contribute meaningfully to the decline in TB mortality (McKeown 1976; Coker 2003; Daniel 2006), nor is there particularly convincing evidence that public health measures contributed to the decline in mortality from other important airborne diseases such as influenza, scarlet fever and whooping cough (Condran and Crimmins-Gardner 1978; Condran and Cheney 1982; Swedlund and Donta 2002; Bootsma and Ferguson 2007).

Gaining a better understanding of the factors that contributed to the control of infectious diseases in the United States could help in the design and implementation of public health interventions in the developing world, where TB infections are still widespread (World Health Organization 2015; Houben and Dodds 2016). Although most TB infections can be successfully treated with antimicrobial drugs, the World Health Organization estimates that 3.3 percent of new TB cases are multidrug-resistant (WHO 2015, p. 4). The recommended treatment for drug-susceptible TB lasts 6 months, but treatment for multidrug-resistant TB takes 20 months, requires more toxic drugs, and has a much lower success rate (Lange et al. 2014; WHO 2015, p. 56).[4] With multidrug resistant TB infections on the rise (Lange et al. 2014), some experts have suggested that it may be "time to bring back sanatoria" (Dheda and Migliori 2012, p. 773). At a minimum, assessing the effectiveness of basic public health measures, many of which were pioneered by the TB movement, has taken on a new urgency.

[3] Relatedly, Clay et al. (2014) found that waterborne lead exposure was associated with higher rates of infant mortality at the turn of the 20th century.

[4] Multidrug-resistant TB is caused by the bacteria adapting to isoniazid and rifampicin, the two most potent anti-TB drugs, making them ineffective.

2.1. A brief introduction to tuberculosis

TB can affect bones, the central nervous system, and other organ systems, but it is primarily a pulmonary disease. In 1882, Robert Koch demonstrated that TB is caused by *Mycobacterium tuberculosis*, which can be spread through coughing, sneezing or spitting, although many turn-of-the-century doctors in the United States still believed that TB was inherited (Teller 1988, p. 23).[5] During the period under study, TB was often referred to as "consumption" and its sufferers were referred to as "consumptives" (Bynum 2012), reflecting the gradual weight loss caused by the disease.

Over 90 percent of TB infections are latent–asymptomatic and non-communicable (Lawn and Zumla 2011, p. 61). However, approximately half of active cases ultimately result in death if left untreated (Rutledge and Crouch 1919; Gideon and Flynn 2011). Individuals suffering from active pulmonary TB exhibit a chronic cough, fevers, night sweats, and weight loss (Lawn and Zumla 2011, p. 65).

At the turn of the 20th century, TB was the second-leading cause of death in the United States (Jones et al. 2012).[6] It was greatly feared, in part because it often affected healthy men and women in the prime of life (Donald 2016; Tomes 2000). Incident rates were highest in the rapidly growing urban areas of the United States, where people lived and worked in close proximity to one another. In rural areas of the United States, the TB mortality rate was roughly half that of large

[5] See Lawn and Zumla (2011) for more about the history and microbiology of *Mycobacterium tuberculosis*.

[6] TB has a long, and reasonably well documented, history. Lesions and other tubercular deformities have been found on the mummified remains of ancient Egyptians, and classical Greek and Roman doctors recognized its symptoms (Daniel 2000, p. 29; Daniel 2006, p. 1863; Smith 2003, p. 465). In Homer's *Odyssey*, the poet referenced a "grievous consumption", which took the soul from one's body (Bynum 2012, p. 13). TB mortality rates in Europe soared with the growth of urban centers such as London and Paris, and peaked in the first half of the 19th century (Dubos and Dubos 1952, p. 9 and pp. 185-186; Smith 2003, p. 465).

cities such as Boston, New Orleans, New York, San Francisco, and Washington DC.[7] An effective treatment would not be introduced until after the Second World War (Daniel 2006), yet the TB mortality rate fell by more than 60 percent from 1900 to 1930 (Jones et al. 2012).[8] Many, if not most, contemporary observers credited the TB movement for this dramatic reduction in TB mortality (Emerson 1922; Bates 1992, pp. 317-318).

3. THE TUBERCULOSIS MOVEMENT

The TB movement was, in many respects, the first modern public health campaign. Dedicated to eradicating a specific disease, it was spearheaded by voluntary groups, involved laypersons as well as medical professionals, and, beginning in 1908, was almost entirely funded by the sale of Christmas seals (Knopf 1922, pp. 55-66; Shryock 1957, pp. 55-57; Rosen 2015, pp. 226-231).[9] By harnessing the enthusiasm of laypersons, and coupling this enthusiasm with the knowledge and guidance of professionals, the TB movement inspired and directly shaped subsequent public health campaigns in the United States and around the world (Jacobs 1921; Shryock 1957, pp. 55-56 and pp. 179-182; Rosen 2015, pp. 226-231).

Between 1900 and 1917, hundreds of state and local TB associations were established across the United States (NASPT 1911, 1916, 1919). By 1917, the last year for which we have data, the NASPT was raising well over a million dollars per year through the sale of Christmas seals, and

[7] See the U.S. Bureau of the Census (1908, p. 66) for TB mortality rates in cities with a population of greater than 100,000 and in the rural areas of registration states.

[8] The first vaccine, BCG, was introduced in 1921 (Lawn and Zumla 2011, p. 67). Although vaccination campaigns were undertaken in Europe, no such campaign was launched in United States (Cutler et al. 2006, p. 103). Today, despite widespread use of the BCG vaccine, TB is still one of the leading causes of mortality in developing nations, with 1.5 million people succumbing to it every year (World Health Organization 2015). It is estimated that approximately one-fourth of the world's population has a latent TB infection (Houben and Dodd 2016).

[9] Even today, the American Lung Association's mission is largely funded by the sale of Christmas seals (see www.christmasseals.org).

every state had its own association (Knopf 1922). TB associations sponsored lectures, mounted exhibits, distributed press releases, and gave out circulars emphasizing the importance of germ awareness and proper hygiene (Teller 1988, pp. 59-61). Men were urged to shave their beards and carry pocket spittoons, women were urged to stop wearing trailing dresses, and children were taught to play outdoors, keep their face, hands and fingernails clean, and cover their coughs and sneezes.[10]

The goals and aspirations of TB associations went well beyond educating the public. TB associations provided financial support to sanatoriums, TB hospitals, open-air camps, and dispensaries. They also advocated for the passage of legislation designed to curb the spread of TB and worked closely with local and state health officials, who adopted and distributed their educational materials.[11] Below, we describe the history and functions of sanatoriums, TB hospitals, open-air camps, and dispensaries. After describing these institutions, we briefly summarize the anti-TB legislation passed during the period under study.[12]

3.1. Sanatoriums

[10] For a historical perspective on the hygiene practices promoted by tuberculosis associations see Tomes (1998, pp. 113-134) and Tomes (2000). An exhaustive list of contemporary hygiene-related admonitions is provided by Knopf (1901). For instance, Knopf (1901, pp. 21-22) wrote:

> In factories, stores, railway cars, waiting-rooms…, menageries—in short wherever many people congregate—there should be a sufficient number of cuspidors well kept and regularly cleaned. They should be made of unbreakable material and have wide openings. If such measures are carried out, there will be no excuse for any one to expectorate on the floor and thus endanger the lives of his fellow-men.

Knopf (1901) also urged children "to always play outdoors unless the weather is too stormy" (p. 72), and advised them to "learn to love fresh air", not to "kiss any one on the mouth", and not to "put pencils in your mouth or wet them with your lips" (p. 71).

