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Was the First Public Health Campaign Successful?†

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The US tuberculosis (TB) movement pioneered many of the strategies of modern public health campaigns. Using newly transcribed mortality data at the municipal level for the period 1900–1917, we explore the effectiveness of public health measures championed by the TB movement, including the establishment of sanatoriums and open-air camps, prohibitions on public spitting and common cups, and requirements that local health officials be notified about TB cases. Our results suggest that 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. (*JEL* H51, I12, I18, N31, N32)

In 1900, 194 out of every 100,000 Americans died of tuberculosis (TB), making it the second-leading cause of death, behind only pneumonia/influenza (Jones, Podolsky, and Greene 2012). Although an effective treatment would not be introduced until after World War II (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, Podolsky, and Greene 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, 96–197; Lönnroth et al. 2009; and Mercer 2014, 127–29). 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

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questioned whether such measures contributed meaningfully to the decline in TB mortality (McKeown 1976, Coker 2003, and Daniel 2006).[1]

Drawing on newly transcribed 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 when the National Association for the Study and Prevention of Tuberculosis (NASPT) was founded in 1904 (Shryock 1957, 52; Teller 1988, 30). Spearheaded by voluntary associations and supported by the sale of Christmas Seals, the US TB movement pioneered many of the strategies of modern public health campaigns (Teller 1988, 1, 121–26; Jones and Greene 2013; and Rosen 1993, 226–31).

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 bans on public spitting and requirements that doctors notify local public health officials about active TB cases.

Although remarkable in its scope and intensity, the effectiveness of the US TB movement has, to date, not been studied in a systematic fashion.[2] Using municipal-level data for the period 1900–1917 from *Mortality Statistics*, which was published on an annual basis by the US 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. 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 stand out: there is evidence, albeit tentative, that requiring TB cases to be reported to local health officials led to a modest reduction in pulmonary TB mortality; likewise, the opening of a state-run sanatorium is associated with a modest reduction in pulmonary TB mortality. However, these two measures can explain, at most, only a small portion of the overall decline in pulmonary TB mortality during the period 1900–1917.

[1] See also Tomes (1989), Bates (1989, 1992), Vynnycky and Fine (1999), and Wilson (2005). Bates (1989, 349) writes 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, 477), although also skeptical, argues 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."

[2] While we are the first to systematically investigate the effectiveness of the US TB movement, two recent working papers provide estimates of the effects of particular anti-TB measures implemented before an effective treatment was available. Hollingsworth (2014) examines the relationship between sanatoriums and pulmonary TB mortality using data from North Carolina for the period 1932–1940. He finds that an additional sanatorium bed reduced the pulmonary TB mortality rate among whites by 0.695 per 100,000 population, but had no effect on the TB mortality rate among blacks. Using municipal-level data from Denmark for the period 1890–1939, Hansen, Jensen, and Madsen (2017) finds evidence to suggest that the opening of TB dispensaries reduced the TB mortality rate. TB dispensaries and their activities in the United States are discussed below.

I. Background

Today, cancer and coronary heart disease are the leading causes of death in the United States (National Center for Health Statistics 2016), but, at the turn of the twentieth century, most Americans did not expect to die from these so-called "modern diseases"; influenza, pneumonia, tuberculosis, and gastrointestinal infections took a far greater toll (Jones, Podolsky, and Greene 2012). The United States experienced a rapid decline in mortality from infectious diseases during the early 1900s (Jones, Podolsky, and Greene 2012). By 1930, coronary heart disease had become the leading cause of death (Jones, Podolsky, and Greene 2012), and by 1948, Secretary of State George Marshall could declare with confidence that the conquest of all infectious diseases was imminent (Garrett 1994, 30).

In an oft-cited review, Cutler, Deaton, and Lleras-Muney (2006) attributes the unprecedented decline in infectious disease mortality in the United States and other Western countries to basic public health measures, including the building of sewage systems, the delivery of clean water, and educational campaigns designed to promote better hygiene. The evidence that sewers and clean water contributed to declines in mortality from 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, and Beach et al. 2016).[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, and Daniel 2006). Indeed, there is no 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, and 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 future public health interventions in the developing world where TB remains widespread (World Health Organization 2015, Houben and Dodds 2016). Although most TB infections can be successfully treated with antimicrobial drugs, the World Health Organization (WHO) estimates that 3.9 percent of new TB cases are multidrug-resistant (WHO 2016, 38). The recommended treatment for drug-susceptible TB lasts 6 months, but treatment for multidrug-resistant TB takes 9–12 months, requires more toxic drugs, and has a much lower success rate (WHO 2016, 4).[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, 773). At a minimum, assessing the effectiveness of basic public health measures, many of which were pioneered by the US TB movement, has taken on a new urgency.

[3] Relatedly, Clay, Troesken, and Haines (2014) finds that waterborne lead exposure was associated with higher rates of infant mortality at the turn of the twentieth 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 (Lange et al. 2014).

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, 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.

Most *Mycobacterium tuberculosis* infections are asymptomatic and cannot be spread (CDC 2013, 28). However, between 5 and 15 percent of infections develop into active TB (WHO 2016, 125), typically within the first two years of initial transmission (Sia and Wieland 2011, 352).[6] Without treatment, 70 percent of those with active TB eventually succumb to the disease (Tiemersma et al. 2011), passing along their infection 10–15 times per year in the absence of effective control measures (Styblo 1985; van Leth, van der Werf, and Borgdorff 2008; and WHO 2017).[7] Symptoms include a chronic cough, chest pains, fatigue, fevers, night sweats, and weight loss (Lawn and Zumla 2011, 65).

At the turn of the twentieth century, TB was the second-leading cause of death in the United States (Jones, Podolsky, and Greene 2012).[8] It was greatly feared, in part because it often affected healthy men and women in the prime of life (Donald 2015, 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 cities such as Boston, New Orleans, New York, San Francisco, and Washington, DC.[9] An effective treatment would not be introduced until after World War II (Daniel 2006), yet the TB mortality rate fell by more than 60 percent from 1900 to 1930 (Jones, Podolsky, and Greene 2012).[10] Many, if not most, contemporary observers credited the TB movement for this dramatic reduction in TB mortality (Emerson 1922; Bates 1992, 317–18).

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

[6] Approximately half of TB infections that become active do so within the first two years (Sia and Wieland 2011, 352).

[7] Thompson (1943) examined 406 TB patients diagnosed between 1928 and 1938. One year after their diagnosis, 40 percent had died; two years after diagnosis, almost 60 percent had died. In a review of studies from the pre-chemotherapy era, Tiemersma et al. (2011) concluded that the time from onset to either cure or death for active TB was, on average, three years. Approximately one-fourth of active TB cases will naturally transition to latency within five years (Grzybowski and Enarson 1978).

[8] 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, 29; Daniel 2006, 1863; and Smith 2003, 465). In Homer's *Odyssey*, the poet referenced a "grievous consumption," which took the soul from one's body (Bynum 2012, 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 nineteenth century (Dubos and Dubos 1952; Smith 2003, 465).

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

[10] The first vaccine, BCG, was introduced in 1921 (Lawn and Zumla 2011, 67). Although vaccination campaigns were undertaken in Europe, no such campaign was launched in the United States (Cutler, Deaton, and Lleras-Muney 2006, 103). Today, despite widespread use of the BCG vaccine, TB is still one of the leading causes of mortality in developing nations, with 1.4 million people succumbing to it every year (WHO 2016). It is estimated that approximately one-fourth of the world's population has a latent TB infection (Houben and Dodd 2016).

II. 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 and medical professionals, and, beginning in 1908, was almost entirely funded by the sale of Christmas Seals (Knopf 1922, 55–66; Shryock 1957, 55–57; and Rosen 2015, 226–31).[11] 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, 55–56 and 179–82; and Rosen 2015, 226–31).

Between 1900 and 1917, hundreds of state and local TB associations were established across the United States (Jacobs 1911, NASPT 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 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, 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.[12]

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.[13] Below, we describe the history and functions of sanatoriums, TB hospitals, open-air camps, and

[11] Emily P. Bissells sold the first Christmas Seals in 1907, raising $3,000 for a small sanatorium located near Wilmington, Delaware (Knopf 1922, 55; Zunz 2011). The next year, with the help of the American Red Cross, a total of $135,000 was raised through the sale of Christmas Seals. In addition to selling Christmas Seals, the NASPT was supported through membership dues, donations, and the sale of supplies (Knopf 1922, 52). Even today, the American Lung Association's mission is largely funded by the sale of Christmas Seals (see www.christmasseals.org).

[12] For a historical perspective on the hygiene practices promoted by tuberculosis associations, see Tomes (1999, 13–134) and Tomes (2000). An exhaustive list of contemporary hygiene-related admonitions is provided by Knopf (1901). For instance, Knopf (1901, 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" (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" (71).

[13] Teller (1988, 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."

dispensaries. After describing these institutions, we briefly summarize the anti-TB legislation passed during the period under study.[14]

Sanatoriums.—The first sanatoriums in the United States were established at the end of the nineteenth century (Knopf 1922, 10). Often 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 as compared to those who went untreated (Bignall 1977; Teller 1988, 89–90; and Daniel 2006), medical professionals at the turn of the twentieth century, including the leaders of the TB movement, were convinced that sanatoriums could cure pulmonary TB (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, 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 and Teller 1988, 82). Some sanatoriums catered to the rich, offering excellent food and a spa-like atmosphere (Bates 1992, 195; Rappold 2007), while 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.[15]

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 1909, and Newsholme 1908). TB patients were observed to recover when provided with nutritious food and an opportunity to rest, only to relapse upon discharge. More resources, they argued, should be devoted toward isolating the most infections patients—those with advanced pulmonary TB (Bloede 1908, Brown 1909, Newsholme 1908, Hutchinson 1911, and Flick 1913). 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, 92; and Abel 2007, 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; and Teller 1988, 92).[16]

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, Townsend 1909). During the day, patients received care and were taught how to

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

[15] See Klebs (1909), Bignall (1977), Feldberg (1995, pp. 93–94), Rothman (1995, pp. 207–210), Abel (2007, 43), and Rappold (2007) for more details on the conditions in sanatoriums. Online Appendix Figure A1 shows the sanatoriums that contributed identifying variation to our analysis in 1905, 1910, and 1917.

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

avoid infecting their family, friends, and coworkers. At night, they returned home "to practice the lessons learned" (Townsend 1909, 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, more than 60 open-air camps were operating across the country (NASPT 1916).

Dispensaries.—TB 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, 112; Bynum 2012).[17] Dispensaries also provided medicines such as cod liver oil or opiate-based cough mixtures (Bynum 2012, Fraser and Clark 1912), which offered temporary relief but could not cure TB. Using municipal-level data from Denmark, Hansen, Jensen, and Madsen (2017) finds 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."[18] 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).