[11] Teller (1988, p. 46) wrote that "cooperation between public health officials and the voluntary associations was very common", but noted that "some officials resented the interference of the tuberculosis associations or thought their enthusiasm was misplaced."

[12] Knopf (1922), Shryock (1957), and Teller (1988), among others, provide detailed histories of the TB movement.

The first sanatoriums in the United States were established at the end of the 19th century (Knopf 1922, p. 10). Typically located in rural areas or the mountains, they provided a place for TB patients to rest, breathe fresh air, and eat nutritious food. Although TB patients admitted to sanatoriums had similar recovery rates to those who went untreated (Bignall 1977; Teller 1988, pp. 89-90; Daniel 2006), medical professionals at the turn of the 20th century, including the leaders of the TB movement, were convinced of their effectiveness (Wethered 1906; Knopf 1908). In addition to offering the promise of a cure, sanatoriums isolated TB patients from the community at large and taught them how to avoid infecting their family, friends, and coworkers.

In 1900, there were only 34 sanatoriums operating in the United States, with a total capacity of roughly 4,500 beds (Rothman 1995, p. 198). After the NASPT began selling Christmas seals, additional funds became available and the number of sanatoriums grew rapidly. By 1917, there were well over 200 sanatoriums in operation with a total capacity of more than 19,000 beds (NASPT 1916; Teller 1988, p. 82). Some sanatoriums catered to the rich, offering excellent food and a spa-like atmosphere (Bates 1992, p. 195; Rappold 2007). In contrast, conditions at publicly funded sanatoriums could be quite primitive with patients living in tents or lean-tos on the outskirts of urban areas. Several publicly funded sanatoriums required patients to perform manual labor as a means of controlling costs.[13]

3.2. TB hospitals

By 1908, a number of prominent public health experts had come to the conclusion that sanatoriums were inadequate to the task at hand (Bloede 1908; Brown 1908; Newsholme 1908). TB patients were observed to recover when provided with nutritious food and an opportunity to rest,

[13] See Klebs (1909), Bignall (1977), Feldberg (1995, pp. 93-94), Rothman (1995, pp. 207-210), Abel (2007, p. 43) and Rappold (2007) for more details on the conditions in sanatoriums.

only to relapse upon discharge. More resources, they argued, should be devoted towards isolating the most infections patients—those with advanced pulmonary TB (Bloede 1908; Brown 1908; Newsholme 1908; Hutchinson 1911; Flick 1912). Although a handful of hospitals specialized in caring for these patients, beds were in short supply and conditions were generally abysmal (Waters 1912; Teller 1988, p. 92; Abel 2007, p. 42). Working together, local TB associations and municipal governments opened more facilities; by 1917, there were roughly 150 TB hospitals operating in the United States (NASPT 1916; Knopf 1922; Teller 1988, p. 92).[14]

3.3. Open-air camps

Open-air camps (also referred to as day camps), were seen as a low-cost alternative to sanatoriums for ambulatory TB patients (Robbins 1906; Townsand 1909). During the day, patients received care and were taught how to avoid infecting their family, friends, and coworkers. At night, they returned home "to practice the lessons learned" (Townsand 1909, p. 755). The first open-air camp in the United States was established by the Boston Association for the Relief and Control of Tuberculosis in 1905 (Robbins 1906). A decade later, roughly 50 open-air camps were operating across the country (NASPT 1916).

3.4. Dispensaries

Dispensaries functioned as diagnostic units, disseminated educational materials to the public, and served as "clearing houses", sending patients to physicians, sanatoriums or TB hospitals for treatment (Knopf 1911, p. 112; Bynum 2012).[15] Dispensaries also provided medicines such as cod

[14] This count includes both hospitals specializing in the care of TB patients and general hospitals with wards set aside specifically for TB patients.

[15] Dispensary staff made home visits to educate TB patients on disposing of their sputum, using separate utensils, and cleaning their home and laundry (Bynum 2012).

liver oil or opiate-based cough mixtures (Bynum 2012; Fraser and Clark 1912), which offered temporary relief but could not cure TB. The first TB dispensary in the United States was established in 1891 by Philadelphia's Rush Hospital for Consumption and Allied Diseases; by 1917, there were hundreds of dispensaries in operation across the country (NASPT 1919).

3.5. Reporting requirements

Tuberculosis associations advocated forcefully, and often successfully, for the passage of laws designed to prevent the spread of the disease. In particular, reporting requirements were viewed as crucial to the success of the anti-TB campaign (Knopf 1922, p. 149; Teller 1988, p. 22; Rothman 1995, p. 187).

At the turn of the 20th century, it was common for physicians to conceal a TB diagnosis from their patients (Ambler 1903; Cabot 1908; Girdwood 1910). Physicians feared that their patients, upon being told that they had an incurable disease, would seek a second opinion or remove themselves to a sanatorium (Fox 1975). By obligating physicians to notify local health officials of active TB cases, reporting requirements were designed to put an end to this practice and facilitate the monitoring and education of TB patients. During the period under study, 27 states and over 100 municipalities adopted reporting requirements (NASPT 1911, 1916). In New Jersey, New York, Minnesota, Virginia and Wisconsin, so-called "careless consumptives" could be forcibly committed to TB hospitals or sanatoriums (Teller 1988, pp. 93-94; Roberts 2009, p. 186).

3.6. Disinfection laws

Between 1900 and 1917, 15 states and over 150 municipalities adopted disinfection requirements (NASPT 1916). When a living space was left vacant by the death or removal of a TB patient, the attending physician was expected to notify public health officials so that it could be disinfected. Health officers directed the disinfection and, when deemed necessary, the renovation of the premises.[16]

3.7. Spitting bans

Chewing tobacco was popular at the turn of the twentieth century, and spittoons could be found in offices, hotels, and public buildings. Despite the availability of spittoons, contemporary accounts describe sidewalks and even the floors of street cars as covered in spittle (O'Conner 2015). By 1917, there were over 150 municipal bans on spitting (NASPT 1916). There is anecdotal evidence, however, that these bans were not particularly well enforced. Despite fines as high as $25 dollars per infraction, very few people were actually arrested for spitting in public (Newton 1910).[17]

3.8. Common drinking cup bans

Common drinking cups, which were located in schools, trains and next to municipal water pumps, were viewed as yet another important source of TB infection (Sedgwick 1902; Tomes 1998; Sattar 2016). By 1917, 17 states and more than 150 municipalities had banned the use of the common cup (NASPT 1911, 1916). Working with local governments, tuberculosis associations made drinking fountains available in schools and other public buildings, but common cups continued to be popular especially in small towns and rural areas (Nydegger 1917; Boudreau 1920; Gladden 1921; McGuire 2012).[18]

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[16] Knopf (1901, pp. 22-23) provided step-by-step instructions on the "disinfection of the sick-room." See Vallejo, California (1913) and Colorado (1914) for examples of disinfection laws.

[17] Enforcement appears to have been stricter in New York City where, according to Newton (1910), health officers had made 2,513 arrests for violations of the anti-spitting ordinance passed in 1896. Although anti-spitting laws are still on the books, enforced appears to be extremely lax (York 2003; Williams 2015).

[18] Along with drinking fountains, dispensable cups (e.g., the Dixie Cup) eventually replaced the common cup entirely (Lee 2007).

4. Mortality Data and Empirical Framework

Municipal-level mortality data come from *Mortality Statistics*, published annually by the U.S. Census Bureau. The inaugural issue of *Mortality Statistics* was published in 1900 and contained mortality counts by cause for over 300 municipalities.[19] By 1917, mortality counts from over 500 municipalities were available. Although the Census Bureau continued to publish *Mortality Statistics* through 1922, we chose to focus on the period 1900-1917 in an effort to avoid potential confounding from the effects of the 1918 influenza epidemic.

In Figure 1, we report the pulmonary TB mortality rate per 100,000 population for the 548 municipalities in our sample by year.[20] The pulmonary TB mortality rate was 173 per 100,000 population in 1900.[21] From 1900 to 1917, it fell by nearly 28 percent, to 125. We begin our exploration of whether the anti-TB measures championed by the TB movement and described in the previous section contributed to this dramatic reduction in pulmonary TB mortality by estimating the following baseline regression:

$$\text{(1)} \qquad \ln(\textit{Pulmonary TB Mortality}_{mt}) = \beta_0 + \boldsymbol{X}_{mt}\boldsymbol{\beta_1} + v_m + w_t + \Theta_m \cdot t + \varepsilon_{mt},$$

where m indexes municipalities and t indexes years. Our interest is the variables that compose the vector $\boldsymbol{X}_{mt}$, which were constructed using information available in NASPT (1911, 1916, 1919) and

[19] Cause of death was obtained from the death certificate and coded using the *International Classification of Diseases*. When more than one medical condition was listed on the death certificate, cause of death was based on a standardized algorithm (Armstrong, Conn and Pinner 1999). There is evidence that deaths from TB were, with some frequency, attributed to bronchitis, malaria, and/or pneumonia (Cabot 1900, p. 27; Cabot 1912), an issue we address below.

[20] On average, each municipality contributed 13.6 observations to the analysis.

[21] By comparison, the U.S. mortality rate from all forms of TB was 222 per 100,000 population (U.S. Bureau of the Census 1908, p. 66).

Knopf (1922). Specifically, the vector $\boldsymbol{X}_{mt}$ includes separate indicators for whether municipality m was served by a sanatorium, TB hospital, or an open-air camp in year t. Appendix Table XXX provides details when the first sanatorium, TB hospital, and open air camp opened in each of the municipalities in our sample.

The terms v_{m} and w_t represent municipality and year fixed effects, respectively. The municipality fixed effects control for municipal-level determinants of pulmonary TB mortality that were constant over time. The year fixed effects control for common shocks to pulmonary TB mortality, although it should be noted that there were no national newspapers or commercial radio broadcasts. Efforts to educate the public about TB and encourage good hygiene were undertaken entirely at the local (e.g., municipal) level until 1908, when the NASPT established a press service that released bulletins to newspapers and wire services (Teller 1988, p. 59).[22] Throughout the period under study, magazines such as *Good Housekeeping*, *Ladies Home Journal*, and *Popular Science Monthly* ran stories promoting "antisepticonsciousness" (McClary 1980; Tomes 2000; 2002). Any effect of these stories on TB mortality would be captured by the year fixed effects. In addition to the municipal and year fixed effects, we include municipality-specific linear time trends ($\Theta_m \cdot t$) to account for the possibility that pulmonary TB mortality rates evolved at different rates in municipalities that adopted anti-TB measures as compared to those that did not. Standard errors are corrected for clustering at the state level (Bertrand et al. 2004), although clustering at the municipal level produced almost identical results to those reported below.

[22] Many state and local TB associations established their own press services after 1908 (Teller 1988, p. 59), but before then newspapers regularly covered the parades, exhibits, and Christmas seal campaigns sponsored by these associations (Tomes 2002). The first U.S. commercial radio broadcast occurred on November 2, 1920 (election night) in Pittsburgh. Up until then, radio stations were operated by amateur hobbyists whose target audience was composed of other hobbyists (Sterling and Kittross 2002, pp. 44-48 and p. 66).
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After estimating the baseline regression, we augment the vector $\boldsymbol{X}_{mt}$ with an indicator for whether municipality *m* required the reporting of TB cases. By 1917, 91 municipalities in our sample had adopted ordinances requiring that active TB cases be reported to local health officials (Appendix Table XXX). We also include an indicator for whether the municipality was located in a state that required the reporting of TB cases, and separate indicators for whether it required the disinfection of premises vacated by TB patients and whether it was located in a state that required disinfection.

Next, we augment the vector $\boldsymbol{X}_{mt}$ with an indicator for whether municipality *m* prohibited spitting in public. We also include separate indicators for whether it prohibited the common cup and whether it was located in a state with a common cup ban. Finally, we include separate indicators for whether municipality *m* had a TB association, whether it was located in a state with a TB association, and whether it was served by a TB dispensary. Descriptive statistics and definitions for all of the variables used in the analysis are reported in Table 1. More information on the when the various anti-TB measures were adopted by the municipalities in our sample is available in Appendix Table XXX.

5. RESULTS

In the first column of Table 2 we report estimates from the baseline model, which focuses on the relationship between pulmonary TB mortality and the institutions explicitly designed to isolate and care for TB patients. While the estimated coefficients of the sanatorium and open-air camp indicators are negative, they are small in magnitude and not statistically distinguishable from zero. The relationship between pulmonary TB mortality and the TB hospital indicator is positive, but also insignificant.

In the second column of Table 2, we report estimates from a regression model that includes the reporting and disinfection indicators on the right-hand side. The adoption of a reporting requirement at the municipal level is associated with a 5.5 percent ($e^{-.057} - 1 = .055$) decrease in the pulmonary TB mortality rate, an estimate that is statistically significant at the 5 percent level. By contrast, there is little evidence that state reporting requirements mattered: the estimated coefficient of the state reporting requirement indicator is small and insignificant. Likewise, there is little evidence that disinfection requirements at either the municipal or state levels had an effect on pulmonary TB mortality.

In the third column of Table 2, we report estimates from a regression model that includes spitting and common cup bans on the right-hand side; in the fourth column, we report estimates from a regression model that includes the TB association indicators and an indicator for whether there was a dispensary in operation in municipality *m* and year *t*. None of these anti-TB measures appear to have had an appreciable impact on the pulmonary TB mortality rate. The estimated coefficients are, without exception, small in magnitude and measured imprecisely. By contrast, the relationship between municipal reporting requirements and pulmonary TB mortality is negative, significant, and remarkably stable in terms of magnitude across these specifications.

5.1. A closer look at the role of sanatoriums

Up to this point in the analysis, we have attempted to capture the effect of the sanatorium movement with a simple indicator of whether municipality *m* was served by a sanatorium in year *t*. However, the most populous cities in the United States were typically served by multiple sanatoriums by the end of the period under study. Moreover, private sanatoriums were often located in rural areas where air pollution, which was intense in industrial cities such as Chicago, Pittsburgh and St. Louis (Stradling and Thorsheim 1999), would not interfere with recovery.[23]

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[23] Private sanatoriums catered to the affluent, but could be as large as publicly funded sanatoriums. For instance, the Agnes Memorial Sanatorium in Denver, CO accommodated over 150 patients in 1916, while the Sanatorium of the New Bedford Anti-Tuberculosis Association in New Bedford, MA accommodated over 100 patients (NASPT 1916).