Reporting Requirements.—Tuberculosis associations advocated forcefully, and often successfully, for the passage of laws designed to prevent the spread of the disease. In particular, laws requiring the reporting of active TB cases to local health officials were a key feature of the campaign (Knopf 1922, 149; Teller 1988, 22; amd Rothman 1995, 187). At the turn of the twentieth century, it was common for physicians to conceal a TB diagnosis from their patients (Ambler 1903, Cabot 1909, and 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 (Jacobs 1911, NASPT 1916).[19] Today, notification policies and practices are well established in developed, Western countries, yet under-notification remains a problem in the developing world (Uplekar et al. 2016).[20]

[17] 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).

[18] Hansen, Jensen, and Madsen (2017) also finds 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 country, TB patients "had the liberty of choosing the sanatorium across the country that they liked the most." By contrast, going to an out-of-state sanatorium was too expensive for all but the wealthiest TB patients in the United States (Rothman 1995, 207–10).

[19] Online Appendix Figure A2 shows the municipal reporting ordinances that contributed identifying variation to our analysis in 1905, 1910, and 1917.

[20] The World Health Organization's End TB Strategy specifically highlights mandatory TB case notification as integral to ending the TB epidemic by 2030 (Uplekar et al. 2016).

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.[21]

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). The first anti-spitting ordinances were adopted before the founding of the NASPT. For instance, Chicago, Illinois, and New Haven, Connecticut, prohibited public spitting in 1901; Youngstown, Ohio, and several other cities followed suit in 1902 (online Appendix Table A1). Anti-spitting ordinances gained popularity during the period under study and by 1917, over 150 municipalities across the United States had banned spitting in public (NASPT 1916). There is anecdotal evidence, however, that these bans were not particularly well enforced. Despite fines as high as $25 dollars per offense, few people were actually arrested for spitting in public (Newton 1910).[22]

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 1999, and Sattar 2016). By 1917, 17 states and more than 150 municipalities had banned the use of the common cup (Jacobs 1911, NASPT 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 1919, Boudreau 1920, Gladden 1921, and McGuire 2012).[23]

III. Mortality Data and Empirical Framework

Municipal-level mortality data come from *Mortality Statistics*, published annually by the US Census Bureau. The inaugural issue of *Mortality Statistics* was published in 1900 and contained mortality counts by cause for over 300 municipalities.[24] By 1917, mortality counts for over 500 municipalities were available. We focus on the

[21] Knopf (1901, 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.

[22] 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, enforcement appears to be extremely lax (York 2003, Williams 2015).

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

[24] 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, 27; Cabot 1912), an issue we address below.

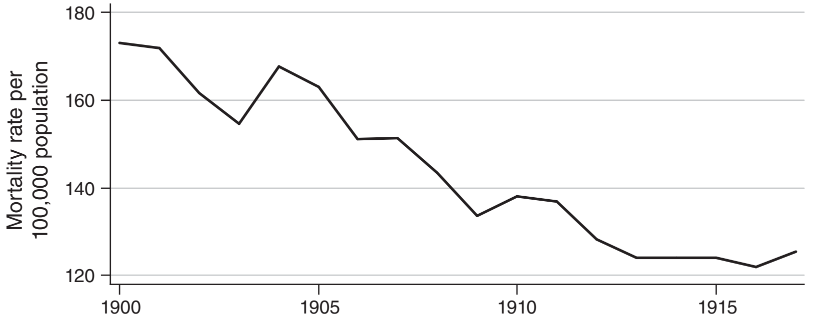

Figure 1. Pulmonary TB Mortality Rates, 1900–1917

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

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.[25] The pulmonary TB mortality rate was 173 per 100,000 population in 1900.[26] From 1900 to 1917, it fell by nearly 28 percent, to 125. We begin our exploration of whether the anti-TB measures described in the previous section contributed to this dramatic reduction in the pulmonary TB mortality rate by estimating the following baseline regression:

$$\ln(\textit{Pulmonary TB Mortality}_{mt}) = \beta_0 + \mathbf{Z}_{mt}\boldsymbol{\beta}_1 + \mathbf{X}_{mt}\boldsymbol{\beta}_2 + v_m + w_t + \Theta_m \cdot t + \varepsilon_{mt}, \tag{1}$$

where m indexes municipalities and t indexes years. Our interest is in the variables that compose the vector $\mathbf{Z}_{mt}$, which were constructed using information available in NASPT (1916, 1919) and Jacobs (1911). Specifically, the vector $\mathbf{Z}_{mt}$ includes separate indicators for whether municipality m was served by a sanatorium, a TB hospital, or an open-air camp in year t.[27] Sanatoriums, TB hospitals, and open-air camps could have affected TB mortality by isolating patients from the general population or by modifying their behavior upon discharge, both of which can be thought of as reducing the transmission coefficient in the Standard Inflammatory Response (SIR) model of disease diffusion.[28]

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

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

[27] Online Appendix Table A1 details when the first sanatorium, TB hospital, and open-air camp opened in each of the municipalities in our sample. Note that online Appendix Table A1 lists only municipalities for which we have TB mortality data both before and after the particular anti-TB measure was established.

[28] The SIR model was developed by Kermack and McKendrick (1927, 1932, 1933). See Blower et al. (1995); Porco and Blower (1998); Hollingsworth (2014); and Hansen, Jensen, and Madsen (2017) for examples of the SIR model adapted to TB, where the transmission coefficient, β, is equal to the probability that an individual with active TB will transmit his or her infection. It is also possible that sanatoriums reduced the TB mortality rate by

The vector of controls, $\mathbf{X}_{mt}$, consists of municipality characteristics from the 1900, 1910, and 1920 censuses (and linearly imputed for intercensal years). It includes the fraction of the population that was female, black, foreign-born, younger than 18, and literate. In online Appendix Table A2, we explore whether these municipal-level characteristics predicted the adoption of anti-TB measures.[29]

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. It is worth emphasizing that efforts to educate the public about TB and encourage good hygiene were undertaken entirely at the local (i.e., municipal) level until 1908, when the NASPT established a press service that released bulletins to newspapers and wire services (Teller 1988, 59).[30] Although there were no national newspapers or commercial radio broadcasts during the period under study, magazines with wide readership such as *Good Housekeeping, Ladies Home Journal*, and *Popular Science Monthly* ran stories promoting antiseptic-consciousness (McClary 1980; Tomes 2000, 2002). Any effect these publications might have had on TB mortality is captured by the year fixed effects. In addition to the municipality 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 versus those that did not. All regressions are weighted by municipality population and standard errors are corrected for clustering at the state level (Bertrand, Duflo, and Mullainathan 2004).[31]

After estimating the baseline regression described above, we augment the vector $\mathbf{Z}_{mt}$ with other anti-TB measures, all of which can be thought of as reducing the transmission coefficient in the SIR model. First, we include separate indicators for whether municipality m required the reporting of TB cases and whether it was located in a state that required the reporting of TB cases.[32] Next, we include separate indicators for whether municipality m required the disinfection of premises vacated by TB patients, whether it was located in a state that required disinfection, whether it prohibited spitting in public, whether it prohibited common drinking cups, and whether it was located in a state with a common cup ban. Finally,

providing patients with an opportunity to rest and eat nutritious foods, which could have increased the natural cure rate (Hollingsworth 2014). However, as noted in the previous section, TB patients admitted to sanatoriums seem to have had similar recovery rates to those who went untreated (Bignall 1977; Teller 1988, 89–90; Daniel 2006). See Adda (2016) for an application of the SIR model to high-frequency data on viral diseases in France.

[29] The estimates reported in the first column of online Appendix Table A2 suggest that it is difficult to predict the adoption of at least one municipal anti-TB measure (*Any Anti-TB Measure*) by 1917. By contrast, population, percent foreign-born, and percent literate are positively associated with the number of anti-TB measures adopted by 1917.

[30] Many state and local TB associations established their own press services after 1908 (Teller 1988, 59), but before then newspapers regularly covered the parades, exhibits, and Christmas seal campaigns sponsored by these associations (Tomes 2002). The first US commercial radio broadcast occurred on November 2, 1920 (election night) in Pittsburgh, Pennsylvania. Up until then, radio stations were operated by amateur hobbyists whose target audience was other hobbyists (Sterling and Kittross 2001, 44–48 and 66).

[31] Clustering standard errors at the municipal level produced similar results to those reported below.

[32] By 1917, 91 municipalities in our sample had adopted ordinances requiring that active TB cases be reported to local health officials. We observe mortality data before and after the adoption of a reporting ordinance for 71 of these municipalities (see online Appendix Table A1).

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.[33] After providing estimates of the regressions described above, we conduct a series of robustness checks, which are described in Section VI.

Descriptive statistics and definitions for all of the variables used in the analysis are reported in Table 1.[34] Information on when the municipal anti-TB measures were adopted is available in Figure 2 and online Appendix Table A1. Information on when the state anti-TB measures were adopted is available in online Appendix Table A3.

IV. Baseline 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 and statistically indistinguishable from zero. The relationship between pulmonary TB mortality and the TB hospital indicator is positive, but also insignificant.

The second column of Table 2 presents estimates from a regression model that also includes the two reporting indicators. The estimated coefficients of these indicators, although negative, are not significant at conventional levels. In the third column of Table 2, we report estimates from a regression model that includes disinfection requirements, spitting bans, and common cup bans. There is little evidence that these interventions mattered at the municipal or state levels, but the adoption of a reporting requirement at the municipal level is now associated with a 6 percent $(e^{-0.060} - 1 = -0.058)$ decrease in the pulmonary TB mortality rate, an estimate that is statistically significant at the 10 percent level. Finally, in the fourth column of Table 2, we report estimates from a regression model that also includes the state and local TB association indicators and an indicator for whether a municipal dispensary was operating. The adoption of a reporting requirement at the municipal level is still associated with a 6 percent decrease in the pulmonary TB mortality rate, but no other anti-TB measure appears to have had an appreciable impact on the pulmonary TB mortality rate.[35]

[33] Because we know the exact dates when state TB associations began operation, the first year of the state TB indicator is coded as a fraction. Our definition of TB dispensaries also includes clinics where special medical staffs and separate hours were set aside for TB patients (Jacobs 1911 and NASPT 1916, 1919).

[34] Although not shown in Table 1, we also include binary indicators to control for missing information on the municipal-level anti-TB measures. For instance, if a city had a common cup ban but information on when the ban went into place was missing, we coded *Common Cup Ordinance* as equal to zero and included a separate indicator for this missing information. With one exception, each of our municipal-level anti-TB measures has non-missing information for at least 92 percent of the sample. We observe non-missing information for the municipal disinfection ordinances for 73 percent of the sample.