In the first column of Table 3, we replace the sanatorium indicator with a continuous variable equal to the number of sanatoriums in municipality *m* at time *t*. In 1900, only three municipalities in our sample were served by a sanatorium; by 1910, 37 of the municipalities in our sample were served by at least one sanatorium, 8 had at least two, and 4 had three or more; by 1917, 80 municipalities were served by at least one sanatorium, 13 had at least two, and 6 had three or more.[24]

The estimated coefficient of the continuous sanatorium variable is positive, but not significant at conventional levels. In an effort to rule out reverse causality, we experimented with adding leads of the sanatorium variables to the regression model. There was no evidence that sanatoriums were opened in response to upswings (or downswings) in TB mortality.[25]

In columns (2) and (3) of Table 3, we explore whether the opening of sanatoriums at the state, as opposed to the municipal, level had an effect on pulmonary TB mortality. Specifically, in column (2) we show the results of augmenting the baseline equation with an indicator for whether municipality *m* was located in state with a sanatorium, and in column (3) we include the total number of sanatoriums operating in the state at time *t*. The results suggest that the opening of sanatoriums at the state level did little to curb the spread of pulmonary TB.

Finally, in column (4) of Table 3, we investigate the role of state-run sanatoriums. In 1900, there were no state-run sanatoriums in the country, but by the end of the period under study there were 29 in operation and they represented a substantial portion of total capacity (NASPT 1919).[26]

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[24] See Appendix Tables XXX and XXX.

[25] These results are available upon request. We experimented with including 1-3 leads of the sanatorium indicator as well as including 1-3 of the continuous sanatorium measure. The estimated coefficients of these leads were consistently small and statistically insignificant. We found similar results when we experimented with using continuous variables for open-air camps and TB hospitals.

[26] According to Teller (1988, p. 82), there were 94 public sanatoriums operating in the United States by 1916. A total of 7,501 beds were available in state-run sanatoriums, 1,279 beds were available in federal sanatoriums, and 4,736 beds were

State-run sanatoriums were typically located in rural areas and were considered more desirable than county-run or municipal sanatoriums. Unlike other publicly funded sanatoriums, state-run sanatoriums often charged weekly fees to "keep out the riffraff" and prioritized admitting incipient TB cases over chronic or advanced cases (Rothman 1995, pp. 207-208).[27]

The estimated effect of state-run sanatoriums is negative and significant, although relatively small in terms of magnitude. Specifically, the opening of a state-run sanatorium is associated with a 3.8 percent reduction in the pulmonary TB mortality rate. This effect is explored in greater depth below.

5.2 Extensions and robustness checks

In Table 4, we present estimates of equation (1) augmented with leads and lags of the municipal reporting ordinance. Consistent with the parallel trends assumption, there is little evidence that pulmonary mortality increased in the years leading up to when the reporting of TB cases was required. Before Year 0 (the year in which doctors were required to report active TB cases to local health officials), estimates of the relationship between the reporting indicator and pulmonary TB mortality are small and statistically insignificant; after three years, these estimates are consistently

available in municipal sanatoriums. By comparison, there were 87 private sanatoriums operating in the United States in 1916, with a total of 3,447 beds, and 42 philanthropic sanatoriums with a total of 2,711 beds (Teller 1988, p. 82).

[27] Dr. Herbert Clapp, a supervising physician at the Massachusetts state-run sanatorium, described cases that should be refused admission:

> No bedridden patients should be accepted, nor even those who are confined to their rooms. If an applicant is not strong enough to ride some distance to the examining office, it is cause enough for his rejection…No case of acute tuberculosis should be admitted, nor any case with high fever, nor even with a temperature which, after rest in bed with open windows for one or two weeks, does not come down to perhaps 100° (Clapp 1906, pp. 342-343).

negative and significant at conventional levels. Three or more years after being adopted, the reporting ordinance is associated with a 9-12 percent decrease in pulmonary TB mortality.[28]

Previous studies have produced strong evidence that turn-of-the-century efforts to improve water quality led to substantial reductions in mortality from waterborne diseases (Troesken 2001; Cutler and Miller 2005; Ferrie and Troesken 2008). Moreover, there is evidence, albeit descriptive in nature, that these efforts reduced mortality from non-waterborne diseases, including TB (Sedgwick and MacNutt 1910; McGee, 1920).[29] Although some contemporary researchers suggested that tuberculosis might be transmitted through waste water (Brown et al. 1916; Fink et al. 1917), a more likely explanation for what was dubbed the "Mills–Reincke Phenomenon" is that typhoid and other gastronomical diseases weakened the host, increasing his or her susceptibility to infection from *Mycobacterium tuberculosis* (Ferrie and Troesken 2008).

Because municipal chlorination and filtration projects could have been correlated with the adoption of TB reporting requirements, we included the mortality rate from typhoid on the right-hand side of the estimation equation as a robustness check (Clay et al. 2014). The results of this exercise are reported in the first column of Table 5. Including the typhoid mortality rate as a proxy for water quality reduces the magnitude of the estimated relationship between municipal reporting requirements and pulmonary TB mortality. Specifically, requiring that TB cases be reported to local health officials is associated with a 4.9 percent decrease in pulmonary TB mortality, an estimate that is significant at the 10 percent level.

[28] In Appendix Table XXX, we present estimates of equation (1) augmented with leads and lags of the state-run sanatorium indicator. Again, consistent with the parallel trends assumption, there is little evidence that pulmonary mortality increased in the years leading up to the opening of the first state-run sanatorium. By contrast, after 3 years it is associated with a 3-5 percent decrease in pulmonary TB mortality, although it should be noted that the estimated coefficient of the *3+ Years After State-Run Sanatorium* is not consistently significant at conventional levels.

[29] See also Ferrie and Troesken (2008). Using data from Chicago for the period 1855-1925, these authors found a positive relationship between typhoid mortality and mortality from respiratory diseases. Specifically, an additional death from typhoid fever was associated with 1-1.5 additional deaths from tuberculosis and pneumonia.

In column (2) of Table 5, we restricted our attention to municipalities with more than 50,000 residents; in column (3), we restricted our attention to municipalities with more than 100,000 residents. Estimates of the effect of reporting requirements on pulmonary TB mortality for these most populous municipalities are slightly larger than those in Table 2. Likewise, restricting the sample to municipalities with 18 years of non-missing data produced a slightly larger estimate of the relationship between reporting requirements and pulmonary TB mortality.

Reporting requirements were aimed at reducing the human-to-human transmission of pulmonary TB. In column (5) of Table 5, we test whether they were related to non-pulmonary TB, which was usually caused by contaminated milk (Teller 1988, pp. 67-68).[30] Because the incidence of non-pulmonary TB mortality was much lower than that of pulmonary TB (and was, in fact, equal to zero for 716 municipality-year combinations), we take its quartic root instead of taking its natural log.[31] Reassuringly, requiring that TB cases be reported to local health officials is not associated with decreased mortality from non-pulmonary TB. In fact, the estimated marginal effect, although small relative to the mean of non-pulmonary TB mortality, is actually positive. By contrast, taking the quartic root of pulmonary TB mortality produces an estimated marginal effect that is similar in magnitude to the original estimate reported in Table 2.

In Table 6, we investigate the robustness of the negative relationship between the opening of a state-run sanatorium and pulmonary TB mortality. Controlling for typhoid mortality reduces the absolute magnitude of this relationship, but the estimated coefficient is still negative and significant

[30] In general, the TB movement was focused on eliminating human-to-human transmission of pulmonary TB and all but ignored bovine TB (Teller 1988, p. 69). Although, a handful of states required the tuberculin testing of dairy cows, bovine TB was not effectively controlled until after 1917, when the USDA undertook a campaign to eradicate the disease (Olmstead and Rhode 2004). Throughout the period under study, milk stations in New York and other cities provided clean milk at a reduced price to poor mothers (Meckel 1990, pp. 78-80). In 1909, Chicago became the first municipality to require the pasteurization of milk. By 1921, most large cities in the United States required pasteurization, which protected consumers from bovine TB and other milk-borne dieses such as typhoid (Meckel 1990, p. 89).

[31] This method of dealing with zeros has been used by Thomas et al. (2006), Tarozzi et al. (2014) and Ashraf et al. (2015), among others. The marginal effect of requiring that TB cases be reported to local health officials is in brackets.

at the 5 percent level. Likewise, restricting the sample to municipalities that contributed 18 years of data produces a slightly smaller estimate than that reported in Table 3, but it is still significant at conventional levels. Finally, while there is no evidence that state-run sanatoriums affected non-pulmonary TB mortality, their impact appears to have been most pronounced in the municipalities with more than 50,000 residents.

6. WAS MORTALITY FROM OTHER AIRBORNE DISEASES AFFECTED?

In Figure 2, we show trends in mortality for influenza/pneumonia and other airborne illnesses, a broad grouping that includes mortality from measles, scarlet fever, whooping cough (i.e., pertussis), and diphtheria/croup. Like pulmonary TB, these diseases are typically transmitted by aerosolized respiratory secretions (for instance, from coughing or sneezing).[32] During the period 1900-1917, mortality from influenza/pneumonia remained relatively stable, while the mortality rate from other airborne illnesses fell from 105.8 to 45.6.

Did the measures championed by the U.S. TB movement affect mortality from influenza/pneumonia and/or other airborne illnesses? Several anti-TB measures could have, in theory, reduced mortality from other diseases transmitted through respiratory secretions. Indeed, the Centers for Disease Control still recommends frequent hand washing and the covering of coughs to prevent the spread of germs, and would presumably frown upon public spitting and the use of common cups. Although the threat of TB has receded and anti-spitting laws are no longer enforced in the United States (York 2003; Williams 2015), authorities in Beijing, London, and Mumbai have justified recent efforts to discourage spitting on public health grounds (Yardley 2007; Pettitt 2015; Sujit and Iyer. 2015).

[32] During the period under study, there were no effective vaccines or cures for influenza, measles, scarlet fever, or whooping cough (Quinn 1989; Roush and Murphy. 2007; Cowling et al. 2013; Cherry 2015). However, diphtheria could be treated using a horse-derived antitoxin (Wagner et al. 2009).

In the first column of Table 7, we report results from regressing mortality due to influenza and pneumonia on the spitting law and common cup indicators. In addition, we control for whether municipality *m* had a TB association and whether it was located in a state with a TB association. This exercise produces no support for the notion that efforts on the part of TB associations to educate the public and legislate its behavior had an impact on mortality due to influenza and pneumonia. When we include the other anti-TB measures (e.g., the sanatorium and TB hospital indicators) on the right-hand side of the regression, the result is similar: there is little evidence of spillover effects to influenza/pneumonia.

Next, we examine the effects of anti-TB measures on mortality from other airborne illnesses (i.e., measles, scarlet fever, whooping cough, and diphtheria/croup). The results provide little support for the notion that the adoption of anti-TB measures contributed to the dramatic reduction in mortality due to these illnesses documented in Figure 2.[33]

7. Gauging the overall impact of the TB movement

We begin this section with an examination of municipal reporting requirements and their contribution to the overall decline in pulmonary TB mortality. As noted above, 91 municipalities in our sample had adopted ordinances requiring that active TB cases be reported to local health officials by 1917 (Appendix Table XXX); the adoption of such an ordinance is associated with an approximately 6 percent decline in the pulmonary TB mortality rate (Table 2).

In an effort to gauge the impact of reporting ordinances, we calculated what the pulmonary TB mortality rate would have been had none of the municipalities in our sample required reporting of active TB cases. Figure 3 shows the predicted pulmonary TB rate for every year *t* (and its 90

[33] Because deaths from TB were, with some frequency, attributed to bronchitis, malaria, and/or pneumonia (Cabot 1900, p. 27; Cabot 1912), we experimented with including these diseases in *Other Airborne Illnesses Mortality*. The estimates reported in Table 7 changed very little using this alternative definition.

percent confidence interval) under this scenario. Predicted pulmonary TB mortality rates are based on the regression estimates in column (4) of Table 2. The actual pulmonary TB mortality rate among the municipalities that compose our sample is also provided.

It is clear that the actual and predicted pulmonary TB mortality rates are not far apart throughout the period under study, suggesting that the ordinances did not contribute substantially to the observed overall decline in pulmonary TB mortality. By 1917, the actual pulmonary TB mortality rate among municipalities in our sample was 125, its lowest level during the period under study. Had no municipality adopted a reporting ordinance, we predict that it would have been 128. Even using the upper bound of the 90 percent confidence interval, we predict that the pulmonary TB mortality rate would have fallen from 173 to 132 had no reporting ordinances been adopted.

Finally, we use a similar strategy, and the regression estimates in column (4) of Table 2, to gauge the combined contribution of all the anti-TB measures adopted during the period under study (Figure 4). From 1900 to 1917 the pulmonary TB mortality rate among the municipalities in our sample fell by nearly 28 percent, from 173 to 125 per 100,000 population. Had no anti-TB measures been adopted, we predict that the pulmonary TB mortality rate would have been 122 in 1917. Using the upper bound of the 90 percent confidence interval, we predict that the pulmonary TB mortality rate would have still fallen by 22 percent, to 135.5, had the TB movement never existed and no anti-TB measures been undertaken at either the municipal or state levels.

8. Conclusion

One every 4 people alive today has a latent tuberculosis (TB) infection (Houben and Dodds 2016). Most TB infections, if they become active, can be successfully treated with antimicrobial medicines, but the WHO (2015, p. 56) estimates that 3.3 percent of new TB cases are multidrug-resistant.[34] With experts warning that multidrug-resistant strains of TB represent a "looming public health crisis" (Frieden 2015), it is perhaps more important than ever that we accurately assess the effectiveness of basic, "low-tech" public health measures, many of which were pioneered by the TB movement.

The U.S. TB movement can be traced to the establishment of the Pennsylvania Society for the Prevention of Tuberculosis in 1892 (Shryock 1957, p. 52). It gained momentum with the establishment of National Association for the Study of the Prevention and of Tuberculosis (NASPT) in 1904. Between 1904 and 1917, hundreds of state and local TB associations were established across the country with the goal of educating the public and providing support to sanatoriums, TB hospitals, and open-air camps. TB associations also advocated for the passage of legislation aimed at curbing the spread of TB. Such legislation included bans on public spitting and requirements that active TB cases be reported to health officials. Reporting requirements prevented physicians from concealing a diagnosis of TB from their patients and allowed health officials to monitor TB patients (Teller 1988, p. 22).

Despite the remarkable scope and influence of the TB movement, its effect on TB mortality has not been studied in a systematic fashion. In fact, most historians appear to be of the opinion that gauging the impact of the TB movement on TB mortality is impossible. For instance, Bates (1989, p. 349) wrote that, "in the absence of controlled studies," we may never know "whether or to what degree the tuberculosis movement contributed to the declining death rate in the United States or improved the health of tuberculosis patients." Experts from other disciplines have also expressed skepticism regarding the effectiveness of the TB movement (McKeown 1976; Coker 2003; Daniel 2006).