[35] It should be noted that, accounting for the family-wise error rate (FWER) using the step-down method proposed by Holm (1979), we fail to reject the null that municipal reporting requirements had no effect on pulmonary TB mortality. Because the *p*-value for this test is the minimum *p*-value from the estimates reported in column 4 of Table 2, the Holm-corrected critical value is equivalent to the Bonferroni correction, which has been characterized as overly conservative (Austin, Dialsingh, and Altman 2014). In online Appendix Table A4, we report estimates of equation (1) without controlling for municipality-specific linear trends. Even without municipality-specific linear trends, requiring TB cases to be reported to local health officials is associated with a 5–6 percent decrease in

Table 1—Descriptive Statistics for Pulmonary TB Mortality Analysis, 1900–1917

	Mean (SD)	Description
Pulmonary TB mortality	141.5 (78.7)	Pulmonary tuberculosis mortality per 100,000 population
Sanatorium	0.078 (0.268)	= 1 if municipality had a sanatorium, = 0 otherwise
TB hospital	0.087 (0.281)	= 1 if municipality had a TB hospital, = 0 otherwise
Open-air camp	0.068 (0.251)	= 1 if municipality had an open-air camp, = 0 otherwise
Reporting ordinance	0.131 (0.338)	= 1 if municipality required reporting of TB cases, = 0 otherwise
State reporting law	0.510 (0.500)	= 1 if state required reporting of TB cases, = 0 otherwise
Disinfection ordinance	0.067 (0.249)	= 1 if municipality required disinfection of premises after removal of a TB patient, = 0 otherwise
State disinfection law	0.079 (0.269)	= 1 if state required disinfection of premises after removal of a TB patient, = 0 otherwise
Spitting ordinance	0.273 (0.446)	= 1 if municipality had an anti-spitting ordinance, = 0 otherwise
Common cup ordinance	0.018 (0.134)	= 1 if municipality had a common cup drinking ban, = 0 otherwise
State common cup law	0.110 (0.314)	= 1 if state had a common cup drinking ban, = 0 otherwise
Municipal TB association	0.360 (0.480)	= 1 if municipality had a TB association, = 0 otherwise
State TB association	0.697 (0.451)	= 1 if state had a TB association, = 0 otherwise
Dispensary	0.261 (0.439)	= 1 if municipality had a TB dispensary, = 0 otherwise
Percent female	0.486 (0.105)	Percent of municipal population that was female
Percent black	0.046 (0.101)	Percent of municipal population that was black
Percent foreign	0.193 (0.120)	Percent of municipal population that was foreign born
Percent under 18	0.323 (0.081)	Percent of municipal population that was under 18 years of age
Percent literate	0.732 (0.161)	Percent of municipal population that was literate
Observations	7,439	

Note: Unweighted means with standard deviations are in parentheses.

pulmonary TB mortality, but there is little evidence that any of the other anti-TB measures were effective. Because municipal water filtration and chlorination projects could have been correlated with the adoption of TB reporting requirements, we experimented with including the typhoid mortality rate on the right-hand side of the estimation equation (Clay, Troesken, and Haines 2014). Estimates from these specifications were similar to those reported in Table 2. We also estimated unweighted regressions. The adoption of a municipal reporting ordinance was associated with a 5 percent decrease in the pulmonary TB mortality rate, but this estimate was statistically insignificant at conventional levels.

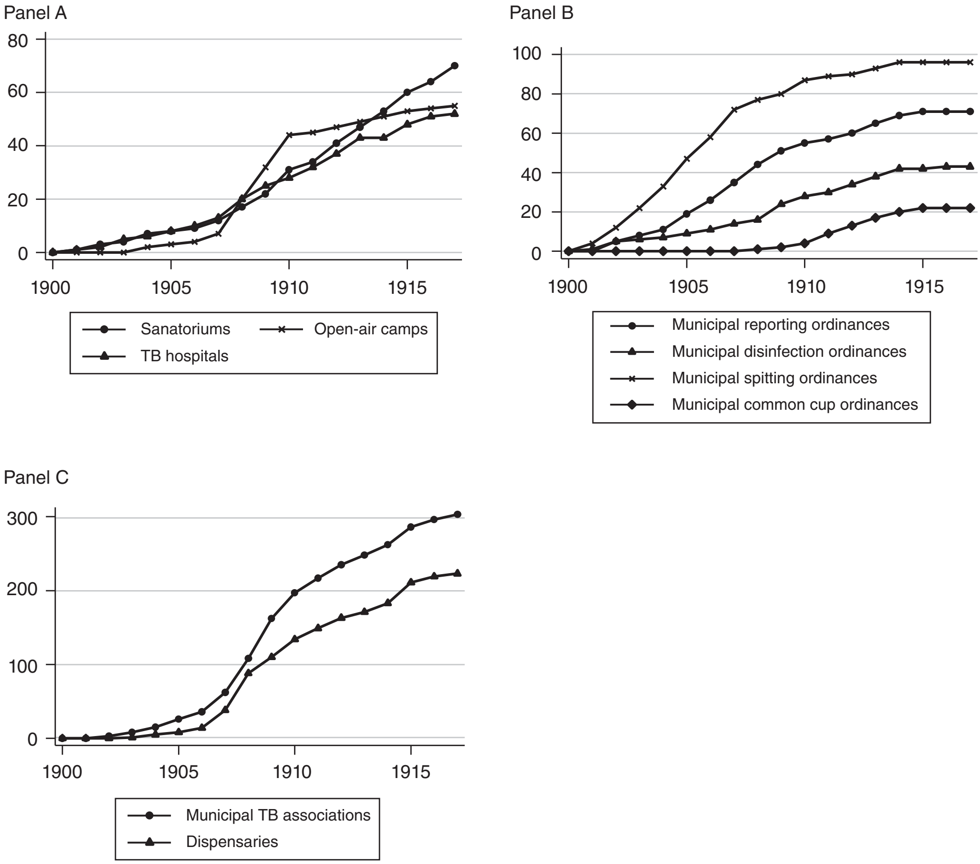

Figure 2. Number of Municipal-Level Anti-TB Measures over Time

Notes: The figure is based on data from online Appendix Table A1. Only anti-TB measures that contributed identifying variation to estimates based on equation (1) were used to construct the trends above.

V. Extensions and Robustness Checks

The regression estimates in Table 2 provide evidence that the measures championed by the TB movement were generally ineffective. One potential explanation for this result is multicollinearity: municipalities occasionally passed two or more anti-TB measures at the same time or within the space of a few years (online Appendix Table A5), making it potentially difficult to distinguish the effect of one anti-TB measure from another.

To address this issue, we regress TB mortality on each of the 13 anti-TB measures separately. In addition, we replace each anti-TB measure with a series of its leads and lags, which allows us to explore whether changes in TB mortality predicted their passage and whether their effects grew stronger over time. Because we have no strong priors about the correct lag structure for the anti-TB interventions under study, we flexibly estimate their effects one to five or more years after the year

Table 2—Pulmonary TB Mortality and Anti-TB Measures, 1900–1917

	(1)	(2)	(3)	(4)
Sanatorium	−0.017	−0.020	−0.015	−0.017
	(0.025)	(0.026)	(0.024)	(0.024)
TB hospital	0.022	0.024	0.021	0.023
	(0.028)	(0.027)	(0.029)	(0.028)
Open-air camp	−0.022	−0.021	−0.018	−0.016
	(0.021)	(0.019)	(0.021)	(0.020)
Reporting ordinance	—	−0.042	−0.060	−0.061
		(0.030)	(0.030)	(0.028)
State reporting law	—	−0.012	−0.007	−0.011
		(0.015)	(0.015)	(0.016)
Disinfection ordinance	—	—	0.040	0.034
			(0.032)	(0.032)
State disinfection law	—	—	−0.026	−0.023
			(0.029)	(0.030)
Spitting ordinance	—	—	0.019	0.015
			(0.027)	(0.024)
Common cup ordinance	—	—	0.012	0.016
			(0.021)	(0.021)
State common cup law	—	—	−0.020	−0.021
			(0.021)	(0.022)
Municipal TB association	—	—	—	0.004
				(0.016)
State TB association	—	—	—	0.022
				(0.021)
Dispensary	—	—	—	0.019
				(0.019)
F-test: Joint significance	0.480	1.76	3.45	2.46
Mean	141.5	141.5	141.5	141.5
Number of municipalities	548	548	548	548
Observations	7,439	7,439	7,439	7,439
R^2	0.882	0.882	0.883	0.883

Notes: 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 demographic characteristics 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.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

of implementation (i.e., year zero).[36] Regression estimates for the municipal-level anti-TB measures are reported in Table 3, panels A–C; estimates for state-level anti-TB measures are reported in online Appendix Table A6.

The results suggest that multicollinearity is an unlikely explanation for the small and insignificant estimated coefficients in Table 2, and show that anti-TB measures were likely not implemented in response to increases in TB mortality. There is evidence of a negative association between open-air camps and pulmonary TB mortality

[36] Given that approximately half of active TB cases take more than two years to develop after the initial infection (Sia and Wieland 2011, 352), and that the average time from onset to either cure or death for active TB is three years in the absence of treatment (Tiemersma et al. 2011), substantial lags after implementation are plausible.

Table 3A—Pulmonary TB Mortality Regressed on Each Municipal Anti-TB Measure Separately

	Sanatorium		TB hospital		Open-air camp	
Municipal anti-TB measure	−0.017	—	0.020	—	−0.019	—
	(0.026)		(0.028)		(0.019)	
5 years prior	—	−0.016	—	−0.008	—	−0.011
		(0.018)		(0.028)		(0.013)
4 years prior	—	−0.014	—	−0.012	—	−0.011
		(0.028)		(0.037)		(0.013)
3 years prior	—	−0.044	—	0.001	—	−0.031
		(0.034)		(0.038)		(0.028)
2 years prior	—	−0.022	—	0.013	—	−0.059
		(0.039)		(0.052)		(0.032)
1 year prior	—	−0.027	—	0.010	—	−0.026
		(0.041)		(0.056)		(0.035)
Year 0	—	−0.012	—	0.024	—	−0.053
		(0.041)		(0.069)		(0.044)
1 year after	—	−0.065	—	0.014	—	−0.062
		(0.057)		(0.071)		(0.052)
2 years after	—	−0.078	—	0.017	—	−0.083
		(0.070)		(0.072)		(0.052)
3 years after	—	−0.050	—	0.043	—	−0.092
		(0.062)		(0.078)		(0.050)
4 years after	—	−0.072	—	0.050	—	−0.104
		(0.063)		(0.086)		(0.060)
5+ years after	—	−0.070	—	0.036	—	−0.106
		(0.068)		(0.082)		(0.076)
Mean	141.5	141.5	141.5	141.5	141.5	141.5
Number of municipalities	548	548	548	548	548	548
Observations	7,439	7,439	7,439	7,439	7,439	7,439
R^2	0.882	0.882	0.882	0.882	0.882	0.882

Notes: 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 demographic characteristics listed in Table 1, municipality fixed effects, year fixed effects, and municipality-specific linear trends. The omitted category in the event-study analyses is six or more years prior to implementation. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

after three or four years, but the decline in pulmonary TB mortality appears to have begun before year zero, pointing to an unobserved factor driving this association. Similarly, there is evidence that pulmonary TB mortality began to fall before doctors were required to report active TB cases to local health officials.[37]

In Table 4, we consider alternative specifications. We begin by estimating the relationship between pulmonary TB mortality and the total number of anti-TB measures implemented by municipality m as of year t. The results, which are reported in the first column of Table 4, provide no evidence of a relationship between pulmonary

[37] In online Appendix Table A7, we report event-study estimates for each municipal anti-TB measure conditioning on the other eight municipal anti-TB measures and the four state-level measures. Municipal reporting requirements are associated with statistically significant reductions in pulmonary TB mortality, but, again, there is some evidence of a pretreatment reduction in TB mortality.