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[34] Multidrug-resistant TB is caused by the bacteria adapting to the drugs typically used to treat it, making them ineffective. The recommend treatment for drug-susceptible TB lasts six-months, but treatment for multidrug-resistant TB takes 20 months, requires more toxic drugs, and has a much lower success rate (WHO 2015, p. 4).

Using newly digitized mortality data at the municipal-year level, we explore the effect of the TB movement on pulmonary TB mortality. We find strong evidence that requiring TB cases to be reported to local health officials led to a 6 percent reduction in the pulmonary TB mortality rate. We also find that the establishment of a state-run sanatorium led to an almost 4 percent reduction in the pulmonary TB mortality rate. By contrast, there is no evidence that other anti-TB measures (for instance, requiring the premises of deceased TB patients be disinfected) had any effect whatsoever on the pulmonary TB mortality rate.

Finally, in an effort to gauge the overall effect of the TB movement, we calculated what the pulmonary TB mortality rate would have been had no anti-TB measures been undertaken. During the period under study, the pulmonary TB mortality rate among the municipalities in our sample fell by nearly 28 percent, from 173 to 125 per 100,000 population. Had no anti-TB measures been adopted, we predict that the pulmonary TB mortality rate would have been 122 in 1917. Using the upper bound of the 90 percent confidence interval, we predict that the pulmonary TB mortality rate would have still fallen by 22 percent, to 135.5, had the TB movement never existed. Based on these estimates, we conclude that the basic public health measures pioneered by TB movement were ineffectual at curbing the spread of TB.

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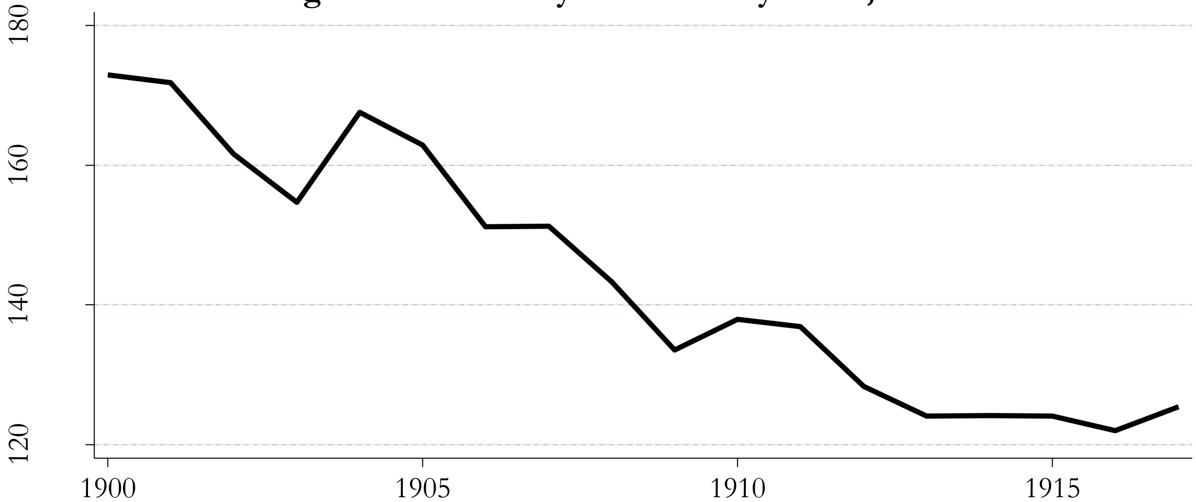
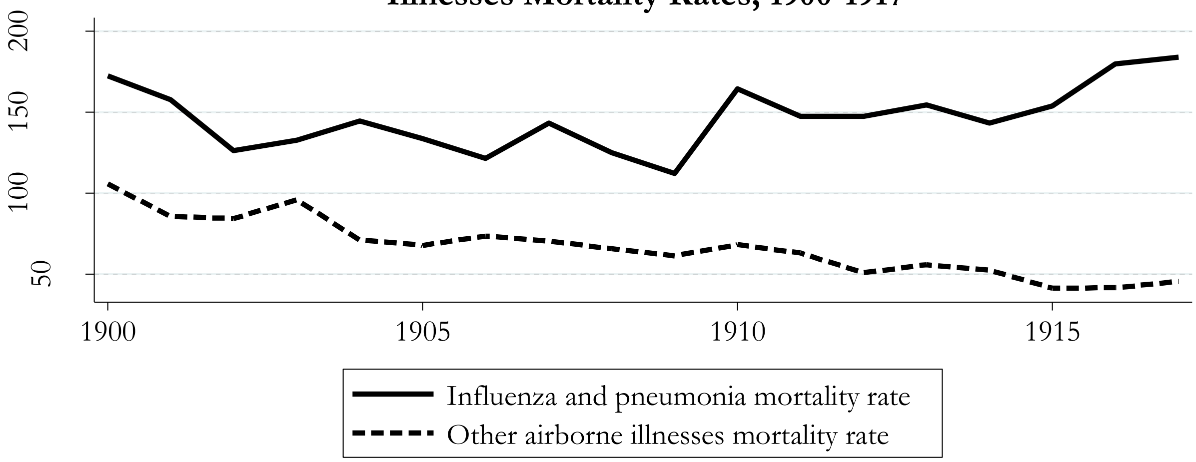
Figure 1. Pulmonary TB Mortality Rates, 1900-1917



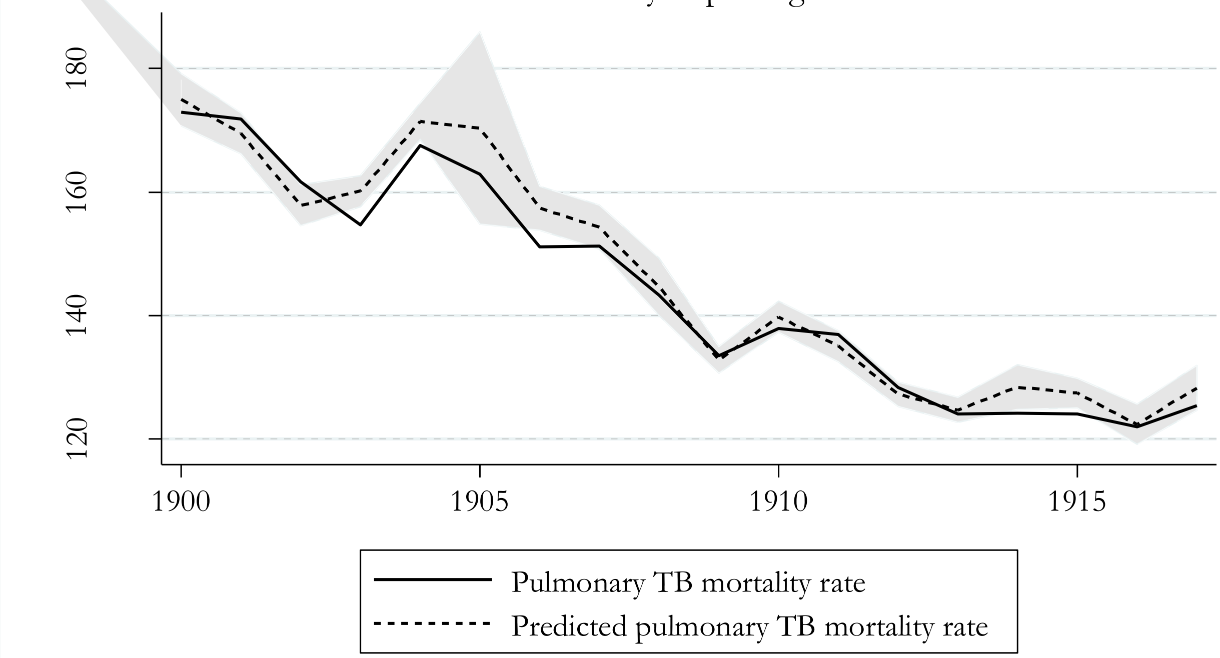
Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau.

Figure 2. Influenza, Pneumonia, and Other Airborne Illnesses Mortality Rates, 1900-1917



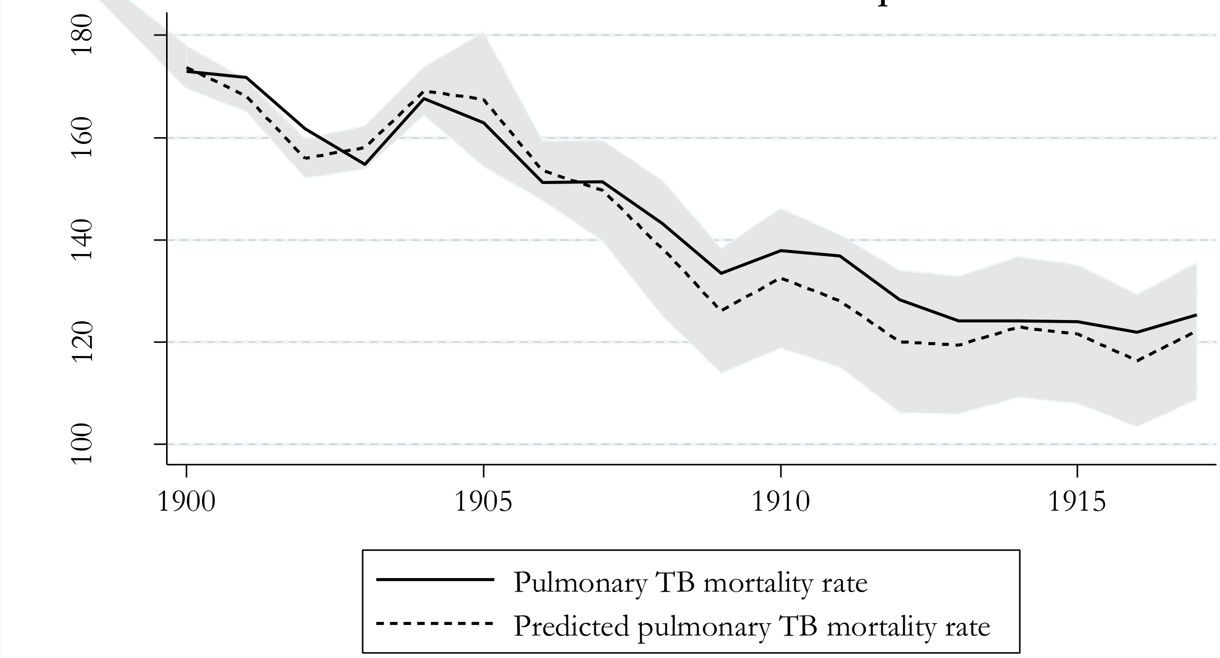
Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Other airborne illnesses include measles, scarlet fever, whooping cough, and diphtheria/croup.

Figure 3. Actual vs. Predicted Pulmonary Tuberculosis Mortality Rates:
The Effect of City Reporting Ordinances



Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Predicted pulmonary TB mortality rates are calculated under the assumption that city reporting ordinances were not implemented. Shaded area represents 90% confidence region around predicted pulmonary TB mortality rates.

Figure 4. Predicted Pulmonary TB Mortality Rates had Anti-TB Measures not been Implemented



Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Predicted pulmonary TB mortality rates are calculated under the assumption that none of the anti-TB measures listed in Table 1 were implemented. Shaded area represents 90% confidence region around predicted pulmonary TB mortality rates.

Table 1. Descriptive Statistics for Pulmonary Tuberculosis Mortality Analysis, 1900-1917

	Mean (SD)	Description
Pulmonary TB Mortality	141.5 (78.7)	Pulmonary tuberculosis mortality per 100,000 population
Sanatorium	.078 (.268)	= 1 if municipality had a sanatorium, = 0 otherwise
TB Hospital	.087 (.281)	= 1 if municipality had a TB hospital, = 0 otherwise
Open-Air Camp	.068 (.251)	= 1 if municipality had an open-air camp, = 0 otherwise
Reporting Ordinance	.131 (.338)	= 1 if municipality required reporting of TB cases, = 0 otherwise
State Reporting Law	.510 (.500)	= 1 if state required reporting of TB cases, = 0 otherwise
Disinfection Ordinance	.067 (.249)	= 1 if municipality required disinfection of premises after death or removal of a TB patient, = 0 otherwise
State Disinfection Law	.079 (.269)	= 1 if state required disinfection of premises after death or removal of a TB patient, = 0 otherwise
Spitting Ordinance	.273 (.446)	= 1 if municipality had an anti-spitting ordinance, = 0 otherwise
Common Cup Ordinance	.018 (.134)	= 1 if municipality had a common cup drinking ban, = 0 otherwise
State Common Cup Law	.110 (.314)	= 1 if state had a common cup drinking ban, = 0 otherwise
Municipal TB Association	.360 (.480)	= 1 if municipality had a TB association, = 0 otherwise
State TB Association	.697 (.451)	= 1 if state had a TB association, = 0 otherwise
Dispensary	.261 (.439)	= 1 if municipality had a TB dispensary, = 0 otherwise
N	7,439	

Notes: Unweighted means with standard deviations in parentheses.

Table 2. Pulmonary TB Mortality and Public Health Interventions, 1900-1917

	(1)	(2)	(3)	(4)
Sanatorium	-.017	-.014	-.016	-.018
	(.026)	(.025)	(.024)	(.024)
TB Hospital	.022	.022	.021	.023
	(.029)	(.028)	(.029)	(.028)
Open-Air Camp	-.021	-.019	-.017	-.015
	(.021)	(.019)	(.022)	(.020)
Reporting Ordinance	…	-.057**	-.061**	-.062**
		(.026)	(.030)	(.028)
State Reporting Law	…	-.008	-.007	-.011
		(.014)	(.015)	(.016)
Disinfection Ordinance	…	.040	.042	.035
		(.030)	(.032)	(.032)
State Disinfection Law	…	-.020	-.024	-.021
		(.025)	(.028)	(.029)
Spitting Ordinance	…	…	.019	.014
			(.026)	(.023)
Common Cup Ordinance	…	…	.010	.014
			(.021)	(.021)
State Common Cup Law	…	…	-.021	-.022
			(.021)	(.022)
Municipal TB Association	…	…	…	.005
				(.016)
State TB Association	…	…	…	.023
				(.020)
Dispensary	…	…	…	.019
				(.019)
N	7,439	7,439	7,439	7,439
R^2	.882	.882	.883	.883

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the pulmonary tuberculosis mortality rate per 100,000 population in municipality *m* and year *t*. Controls include municipality fixed effects, year fixed effects, and municipality-specific linear trends. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 3. A Closer Look at Sanatoriums

	(1)	(2)	(3)	(4)
Sanatorium	…	-.014	-.019	-.019
		(.023)	(.024)	(.023)
Number of Sanatoriums in Municipality	.018	…	…	…
	(.020)			
Any Sanatorium in State	…	.002	…	…
		.017		
Number of Sanatoriums in State	…	…	-.003	…
			(.005)	
State-Run Sanatorium	…	…	…	-.038**
				(.016)
N	7,439	7,439	7,439	7,439
R^2	.883	.883	.883	.883