Table 3B—Pulmonary TB Mortality Regressed on Each Municipal Anti-TB Measure Separately

	Reporting ordinance		Disinfection ordinance		Spitting ordinance	
Municipal anti-TB measure	−0.036 (0.035)	—	0.019 (0.028)	—	0.017 (0.027)	—
5 years prior	—	−0.012 (0.022)	—	0.033 (0.029)	—	0.041 (0.028)
4 years prior	—	−0.012 (0.022)	—	0.045 (0.039)	—	0.029 (0.032)
3 years prior	—	−0.002 (0.027)	—	0.027 (0.047)	—	0.025 (0.038)
2 years prior	—	−0.031 (0.029)	—	0.065 (0.050)	—	0.026 (0.038)
1 year prior	—	−0.050 (0.044)	—	0.048 (0.068)	—	0.046 (0.039)
Year 0	—	−0.086 (0.051)	—	0.051 (0.098)	—	0.030 (0.041)
1 year after	—	−0.070 (0.062)	—	0.083 (0.091)	—	0.057 (0.045)
2 years after	—	−0.078 (0.068)	—	0.105 (0.108)	—	0.087 (0.055)
3 years after	—	−0.095 (0.083)	—	0.093 (0.116)	—	0.055 (0.056)
4 years after	—	−0.107 (0.082)	—	0.117 (0.115)	—	0.065 (0.060)
5+ years after	—	−0.135 (0.087)	—	0.121 (0.136)	—	0.058 (0.062)
Mean	141.5	141.5	141.5	141.5	141.5	141.5
Number of municipalities	548	548	548	548	548	548
Observations	7,439	7,439	7,439	7,439	7,439	7,439
R^2	0.882	0.883	0.882	0.882	0.882	0.882

Notes: 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 demographic characteristics listed in Table 1, municipality fixed effects, year fixed effects, and municipality-specific linear trends. The omitted category in the event-study analyses is six or more years prior to implementation. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

TB mortality and the number of anti-TB measures in place. Likewise, regressing pulmonary TB mortality on an indicator for having implemented any municipal-level anti-TB measure, and regressing pulmonary TB mortality on a set of mutually exclusive indicators for the number of municipal anti-TB measures implemented as of year t produces little evidence that the TB movement was effective.[38]

[38] We also construct an index equal to the sum of the state anti-TB measures listed in Table 1 and an index equal to the total (i.e., municipal plus state) anti-TB measures listed in Table 1. Again, we find no evidence of a relationship between pulmonary TB mortality and these alternative indices. In online Appendix Table A8, we report the results of regressing pulmonary TB mortality on one- to five-year lags of the total number of municipal anti-TB measures implemented in year t. These results provide additional evidence that the TB movement had little to no effect on pulmonary TB mortality.

Table 3C—Pulmonary TB Mortality Regressed on Each Municipal Anti-TB Measure Separately

	Common cup ordinance		Municipal TB association		Dispensary	
Municipal anti-TB measure	0.008 (0.024)	—	0.007 (0.018)	—	0.022 (0.020)	—
5 years prior	—	0.016 (0.028)	—	−0.013 (0.015)	—	0.011 (0.012)
4 years prior	—	0.012 (0.033)	—	−0.019 (0.020)	—	0.012 (0.020)
3 years prior	—	0.024 (0.051)	—	0.003 (0.020)	—	−0.002 (0.030)
2 years prior	—	−0.002 (0.055)	—	−0.019 (0.029)	—	0.003 (0.033)
1 year prior	—	−0.010 (0.061)	—	−0.026 (0.032)	—	0.018 (0.037)
Year 0	—	−0.009 (0.073)	—	−0.018 (0.036)	—	0.009 (0.041)
1 year after	—	0.022 (0.091)	—	−0.011 (0.040)	—	0.028 (0.043)
2 years after	—	0.029 (0.096)	—	−0.007 (0.054)	—	0.075 (0.054)
3 years after	—	−0.008 (0.127)	—	−0.030 (0.048)	—	0.039 (0.055)
4 years after	—	−0.030 (0.143)	—	−0.024 (0.053)	—	0.041 (0.056)
5+ years after	—	−0.036 (0.137)	—	−0.019 (0.058)	—	0.03 (0.068)
Mean	141.5	141.5	141.5	141.5	141.5	141.5
Number of municipalities	548	548	548	548	548	548
Observations	7,439	7,439	7,439	7,439	7,439	7,439
R^2	0.882	0.882	0.882	0.882	0.882	0.883

Notes: 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 demographic characteristics listed in Table 1, municipality fixed effects, year fixed effects, and municipality-specific linear trends. The omitted category in the event-study analyses is six or more years prior to implementation. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

Finally, we evaluate the effectiveness of combinations (or bundles) of anti-TB measures. Sixty-one municipalities had both a TB association and dispensary in 1917, making this the most common bundle by the end of the period under study (online Appendix Table A5). Twelve municipalities had a TB association, dispensary, and sanatorium in 1917, making this the second-most common bundle. Twelve other municipalities had a TB association, dispensary, and spitting ordinance; nine had a TB association and sanatorium; and eight had a TB association, dispensary, spitting ordinance, and reporting ordinance.

To test the effectiveness of these various combinations of anti-TB measures, we define five mutually exclusive count variables: *Bundle* 1, *Bundle* 2, . . . , *Bundle* 5.

TABLE 4—USING ALTERNATIVE MEASURES OF ANTI-TB INTERVENTIONS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total Municipal Anti-TB Measures	0.003 (0.008)	—	—		—	—	—	—
Any Municipal Anti-TB Measure	—	−0.025 (0.020)	—		—	—	—	—
1 *Municipal Anti-TB Measure*	—	—	0.012 (0.024)	—	—	—	—	—
2 *Municipal Anti-TB Measures*	—	—	−0.034 (0.031)	—	—	—	—	—
3+ *Municipal Anti-TB Measures*	—	—	−0.007 (0.022)	—	—	—	—	—
Bundle 1	—	—	—	−0.004 (0.032)	−0.004 (0.032)	−0.004 (0.032)	—	—
Bundle 2	—	—	—	—	−0.069 (0.044)	−0.069 (0.044)	—	—
Bundle 3	—	—	—	—	0.007 (0.044)	0.007 (0.044)	—	—
Bundle 4	—	—	—	—	—	0.114 (0.087)	—	—
Bundle 5	—	—	—	—	—	−0.025 (0.021)	—	—
Reporting Ordinance × Sanatorium	—	—	—	—	—	—	−0.008 (0.035)	—
Reporting Ordinance × TB Hospital	—	—	—	—	—	—	—	−0.031 (0.031)
Mean	141.5	141.5	141.5	141.5	141.5	141.5	141.5	141.5
Number of municipalities	548	548	548	548	548	548	548	548
Observations	7,439	7,439	7,439	7,439	7,439	7,439	7,439	7,439
R^2	0.882	0.882	0.882	0.882	0.882	0.882	0.882	0.882

Notes: 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. In column 1, *Total Municipal Anti-TB Measures* is equal to the sum of the anti-TB measures implemented by municipality m as of year t. In column 2, *Any Municipal Anti-TB Measure* is equal to 1 if municipality m had implemented at least one anti-TB measure as of year t, and is equal to 0 otherwise. In column 3, each indicator is equal to 1 if municipality m had implemented the specified number of anti-TB measures as of year t, and is equal to 0 otherwise. See online Appendix Table A5 for a description of the variables *Bundle* 1–*Bundle* 5. In column 7, *Reporting Ordinance* × *Sanatorium* is equal to 1 if municipality m required that TB cases be reported to local health officials and had a sanatorium in year t, and is equal to 0 otherwise. In column 8, *Reporting Ordinance* × *TB Hospital* is equal to 1 if municipality m required that TB cases be reported to local health officials and had a TB hospital in year t, and is equal to 0 otherwise. All models control for the demographic characteristics listed in Table 1, the state anti-TB measures 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.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

For the 61 municipalities that had a dispensary and municipal TB association in 1917 (i.e., the most common combination), *Bundle* 1 is defined as follows:

$$Bundle\ 1 = \begin{cases} 0 & \text{if neither } \textit{Dispensary} \text{ nor } \textit{Municipal TB Association} \text{ in year } t \\ 1 & \text{if one of } \textit{Dispensary} \text{ or } \textit{Municipal TB Association} \text{ in year } t \\ 2 & \text{if both } \textit{Dispensary} \text{ and } \textit{Municipal TB Association} \text{ in year } t \end{cases}.^{39}$$

[39] See Table 1 for the definitions of the dichotomous variables *Dispensary* and *Municipal TB Association*.

If municipality *m* did not have a dispensary and municipal TB association in 1917, *Bundle* 1 is equal to 0 in every year. For the 12 municipalities that had a dispensary, TB association, and sanatorium in 1917 (i.e., the second-most common combination), *Bundle* 2 is defined as follows:

$$\textit{Bundle } 2 = \begin{cases} 0 & \text{if neither } \textit{Dispensary}, \textit{Municipal TB Association}, \text{ nor } \textit{Sanatorium} \text{ in year } t \\ 1 & \text{if one of } \textit{Dispensary}, \textit{Municipal TB Association}, \text{ or } \textit{Sanatorium} \text{ in year } t \\ 2 & \text{if two of } \textit{Dispensary}, \textit{Municipal TB Association}, \text{ or } \textit{Sanatorium} \text{ in year } t \\ 3 & \text{if } \textit{Dispensary}, \textit{Municipal TB Association}, \text{ and } \textit{Sanatorium} \text{ in year } t \end{cases}.^{40}$$

If municipality *m* did not have a dispensary, municipal TB association, and sanatorium in 1917, *Bundle* 2 is equal to 0 in every year. The three remaining bundle variables (*Bundle* 3, *Bundle* 4, and *Bundle* 5) are defined analogously.

The final columns of Table 4 show the estimated effects of these bundles. We also explore whether reporting requirements were more effective in municipalities that were served by a sanatorium or TB hospital. The estimated coefficient of *Bundle* 1, although negative, is small and statistically insignificant. Although there is some evidence that the second-most common combination of anti-TB measures reduced TB mortality (its estimated coefficient is −0.069), the overall impression is that these various combinations were not particularly effective. Including the count of municipal-level anti-TB measures belonging to the fourth- and fifth-most common bundles (*Bundle* 4 and *Bundle* 5) does not change this basic result, nor is there evidence that reporting requirements were more effective when coupled with sanatoriums or TB hospitals.

VI. Spillovers between Municipalities

In this section, we assess whether there were spillovers across neighboring municipalities. We hypothesize that such spillovers could have occurred in both directions. On one hand, an outbreak could have affected whether anti-TB measures were adopted by neighboring municipalities. Alternatively, patients might have moved in an effort to receive better treatment when a sanatorium or TB hospital opened nearby.

We begin by investigating whether pulmonary TB mortality rates in neighboring municipalities affected the probability that municipality *m* adopted an anti-TB measure by 1917. Specifically, we estimate the following equation:

$$(2) \qquad \textit{Any Anti-TB Measure}_m = \alpha_0 + \alpha_1 \textit{TB Mortality}(<25 \textit{ miles})_m + \mathbf{X}_m \boldsymbol{\beta} + v_s + \varepsilon_m,$$

[40] See Table 1 for the definitions of the dichotomous variables *Dispensary* and *Municipal TB Association*, and *Sanatorium*. If municipality *m* had not implemented the second-most common anti-TB bundle by 1917 (i.e., *Dispensary*, *Municipal TB Association*, and *Sanatorium*), *Bundle* 2 is equal to 0 in every year.

Table 5—Do TB Rates in Neighboring Municipalities Predict Anti-TB Measures in 1917?

	Any anti-TB measure (1)	Number of anti-TB measures (2)	Any anti-TB measure (3)	Number of anti-TB measures (4)	Any anti-TB measure (5)	Number of anti-TB measures (6)	Any anti-TB measure (7)	Number of anti-TB measures (8)
TB mortality in 1900 (<25 miles)	−0.001 (0.0004)	−0.003 (0.002)	…	…	…	…	…	…
TB mortality in 1900 (<50 miles)	…	…	−0.00003 (0.001)	−0.002 (0.003)	…	…	…	…
Δ TB mortality from 1900 to 1910 (<25 miles)	…	…	…	…	0.001 (0.001)	0.008 (0.005)	…	…
Δ TB mortality from 1900 to 1910 (<50 miles)	…	…	…	…	…	…	−0.001 (0.001)	−0.0003 (0.005)
Observations	279	279	289	289	271	271	281	281
R^2	0.335	0.393	0.309	0.406	0.264	0.378	0.246	0.388

Notes: Each column represents the results from a separate OLS regression. In odd-numbered columns, the dependent variable is equal to 1 if the municipality had adopted any anti-TB measure by 1917. In even-numbered columns, the dependent variable is equal to the number of anti-TB measures adopted by the municipality by 1917. Controls include the pulmonary TB mortality rate in 1900, municipal population in 1900, municipal demographic characteristics listed in Table 1 from 1900, and state fixed effects. Standard errors, corrected for clustering at the state level, are in parentheses.

where $Any\ Anti\text{-}TB\ Measure_m$ is equal to 1 if municipality m had adopted at least one anti-TB measure by 1917, and is equal to 0 otherwise. The variable $TB\ Mortality(<25\ miles)_m$ is equal to the pulmonary TB mortality rate in 1900 for municipalities within 25 miles of municipality m, and the vector of controls, $\mathbf{X}_m$, includes the pulmonary TB mortality rate in 1900, municipal population in 1900, and demographic characteristics from 1900. Lastly, v_s are state fixed effects.

Estimates of equation (2), which are reported in the first column of Table 5, provide no evidence that municipalities adopted anti-TB measures in response to outbreaks in neighboring municipalities. In fact, the estimate of α_1 is negative and significant at the 0.05 level. Likewise, the estimated effect of TB mortality among neighboring municipalities on the count of anti-TB measures is negative and significant.[41]

In Table 6, we investigate whether the opening of sanatoriums and TB hospitals in neighboring municipalities affected pulmonary TB mortality in municipality m. The empirical setup is similar to equation (1), but the vector $\mathbf{Z}_{mt}$ is now augmented with indicators for whether neighboring municipalities were served by a sanatorium and/or TB hospital in year t. The results provide little evidence to suggest that patients moved to neighboring municipalities in an effort to receive better treatment when a sanatorium or TB hospital opened nearby.

[41] In the remaining columns of Table 5, we experiment with expanding the definition of a "neighbor" to include municipalities within a 50-mile radius and replacing the neighboring pulmonary TB mortality rate in 1900 with the change in the rate from 1900 to 1910. With the exception of one positive and weakly significant estimate, there is little evidence of spillovers. Sample sizes in Table 5 differ slightly across specifications and are smaller than the $N = 306$ shown in Online Appendix Table A2 because not all neighboring cities have mortality data available starting in 1900.

Table 6—Are Neighboring Sanatoriums and TB Hospitals Related to the TB Mortality Rate?

	(1)	(2)	(3)	(4)
Sanatorium (<25 miles)	0.029 (0.017)	…	…	…
TB hospital (<25 miles)	0.028 (0.026)	…	…	…
Sanatorium (<50 miles)	…	−0.031 (0.020)	…	…
TB hospital (<50 miles)	…	0.023 (0.012)	…	…
Sanatorium or TB hospital (<25 miles)	…	…	0.035 (0.022)	…
Sanatorium or TB hospital (<50 miles)	…	…	…	0.002 (0.026)
Number of municipalities	548	548	548	548
Observations	7,439	7,439	7,439	7,439
R^2	0.883	0.883	0.883	0.883

Notes: 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 demographic characteristics listed in Table 1, the municipal and state anti-TB measures 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.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

VII. A Closer Look at Sanatoriums

The analysis thus far has attempted to capture the effect of sanatoriums using simple indicators for their presence in municipality m or in neighboring municipalities. 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.[42]

In the first column of Table 7, we replace the sanatorium indicator with the number of sanatoriums in municipality m and year t.[43] 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

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

[43] We have also experimented with using the number of sanatoriums per 100,000 population of municipality m in year t, but there is no evidence that this measure was related to the pulmonary TB mortality rate. Online Appendix Table A9 provides descriptive statistics for the alternative measures of sanatoriums considered in Table 7.

Table 7—A Closer Look at Sanatoriums

	(1)	(2)	(3)	(4)	(5)
Sanatorium	…	…	−0.018	−0.014	−0.019
			(0.024)	(0.023)	(0.023)
Number of sanatoriums in municipality	0.018	…	…	…	…
	(0.020)				
Number of sanatorium beds in municipality (100s of beds)	…	−0.002	…	…	…
		(0.003)			
Any sanatorium in state	…	…	0.002	…	…
			(0.015)		
Number of sanatoriums in state	…	…	…	−0.004	…
				(0.005)	
State-run sanatorium	…	…	…	…	−0.040
					(0.015)
Number of municipalities	548	548	548	548	548
Observations	7,439	7,439	7,439	7,439	7,439
R^2	0.883	0.883	0.883	0.883	0.883

Notes: 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 demographic characteristics listed in Table 1, the municipal and state anti-TB measures 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.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

at least two, and 6 had three or more.[44] The estimated coefficient of the continuous sanatorium variable is positive, but not significant at conventional levels.

In column 2, we replace the sanatorium indicator with the number of sanatorium beds in municipality m and year t.[45] In our sample, the average sanatorium had a capacity of nearly 100 beds. However, the number of beds varied widely, with some sanatoriums serving fewer than 10 patients and others accommodating over 1,000. While the estimated coefficient on our measure of sanatorium capacity is negative in sign, it is small in magnitude and statistically indistinguishable from zero.[46]

In columns 3 and 4, 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 3, we show the results of augmenting the baseline equation with an indicator for whether municipality m was located in a state with a sanatorium during year t, and in column 4, we include the total number of sanatoriums operating in a state during year t. The results suggest that the opening of sanatoriums at the state level did little to curb the spread of pulmonary TB.

[44] We have pulmonary TB mortality data before and after the opening of a sanatorium for 70 of these cities (see online Appendix Table A1).

[45] We also experimented with using the number of beds per 100,000 population, but there is no evidence of a negative relationship between this measure and the pulmonary TB mortality rate.

[46] It should be noted that our sanatorium-bed measure is, because of data limitations, somewhat crude. We only observe sanatorium capacity at the three points in time corresponding to the publications of the NASPT's *Tuberculosis Directory* (1916, 1919) and Jacobs (1911). For the intervening years, we assume that capacity remained constant.

Finally, in column 5 of Table 7, 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).[47] 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, 207–08).[48]

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 4 percent ($e^{-0.040} - 1 = -0.039$) reduction in the pulmonary TB mortality rate.[49] In online Appendix Table A10, the state-run sanatorium indicator is replaced by a series of its leads and lags. Consistent with the parallel trends assumption, there is little evidence that pulmonary TB mortality increased in the years leading up to the opening of the first state-run sanatorium. By contrast, we find that 3 or more years after the opening of a state-run sanatorium, pulmonary TB mortality fell by as much as 5 percent, although it should be noted that these estimates are not consistently statistically significant.

VIII. Was Mortality from Other Airborne Diseases Affected?

In Figure 3, 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 (e.g., from coughing or sneezing).[50] 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.

[47] According to Teller (1988, 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 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, 82). See online Appendix Table A3 for the year in which each state-run sanatorium opened. Online Appendix Figure A1 shows the state-run sanatoriums that contributed identifying variation to our analysis in 1905, 1910, and 1917. We observe mortality data for 277 municipalities before and after the opening of 25 state-run sanatoriums.

[48] 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, 342–43).

[49] Because municipal water filtration and chlorination projects could have been correlated with the construction of state-run sanatoriums, we experimented with including the typhoid mortality rate on the right-hand side of the estimation equation (Clay, Troesken, and Haines 2014). Controlling for the typhoid mortality rate as a proxy for water quality reduces the magnitude of the estimated relationship between state-run sanatoriums and pulmonary TB mortality, but only slightly.

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

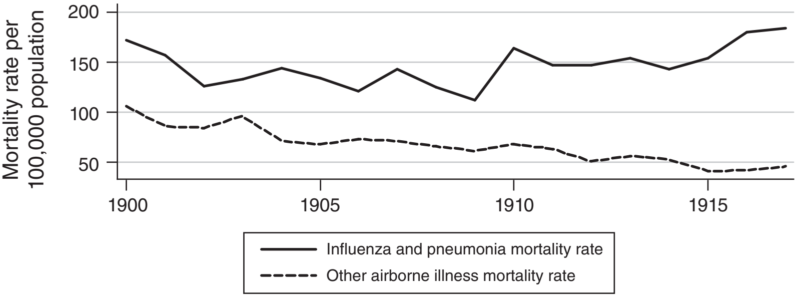

Figure 3. Influenza, Pneumonia, and Other Airborne Illnesses Mortality Rates, 1900–1917

Note: Other airborne illnesses include measles, scarlet fever, whooping cough, and diphtheria/croup.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

Did the measures championed by the 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 and Prevention 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, and Mahamulkar and Iyer 2015).

In the first column of Table 8, we report the results of regressing mortality due to influenza and pneumonia on the spitting ordinance, common cup, and TB association indicators. This exercise produces no support for the notion that these efforts to combat TB had an impact on influenza/pneumonia mortality. When controlled for the other anti-TB measures (e.g., the sanatorium and TB hospital indicators), the results are similar. However, we do find some evidence that municipal spitting laws may have led to small reductions in the influenza/pneumonia mortality rate.