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the pulmonary tuberculosis mortality rate per 100,000 population in municipality *m* and year *t*. Controls include the covariates listed in Table 1, municipality fixed effects, year fixed effects, and municipality-specific linear trends. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 4. Pulmonary TB Mortality and Leads and Lags of Municipal Reporting Ordinances

	(1)	(2)	(3)	(4)
3 Years Prior to Reporting Ordinance	…	…	…	.012
				(.021)
2 Years Prior to Reporting Ordinance	…	…	-.017	-.011
			(.020)	(.027)
1 Year Prior to Reporting Ordinance	…	-.033	-.039	-.034
		(.028)	(.034)	(.042)
Year of Reporting Ordinance	-.067**	-.078**	-.085*	-.079
	(.031)	(.037)	(.043)	(.051)
1 Year After Reporting Ordinance	-.056**	-.068*	-.075*	-.069
	(.027)	(.034)	(.041)	(.051)
2 Years After Reporting Ordinance	-.060*	-.074*	-.082*	-.075
	(.030)	(.037)	(.043)	(.053)
3+ Years After Reporting Ordinance	-.091**	-.108**	-.117**	-.109*
	(.037)	(.044)	(.051)	(.062)
Mean	141.5	141.5	141.5	141.5
N	7,439	7,439	7,439	7,439
R^2	.883	.883	.883	.883

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the pulmonary tuberculosis mortality rate per 100,000 population in municipality *m* and year *t*. Controls include the covariates listed in Table 1, municipality fixed effects, year fixed effects, and municipality-specific linear trends. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 5. Extensions and Robustness of Municipal Reporting Ordinances

	(1)	(2)	(3)	(4)	(5)	(6)
	Control for typhoid mortality	Restrict to cities with population > 50,000	Restrict to cities with population > 100,000	Restrict to cities with 18 years of data	Dependent variable: (*Non-pulmonary TB Mortality*)$^{1/4}$	Dependent variable: (*Pulmonary TB Mortality*)$^{1/4}$
Reporting Ordinance	-.049*	-.067**	-.066	-.071**	.019	-.056**
	(.026)	(.031)	(.040)	(.029)	(.021)	(.025)
					[.639]	[-9.11]
Mean of TB Mortality	141.5	162.0	163.7	143.9	17.6	141.5
N	7,439	1,693	869	5,254	7,439	7,439
R^2	.885	.924	.931	.884	.608	.889

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. Columns (1)-(4): The dependent variable is equal to the natural log of the pulmonary tuberculosis mortality rate per 100,000 population in municipality *m* and year *t*. Columns (5)-(6): The dependent variable is equal to the quartic root of the specified mortality rate per 100,000 population in municipality *m* and year *t*; marginal effects are in brackets. Controls include the covariates listed in Table 1, municipality fixed effects, year fixed effects, and municipality-specific linear trends. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 6. Extensions and Robustness of State-Run Sanatoriums

	(1)	(2)	(3)	(4)	(5)	(6)
	Controlling for typhoid mortality	Restrict to cities with population > 50,000	Restrict to cities with population > 100,000	Restrict to cities with 18 years of data	Dependent variable: (*Non-pulmonary TB Mortality*)$^{1/4}$	Dependent variable: (*Pulmonary TB Mortality*)$^{1/4}$
State-Run Sanatorium	-.034**	-.043**	-.045*	-.034**	.011	-.032**
	(.014)	(.019)	(.024)	(.015)	(.019)	(.015)
					[.391]	[-5.27]
Mean of Mortality Rate	141.5	162.0	163.7	143.9	17.6	141.5
N	7,439	1,693	869	5,254	7,439	7,439
R^2	.886	.925	.932	.884	.608	.890

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. Columns (1)-(4): The dependent variable is equal to the natural log of the pulmonary tuberculosis mortality rate per 100,000 population in municipality *m* and year *t*. Columns (5)-(6): The dependent variable is equal to the quartic root of the specified mortality rate per 100,000 population in municipality *m* and year *t*; marginal effects are in brackets. Controls include the covariates listed in Table 1, municipality fixed effects, year fixed effects, and municipality-specific linear trends. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 7. Did Anti-Spitting Ordinances, Common Cup Bans, or TB Associations have Spillover Effects on other Airborne Illnesses?

	(1)	(2)	(3)	(4)
	Flu and Pneumonia Mortality	*Flu and Pneumonia Mortality*	*Other Airborne Illnesses Mortality*	*Other Airborne Illnesses Mortality*
Spitting Ordinance	-.046	-.050*	-.019	-.017
	(.030)	(.026)	(.043)	(.044)
	[-7.78]	[-8.56]	[-1.49]	[-1.29]
Common Cup Ordinance	.020	.046	-.041	-.016
	(.103)	(.069)	(.033)	(.044)
	[3.41]	[7.76]	[-3.20]	[-1.24]
State Common Cup Law	.060	.064	-.029	-.032
	(.043)	(.039)	(.044)	(.047)
	[10.1]	[10.8]	[-2.23]	[-2.45]
Municipal TB Association	-.021	-.027	.008	.015
	(.025)	(.028)	(.021)	(.023)
	[-3.62]	[-4.64]	[.639]	[1.19]
State TB Association	.004	.011	.053**	.043
	(.039)	(.037)	(.024)	(.026)
	[.743]	[1.83]	[4.12]	[3.34]
Mean of Mortality Rate	148.1	148.1	51.9	51.9
N	7,439	7,439	7,439	7,439
R^2	.739	.743	.567	.568
Other Anti-TB Measures?	No	Yes	No	Yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. Columns (1)-(2): The dependent variable is equal to the quartic root of the influenza and pneumonia mortality rate per 100,000 population in municipality m and year t; marginal effects are in brackets. Columns (3)-(4): The dependent variable is equal to the quartic root of the measles, scarlet fever, whooping cough, and diphtheria/croup mortality rate per 100,000 population in municipality m and year t; marginal effects are in brackets. Controls include municipality fixed effects, year fixed effects, and municipality-specific linear trends. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.

Appendix Table XXX. Pulmonary TB Mortality and Leads and Lags of State-Run Sanatoriums

	(1)	(2)	(3)	(4)
3 Years Prior to State-Run Sanatorium	…	…	…	.005
				(.017)
2 Years Prior to State-Run Sanatorium	…	…	.021	.023
			(.030)	(.033)
1 Year Prior to State-Run Sanatorium	…	-.014	-.004	-.001
		(.017)	(.024)	(.029)
Year of State-Run Sanatorium	-.037***	-.043**	-.033	-.029
	(.013)	(.018)	(.021)	(.027)
1 Year After State-Run Sanatorium	-.049**	-.056**	-.044	-.040
	(.020)	(.025)	(.026)	(.033)
2 Years After State-Run Sanatorium	-.025	-.033	-.019	-.015
	(.023)	(.026)	(.026)	(.033)
3+ Years After State-Run Sanatorium	-.041	-.050*	-.035	-.031
	(.025)	(.029)	(.029)	(.035)
Mean	141.5	141.5	141.5	141.5
N	7,439	7,439	7,439	7,439
R^2	.883	.883	.883	.883

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics* for the period 1900-1917, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the pulmonary tuberculosis mortality rate per 100,000 population in municipality *m* and year *t*. Controls include the covariates listed in Table 1, municipality fixed effects, year fixed effects, and municipality-specific linear trends. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.