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 estimates provide little evidence that the adoption of anti-TB measures contributed to the dramatic reduction in mortality due to these illnesses shown in Figure 3.[51]

[51] Because the influenza/pneumonia mortality rate and the mortality rate due to other airborne illnesses was equal to zero for 2 and 177 municipality-year combinations, respectively, we experimented with taking the quartic root of the dependent variable rather than the natural log. 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. These results were similar to those reported in Table 8. Because deaths from TB were, with some frequency, attributed to bronchitis, malaria, and/or pneumonia (Cabot 1900, 27; Cabot 1912), we also considered definitions of *Other Airborne Illnesses Mortality* that included these diseases. Again, the results were similar to those reported in Table 8.

Table 8—Did Anti-spitting Ordinances, Common Cup Bans, or TB Associations Have Spillover Effects on Other Airborne Illnesses?

	Flu and pneumonia mortality (1)	Flu and pneumonia mortality (2)	Other airborne illnesses mortality (3)	Other airborne illnesses mortality (4)
Spitting ordinance	−0.051	−0.055	−0.025	−0.021
	(0.033)	(0.028)	(0.061)	(0.064)
Common cup ordinance	0.017	0.042	−0.046	−0.013
	(0.106)	(0.074)	(0.043)	(0.043)
State common cup law	0.068	0.074	−0.048	−0.053
	(0.048)	(0.045)	(0.069)	(0.073)
Municipal TB association	−0.021	−0.029	0.018	0.029
	(0.027)	(0.030)	(0.033)	(0.035)
State TB association	0.002	0.010	0.077	0.063
	(0.044)	(0.041)	(0.037)	(0.040)
Mean of mortality rate	148.1	148.1	53.2	53.2
Number of municipalities	548	548	548	548
Observations	7,437	7,437	7,262	7,262
R^2	0.727	0.730	0.605	0.606
Other anti-TB measures?	No	Yes	No	Yes

Notes: Each column represents the results from a separate OLS regression. Columns 1–2: the dependent variable is equal to the natural log of the influenza and pneumonia mortality rate per 100,000 population in municipality m and year t. Columns 3–4: the dependent variable is equal to the natural log of the measles, scarlet fever, whooping cough, and diphtheria/croup mortality rate per 100,000 population in municipality m and year t. Controls include the demographic characteristics 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.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

IX. 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; the adoption of such an ordinance was associated with an approximately 6 percent decline in the pulmonary TB mortality rate (Table 2), although there is some evidence that the reduction in TB mortality preceded adoption (Table 3).

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 4 shows the predicted pulmonary TB rate for every year t (and its 90 percent confidence interval) under this scenario. Predicted pulmonary TB mortality rates are based on estimates from our preferred specification that controls for the demographic characteristics listed in Table 1, the municipal and state anti-TB measures listed in Table 1, municipality fixed effects, year fixed effects, and municipality-specific linear trends. The actual pulmonary TB mortality rate among the municipalities in our sample is shown for reference.

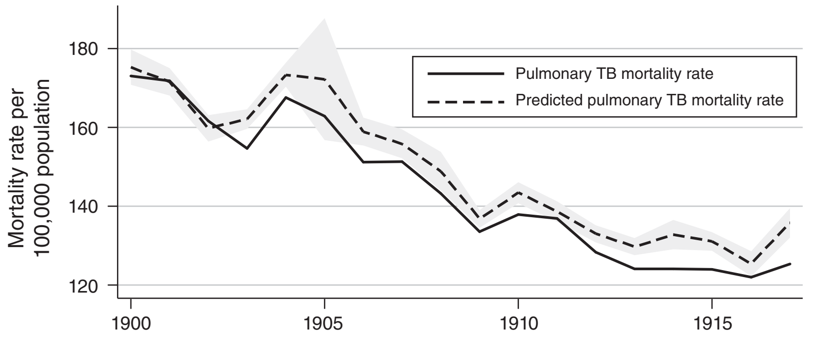

Figure 4. Actual versus Predicted Pulmonary Tuberculosis Mortality Rates: The Effect of City Reporting Ordinances

Notes: Predicted pulmonary TB mortality rates are calculated under the assumption that city reporting ordinances were not implemented. Shaded area represents 90 percent confidence region around predicted pulmonary TB mortality rates.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

The actual and predicted pulmonary TB mortality rates are not far apart throughout the period under study, suggesting that reporting 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 per 100,000 population. Had no municipality adopted a reporting ordinance, we predict that it would have been 136 per 100,000 population. Even using the upper bound of the 90 percent confidence interval, we predict the pulmonary TB mortality rate would have fallen from 173 to 140 per 100,000 population had no reporting ordinances been adopted.

Finally, we use a similar strategy to gauge the combined contribution of all the anti-TB measures adopted during the period under study (Figure 5). 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 130 per 100,000 population in 1917. Using the upper bound of the 90 percent confidence interval, we predict that the pulmonary TB mortality rate would have still fallen to 144 per 100,000 population had no anti-TB measures been implemented at either the municipal or state levels.

X. Conclusion

One out of every four 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 chemotherapy, but the WHO (2016, 38) estimates that 3.9 percent of new TB cases are multidrug-resistant. 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

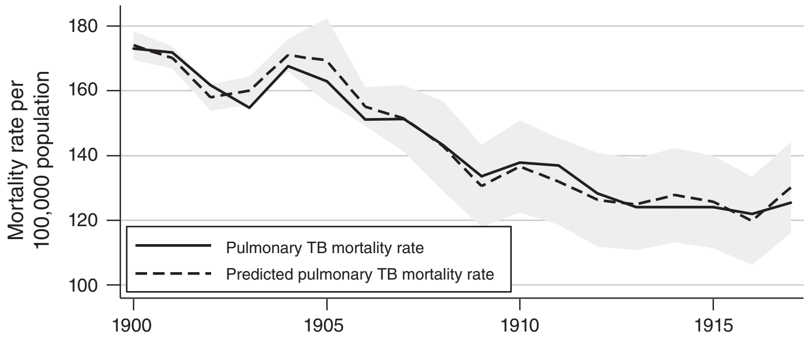

Figure 5. Predicted Pulmonary TB Mortality Rates Had Anti-TB Measures Not Been Implemented

Notes: 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 percent confidence region around predicted pulmonary TB mortality rates.

Source: Based on annual data from *Mortality Statistics* for the period 1900–1917, published by the US Census Bureau

the effectiveness of basic, "low-tech" public health measures, many of which were pioneered by the TB movement.

The US TB movement can be traced to the establishment of the Pennsylvania Society for the Prevention of Tuberculosis in 1892 (Shryock 1957, 52); it gained momentum with the founding of the National Association for the Study and Prevention 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 giving 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 public spitting bans and requirements that active TB cases be reported to health officials. Reporting requirements prevented physicians from concealing TB diagnoses and allowed public health officials to monitor TB patients (Teller 1988, 22).

Although previous studies have focused on specific anti-TB measures undertaken in the pre-chemotherapeutic era (Hollingsworth 2014; Hansen, Jensen, and Madsen 2017), the effect of the TB movement on TB mortality has not been studied in a systematic fashion. In fact, many historians believe that gauging the overall impact of the TB movement is impossible. For instance, Bates (1989, 349) writes 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, and Daniel 2006).

Using newly transcribed mortality data at the municipal-year level, we explore the effect of the TB movement on pulmonary TB mortality. We find evidence, albeit tentative, that requiring TB cases to be reported to local health officials led to a modest reduction in pulmonary TB mortality. 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 to be disinfected or the prohibition of common drinking cups) were effective.

Finally, 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 implemented. 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 still fallen by 25 percent, to 130 per 100,000 population in 1917. Based on these estimates, we conclude that the anti-TB measures introduced at the turn of the twentieth century did not contribute substantially to the marked decline in the TB mortality rate in the United States. Rather, other factors such as better living conditions and improved nutrition must have been responsible.

REFERENCES

Abel, Emily K. 2007. *Tuberculosis and the Politics of Exclusion: A History of Public Health and Migration to Los Angeles*. New Brunswick: Rutgers University Press.

Adda, Jérôme. 2016. "Economic Activity and the Spread of Viral Diseases: Evidence from High Frequency Data." *Quarterly Journal of Economics* 131 (2): 891–941.

Alsan, Marcella, and Claudia Goldin. 2015. "Watersheds in Child Mortality: The Role of Effective Water and Sewerage Infrastructure, 1880 to 1915." National Bureau of Economic Research (NBER) Working Paper 21263.

Ambler, C. P. 1903. "Should the Tuberculosis Patient Know the Truth Regarding His Condition?" *Journal of the American Medical Association* 41 (11): 656–57.

Anderson, D. Mark, Kerwin Kofi Charles, Claudio Las Heras Olivares, and Daniel I. Rees. 2019. "Was the First Public Health Campaign Successful?: Dataset." *American Economic Journal: Applied Economics*. https://doi.org/10.1257/app.20170411.

Armstrong, Gregory L., Laura A. Conn, and Robert W. Pinner. 1999. "Trends in Infectious Disease Mortality in the United States during the 20th Century." *Journal of the American Medical Association* 281 (1): 61–66.

Ashraf, Nava, Diego Aycinena, Claudia Martínez, and Dean Yang. 2015. "Savings in Transnational Households: A Field Experiment among Migrants from El Salvador." *Review of Economics and Statistics* 97 (2): 332–51.

Austin, Stefanie, Isaac Dialsingh, and Naomi Altman. 2014. "Multiple Hypothesis Testing: A Review." *Journal of the Indian Society of Agricultural Statistics* 68 (2): 303–14.

Bates, Barbara. 1989. "*The Tuberculosis Movement: A Public Health Campaign in the Progressive Era*. Michael E. Teller." *Isis* 80 (2): 349–50.

Bates, Barbara. 1992. *Bargaining for Life: A Social History of Tuberculosis, 1876–1938*. Philadelphia: University of Pennsylvania Press.

Beach, Brian, Joseph Ferrie, Martin Saavedra, and Werner Troesken. 2016. "Typhoid Fever, Water Quality, and Human Capital Formation." *Journal of Economic History* 76 (1): 41–75.

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. 2004. "How Much Should We Trust Differences-in-Differences Estimates?" *Quarterly Journal of Economics* 119 (1): 249–75.

Bignall, J. R. 1977. "Treating Tuberculosis in 1905: The First Patients at the Brompton Hospital Sanatorium." *Tubercle* 58 (1): 43–52.

Bloede, Victor G. 1908. "A Comprehensive Plan to the Treatment of the Tuberculosis Problem." *Bulletin of the Johns Hopkins Hospital* 19 (213): 349–52.

Blower, Sally M., Angela R. Mclean, Travis C. Porco, Peter M. Small, Philip C. Hopewell, Melissa A. Sanchez, and Andrew R. Moss. 1995. "The Intrinsic Transmission Dynamics of Tuberculosis Epidemics." *Nature Medicine* 1 (8): 815–21.

Bootsma, Martin C. J., and Neil M. Ferguson. 2007. "The Effect of Public Health Measures on the 1918 Influenza Pandemic in U.S. Cities." *Proceedings of the National Academy of Sciences of the United States of America* 104 (18): 7588–93.

Boudreau, Frank. 1920. "What the Teacher Can Do to Conserve Health and Prevent Disease in School Children." *Ohio Public Health Journal* 11 (9–10): 149–55.

Brown, Lawrason. 1909. *An Outline for a Coordinated Attack upon Tuberculosis*. New York: A. R. Elliot Publishing Company.

Bynum, Helen. 2012. *Spitting Blood: The History of Tuberculosis*. Oxford: Oxford University Press.

Cabot, Richard C. 1900. *Physical Diagnosis of Diseases of the Chest*. New York: William Wood and Co.

Cabot, Richard C. 1909. "Justifiable Lying." *American Primary Teacher* 32 (8): 286–87.

Cabot, Richard C. 1912. "Diagnostic Pitfalls Identified during a Study of Three Thousand Autopsies." *Journal of the American Medical Association* 59 (26): 2295–98.

Centers for Disease Control and Prevention. 2013. *Core Curriculum on Tuberculosis: What the Clinician Should Know.* 6th ed. Washington, DC: Centers for Disease Control and Prevention.

Cherry, James D. 2015. "The History of Pertussis (Whooping Cough): 1906–2015: Facts, Myths, and Misconceptions." *Current Epidemiology Reports* 2 (2): 120–30.

Clapp, Herbert C. 1906. "What Cases Are Suitable for Admission to a State Sanatorium for Tuberculosis, Especially in New England?" In *National Association for the Study and Prevention of Tuberculosis Transactions of the First Annual Meeting*, 339–48. Lancaster, PA: New Era Printing Company.

Clay, Karen, Werner Troesken, and Michael Haines. 2014. "Lead and Mortality." *Review of Economics and Statistics* 96 (3): 458–70.

Coker, R. J. 2003. "Public Health Impact of Detention of Individuals with Tuberculosis: Systematic Literature Review." *Public Health* 117 (4): 281–87.

Colorado (**state**)**.** 1914. "Tuberculosis. Notification of Cases and Control of (Chap. 125, Act Mar. 17, 1913)." *Public Health Reports* (*1896–1970*) 29 (10): 593–95.

Condran, Gretchen A., and Rose A. Cheney. 1982. "Mortality Trends in Philadelphia: Age- and Cause-Specific Death Rates 1870–1930." *Demography* 19 (1): 97–123.

Condran, Gretchen A., and Eileen Crimmins-Gardner. 1978. "Public Health Measures and Mortality in U.S. Cities in the Late Nineteenth Century." *Human Ecology* 6 (1): 27–54.

Cowling, Benjamin J., Dennis K. M. Ip, Vicky J. Fang, Piyarat Suntarattiwong, Sonja J. Olsen, Jens Levy, Timothy M. Uyeki, et al. 2013. "Aerosol Transmission Is an Important Mode of Influenza A Virus Spread." *Nature Communications* 4: Article 1935.

Cutler, David M., Angus Deaton, and Adriana Lleras-Muney. 2006. "The Determinants of Mortality." *Journal of Economic Perspectives* 20 (3): 97–120.

Cutler, David M., and Grant Miller. 2005. "The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States." *Demography* 42 (1): 1–22.

Daniel, Thomas M. 2000. *Pioneers in Medicine and Their Impact on Tuberculosis*. Rochester: University of Rochester Press.

Daniel, Thomas M. 2006. "The History of Tuberculosis." *Respiratory Medicine* 100 (11): 1862–70.

Dheda, Keertan, and Giovanni B. Migliori. 2012. "The Global Rise of Extensively Drug-Resistant Tuberculosis: Is the Time to Bring Back Sanatoria Now Overdue?" *Lancet* 379 (9817): 773–75.

Donald, Peter R. 2015. "A Brief History of Childhood Tuberculosis." In *Handbook of Child and Adolescent Tuberculosis*, edited by Jeffrey R. Starke and Peter R. Donald, 1–11. Oxford: Oxford University Press.

Dubos, René Jules, and Jean Dubos. 1952. *The White Plague: Tuberculosis, Man, and Society*. Boston: Little, Brown and Company.

Emerson, Haven. 1922. "The Causes of the Rapidly Increasing Fall of the Tuberculosis Death Rate in the Last Five Years." *Journal of Outdoor Life* 19 (8): 247–55.

Fairchild, Amy L., and Gerald M. Oppenheimer. 1998. "Public Health Nihilism versus Pragmatism: History, Politics, and the Control of Tuberculosis." *American Journal of Public Health* 88 (7): 1105–17.

Feldberg, Georgina D. 1995. *Disease and Class: Tuberculosis and the Shaping of Modern North American Society.* New Brunswick: Rutgers University Press.

Ferrie, Joseph, and Werner Troesken. 2008. "Water and Chicago's Mortality Transition, 1850–1925." *Explorations in Economic History* 45 (1): 1–16.

Flick, Lawrence F. 1913. "The Economical Administration of the Crusade against Tuberculosis." *Lippincott's Magazine* 91: 439–47.

Fox, Daniel M. 1975. "Social Policy and City Politics: Tuberculosis Reporting in New York, 1889–1900." *Bulletin: History of Medicine* 49 (2): 169–96.

Fraser, A. Mearns, and Hilda Clark. 1912. "A Municipal Dispensary and Tuberculin Treatment." *Lancet* 180 (4640): 289–93.

Frieden, Thomas. 2015. "Drug Resistant Tuberculosis: The Next Global Health Crisis?" *CDC Washington*, December 8. https://www.cdc.gov/washington/testimony/2015/t20151208.htm.

Garrett, Laurie. 1994. *The Coming Plague: Newly Emerging Diseases in a World Out of Balance.* New York: Penguin Group.

Girdwood, John. 1910. "A Doctor's Duty in Tuberculosis." *New York Medical Journal* 92 (15): 709–12.

Gladden, Fred. 1921. "The Principles of Health Control." *Educator-Journal* 21 (6): 344–46.

Grzybowski, Stefan, and Donald Enarson. 1978. "The Fate of Cases of Pulmonary Tuberculosis under Various Treatment Programmes." *Bulletin of the International Union against Tuberculosis and Lung Disease* 53 (2): 70–75.

Hansen, Casper Worm, Peter Sandholt Jensen, and Peter Egedesø Madsen. 2017. "Preventing the White Death: Tuberculosis Dispensaries." University of Copenhagen Department of Economics Discussion Paper 17–19.

Hollingsworth, Alex. 2014. "Controlling TB in a World without Antibiotics: Isolation and Education in North Carolina, 1932–1940." https://static1.squarespace.com/static/51706082e4b054b6c22c8173/t/53d7fe14e4b0ba978ec87eb4/1406664254075/Hollingsworth_2014_Controlling_TB.pdf.

Holm, Sture. 1979. "A Simple Sequentially Rejective Multiple Test Procedure." *Scandinavian Journal of Statistics* 6 (2): 65–70.

Houben, Rein M. G. J., and Peter J. Dodd. 2016. "The Global Burden of Latent Tuberculosis Infection: A Re-estimation Using Mathematical Modelling." *PLOS Medicine*: Article 1002152.

Hutchinson, Woods. 1911. "For the Extermination of Tuberculosis in New York City." *Survey* 26: 297–99.

Jacobs, Philip P. 1911. *A Tuberculosis Directory, Containing a List of Institutions, Associations and Other Agencies Dealing with Tuberculosis in the United States and Canada*. New York: National Association for the Study and Prevention of Tuberculosis.

Jacobs, Philip P. 1921. "Organization for the Prevention and Control of Tuberculosis in the United States." *Journal of Outdoor Life* 18 (1): 10–14.

Jones, David S., and Jeremy A. Greene. 2013. "The Decline and Rise of Coronary Heart Disease: Understanding Public Health Catastrophism." *American Journal of Public Health* 103 (7): 1207–18.

Jones, David S., Scott H. Podolsky, and Jeremy A. Greene. 2012. "The Burden of Disease and the Changing Task of Medicine." *New England Journal of Medicine* 366 (25): 2333–38.

Kermack, W.O., and A.G. McKendrick. 1927. "Contributions to the Mathematical Theory of Epidemics." *Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character* 115 (772): 700–721.

Kermack, W.O., and A.G. McKendrick. 1932. "Contributions to the Mathematical Theory of Epidemics. II. The Problem of Endemicity." *Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character* 138 (834): 55–83.

Kermack, W.O., and A.G. McKendrick. 1933. "Contributions to the Mathematical Theory of Epidemics. III. Further Studies of the Problem of Endemicity." *Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character* 141 (843): 94–122.

Klebs, Arnold. 1909. "Economic and Efficient Construction." In *Transactions of the Fifth Annual Meeting of the National Association for the Study and Prevention of Tuberculosis,* 126–41. Philadelphia, PA: William F. Fell Company.

Knopf, S. Adolphus. 1901. *Tuberculosis as a Disease of the Masses, and How to Combat It*. New York: M. Firestack.

Knopf, S. Adolphus. 1908. "The Popular Lecture in the Crusade against Tuberculosis." In *Transactions of the Sixth International Congress on Tuberculosis,* 663–73. Philadelphia, PA: William F. Fell Company.

Knopf, S. Adolphus. 1911. *Tuberculosis as a Disease of the Masses, and How to Combat It*. 7th ed. New York: The Survey.

Knopf, S. Adolphus. 1922. *A History of the National Tuberculosis Association: The Anti-Tuberculosis Movement in the United States*. New York: National Tuberculosis Association.

Kunitz, Stephen J. 2007. *The Health of Populations: General Theories and Particular Realities.* Oxford: Oxford University Press.

Lange, Christoph, Ibrahim Abubakar, Jan-Willem C. Alffenaar, Graham Bothamley, Jose A. Caminero, Anna Cristina C. Carvalho, Kwok-Chiu Chang, et al. 2014. "Management of Patients with Multidrug-Resistant/Extensively Drug-Resistant Tuberculosis in Europe: A TBNET Consensus Statement." *European Respiratory Journal* 44 (1): 23–63.

Lawn, Stephen D., and Alimuddin I. Zumla. 2011. "Tuberculosis." *Lancet* 378 (9785): 57–72.

Lee, R. Alton. 2007. *From Snake Oil to Medicine: Pioneering Public Health.* Westport, CT: Praeger.

Lönnroth, Knut, Ernesto Jaramillo, Brian G. Williams, Christopher Dye, and Mario Raviglione. 2009. "Drivers of Tuberculosis Epidemics: The Role of Risk Factors and Social Determinants." *Social Science and Medicine* 68 (12): 2240–46.

Mahamulkar, Sujit, and Malathy Iyer. 2015. "Caught Spitting? Do Social Work for a Day, Pay Rs 1,000." *Times of India*, June 16. https://timesofindia.indiatimes.com/city/mumbai/Caught-spitting-Do-social-work-for-a-day-pay-Rs-1000/articleshow/47696047.cms.

McClary, Andrew. 1980. "Germs Are Everywhere: The Germ Threat as Seen in Magazine Articles 1890–1920." *Journal of American Culture* 3 (1): 33–46.

McGuire, Michael J. 2012. "100 Years of Outlawing the Common Cup." *Safedrinkingwater.com*, October 29. https://safedrinkingwaterdotcom.wordpress.com/2012/10/29/100-years-of-outlawing-the-common-cup/.

McKeown, Thomas. 1976. *The Modern Rise of Population*. New York: Academic Press.

Mercer, Alexander. 2014. *Infections, Chronic Disease, and the Epidemiological Transition: A New Perspective*. Rochester: University of Rochester Press.

National Association for the Study and Prevention of Tuberculosis (NASPT). 1916. *A Tuberculosis Directory, Containing a List of Institutions, Associations and Other Agencies Dealing with Tuberculosis in the United States and Canada*. New York: National Association for the Study and Prevention of Tuberculosis.

National Association for the Study and Prevention of Tuberculosis (NASPT). 1919. *A Tuberculosis Directory, Containing a List of Institutions, Associations and Other Agencies Dealing with Tuberculosis in the United States and Canada*. New York: The National Association for the Study and Prevention of Tuberculosis.

National Center for Health Statistics. 2016. *Health, United States, 2015: With Special Feature of Racial and Ethnic Disparities.* US Department of Health and Human Services. Hyattsville, MD, May.

Newsholme, Arthur. 1908. "The Causes of the Past Decline in Tuberculosis and the Light Thrown by History on Preventive Measures for the Immediate Future." Lecture presented at the New National Museum, Washington, DC, September 29.

Newton, Robert J. 1910. "The Enforcement of Anti-spitting Laws." In *National Association for the Study and Prevention of Tuberculosis: Transactions of the Sixth Annual Meeting,* 109–21. Philadelphia: WM. F. Fell Company.

Nydegger, James A. 1919. "School Hygiene A National Problem." *American Journal of Public Health* 9 (6): 442–46.

O'Connor, Patrick J. 2015. "'Spitting Positively Forbidden': The Anti-spitting Campaign, 1896–1910." MA diss. University of Montana.

Pettitt, Josh. 2015. "Spitting Fines Raise £55,000: Hundreds Forced to Pay up over 'Deeply Unpleasant' Habit." *Evening Standard*, February 6. https://www.standard.co.uk/news/london/over-55000-raised-as-councils-begin-giving-fines-for-spitting-on-the-streets-of-london-10027699.html.

Porco, Travis C., and Sally M. Blower. 1998. "Quantifying the Intrinsic Transmission Dynamics of Tuberculosis." *Theoretical Population Biology* 54 (2): 117–32.

Quinn, Robert W. 1989. "Comprehensive Review of Morbidity and Mortality Trends for Rheumatic Fever, Streptococcal Disease, and Scarlet Fever: The Decline of Rheumatic Fever." *Reviews of Infectious Diseases* 11 (6): 928–53.

Rappold, Scott. 2007. "America's Greatest Sanitarium." *Colorado Springs Gazette*, June 17. https://gazette.com/news/america-s-greatest-sanitarium/article_d56f860e-a873-5351-a72c-2aebf45a4123.html.

Robbins, Susane F. 1906. "The Day Camp for Tuberculosis Patients." *American Journal of Nursing* 6 (9): 593–97.

Rosen, George. 2015. *A History of Public Health*. Baltimore: Johns Hopkins University Press.

Rothman, Sheila M. 1995. *Living in the Shadow of Death: Tuberculosis and the Social Experience of Illness in American History.* Baltimore: Johns Hopkins University Press.

Roush, Sandra W., Trudy V. Murphy, and the Vaccine-Preventable Disease Table Working Group. 2007. "Historical Comparisons of Morbidity and Mortality for Vaccine-Preventable Diseases in the United States." *Journal of the American Medical Association* 298 (18): 2155–63.

Sattar, Atia. 2016. "Germ Wars: Dirty Hands, Drinking Lips and Dixie Cups." In *Year's Work in the Oddball Archive*, edited by Jonathan Paul Eburne and Judith Ann Roof, 46–81. Bloomington: Indiana University Press.

Sedgwick, William T. 1902. *Principles of Sanitary Science and the Public Health: With Special References to the Causation and Prevention of Infectious Diseases.* New York: McMillan Company.

Shryock, Richard Harrison. 1957. *National Tuberculosis Association, 1904–1954. A Study of the Voluntary Health Movement in the United States*. New York: National Tuberculosis Association.

Sia, Irene G., and Mark L. Wieland. 2011. "Current Concepts in the Management of Tuberculosis." *Mayo Clinic Proceedings* 86 (4): 348–61.

Smith, Issar. 2003. "Mycobacterium Tuberculosis Pathogenesis and Molecular Determinants of Virulence." *Clinical Microbiology Reviews* 16 (3): 463–96.

Sterling, Christopher H., and John Michael Kittross. 2001. *Stay Tuned: A History of American Broadcasting.* Mahwah: Erlbaum Associates.

Stradling, David, and Peter Thorsheim. 1999. "The Smoke of Great Cities: British and American Efforts to Control Air Pollution, 1860–1914." *Environmental History* 4 (1): 6–31.

Styblo, Karel. 1985. "The Relationship between the Risk of Tuberculosis Infection and the Risk of Developing Infectious Tuberculosis." *Bulletin of the International Union against Tuberculosis and Lung Disease* 60 (3–4): 117–19.

Swedlund, Alan C., and Alison K. Donta. 2002. "Scarlet Fever Epidemics of the Nineteenth Century: A Case of Evolved Pathogenic Virulence?" In *Human Biologists in the Archives: Demography, Health, Nutrition, and Genetics in Historical Populations,* edited by D. Ann Herring and Alan C. Swedlund, 159–77. Cambridge, UK: Cambridge University Press.

Tarozzi, Alessandro, Aprajit Mahajan, Brian Blackburn, Dan Kopf, Lakshmi Krishnan, and Joanne Yoong. 2014. "Micro-loans, Insecticide-Treated Bednets, and Malaria: Evidence from a Randomized Controlled Trial in Orissa, India." *American Economic Review* 104 (7): 1909–41.

Teller, Michael E. 1988. *The Tuberculosis Movement: A Public Health Campaign in the Progressive Era*. New York: Greenwood Press.

Thomas, Duncan, Elizabeth Frankenberg, Jed Friedman, Jean-Pierre Habicht, Mohammed Hakimi, Nicholas Ingwersen, Jaswadi, et al. 2006. "Causal Effect of Health on Labor Market Outcomes: Experimental Evidence." California Center for Population Research Working Paper CCPR-070-06.

Thompson, Brian C. 1943. "Survival Rates in Pulmonary Tuberculosis." *British Medical Journal* 2 (4326): 721.

Tiemersma, Edine W., Marieke J. van der Werf, Martien Borgdorff, Brian G. Williams, and Nico J. D. Nagelkerke. 2011. "Natural History of Tuberculosis: Duration and Fatality of Untreated Pulmonary Tuberculosis in HIV Negative Patients: A Systematic Review." *PLoS ONE* 6 (4): e17601.

Tomes, Nancy J. 1989. "The White Plague Revisited." *Bulletin of the History of Medicine* 63 (3): 467–80.

Tomes, Nancy. 1999. *The Gospel of Germs: Men, Women, and the Microbe in American Life.* Cambridge, MA: Harvard University Press.

Tomes, Nancy. 2000. "The Making of a Germ Panic, Then and Now." *American Journal of Public Health* 90 (2): 191–98.

Tomes, Nancy. 2002. "Epidemic Entertainments: Disease and Popular Culture in Early-Twentieth-Century America." *American Literary History* 14 (4): 625–52.

Townsend, David. 1909. "Day Camp Treatment for Tuberculosis." *American Journal of Public Hygiene* 19 (4): 754–57.

Troesken, Werner. 2001. "Race, Disease and the Provision of Water in American Cities, 1889–1921." *Journal of Economic History* 61 (3): 750–76.

Uplekar, Mukund, Sachin Atre, William A. Wells, Diana Weil, Rafael Lopez, Giovanni Battista Migliori, and Mario Raviglione. 2016. "Mandatory Tuberculosis Case Notification in High Tuberculosis-Incidence Countries: Policy and Practice." *European Respiratory Journal* 48 (6): 1571–81.

U.S. Census Bureau. 1908. *Tuberculosis in the United States*. Washington, DC: Government Printing Office.

Vallejo, California (city). 2013. "Vallejo, Cal.: Tuberculosis. Reporting of Cases of. Precautions to Prevent Infection. (Ord. 101 N. S., Aug. 24, 1912)." *Public Health Reports (1896–1970)* 28 (52): 2879–82.

van Leth, Frank, Marieke van der Werf, and Martien Borgdorff. 2008. "Prevalence of Tuberculosis Infection and Incidence of Tuberculosis: A Re-assessment of the Styblo Rule." *Bulletin of the World Health Organization* 86 (1): 20–26.

Vynnycky, E., and P. E. Fine. 1999. "Interpreting the Decline in Tuberculosis: The Role of Secular Trends in Effective Contact." *International Journal of Epidemiology* 28 (2): 327–34.

Wagner, K.S., P. Stickings, J. M. White, S. Neal, N. S. Crowcroft, D. Sesardic, and A. Efstratiou. 2009. "A Review of the International Issues Surrounding the Availability and Demand for Diphtheria Antitoxin for Therapeutic Use." *Vaccine* 28 (1): 14–20.

Waters, Bertram, H. 1912. "Adequate Hospital Control." In *Transactions of the Eighth Annual Meeting of the National Association for the Study and Prevention of Tuberculosis,* 245–50. Philadelphia: WM. F. Fell Company.

Wethered, Frank J. 1906. "The Sanatorium Treatment of Pulmonary Tuberculosis." *Lancet* 167 (4297): 7–11.

Williams, Brandt. 2015. "Are Minneapolis Laws That Ban Spitting, 'Lurking' Racist?" *Minnesota Public Radio News*, April 3. https://www.mprnews.org/story/2015/04/03/spitting-laws.

Wilson, Leonard G. 1990. "The Historical Decline of Tuberculosis in Europe and America: Its Causes and Significance." *Journal of the Historical Medical Allied Science* 45 (3): 366–96.

Wilson, Leonard G. 2005. "Commentary: Medicine, Population, and Tuberculosis." *International Journal of Epidemiology* 34 (3): 521–24.

World Health Organization. 2015. *2015 Global Tuberculosis Report*. Geneva, Switzerland: WHO Press.

World Health Organization. 2016. *Global Tuberculosis Report 2016*. Geneva: WHO Press.

World Health Organization. 2017. "Tuberculosis." *World Health Organization Fact Sheets,* September 18. http://www.who.int/en/news-room/fact-sheets/detail/tuberculosis.

Yardley, Jim. 2007. "No Spitting on the Road to Olympic Glory, Beijing Says." *New York Times*, April 17. https://www.nytimes.com/2007/04/17/world/asia/17manners.html.

York, Michelle. 2003. "Palmyra Journal; Penalties for Spitting, and a Bit of Snickering." *New York Times*, July 13. https://www.nytimes.com/2003/07/13/nyregion/palmyra-journal-penalties-for-spitting-and-a-bit-of-snickering.html.

Zunz, Olivier. 2011. "Philanthropy by the Rest of Us." *New York Times*, December 22. https://www.nytimes.com/2011/12/23/opinion/christmas-seals-and-mass-philanthropy.html?mcubz=1.

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