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City Health Departments, Public Health Expenditures, and Urban Mortality over 1910-1940

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1 Introduction

In the late nineteenth and early twentieth century, the techniques and tactics of health provision were revolutionized as public health emerged as a distinct field of expertise. This newfound public health knowledge led to ambitious campaigns for sanitation, vaccination, public education, and public hospital construction. Along with implementing specific public health measures, major U.S. cities began to adopt public health departments to carry out these novel public health functions. These initial public health departments set the stage for the modern context of public health administration. Today in the United States, the same local health departments continue to function as a portion of the 2,800 local health departments operating throughout the country (Leep and Shah, 2012).

In this study, we consider the initial establishment of health administration in the form of city-level public health departments during the early twentieth century. Over 1916-1933, U.S. cities opened more than 400 full-time departments of health, and the initial health effects of these 400 administrative units are currently unexplored. We test whether adopting a full-time health department affected health conditions in urban areas using variation in when and where full-time health departments began operating throughout the United States. We combine the timing of each health department's arrival with city-level mortality data over the years 1910 to 1940. Our analysis focuses on several mortality measures, including overall mortality, infant mortality, infectious disease mortality, and cause-specific mortality.[1] Then, using an event-study design, we track changes in city-level mortality conditions following the initiation of a health department. Our main findings indicate that opening a full-time health department failed to noticeably impact city-level mortality conditions. We observe similar null results for part-time health departments, except a small reduction in typhoid mortality upon arrival.

Why did urban health departments appear to have so little effect? While some health department activities were likely important for mortality reductions—such as banning the sale of frozen sewage as household ice, as late as the turn of the twentieth-century (Leavitt, 1982, p. 61-63)—historical records suggest that others were more dubious in value. In some cases, these two types of activities (beneficial and unhelpful) were heavily intertwined. While it may have been useful to "stop the popular habits of giving coffee and beer to newborns to stop their cries" (Leavitt, 1982, p. 221), it was likely less salutary to blame immigrants and unmarried women for their lack of compliance with cultural norms (Stern, 2019). More generally, "the web of politics engulfed the office" of health commissioner (Leavitt, 1982, p. 53), leaving departments "bound by what the local politicians would accept." (Leavitt, 1982, p. 75) Even the best health departments were typically underfunded, understaffed, and forced to navigate complex political terrain (Leavitt, 1982, p. 56-57) (Hammonds, 1999, p. 175), resulting in ambitious initiatives that were essentially squandered.

Based on these anecdotal observations demonstrating the ineffectiveness of full-time health departments, three overarching alternative explanations stand out. One possibility is that health departments were simply ineffective due to such factors as inadequate capacity, political under-

[1] Our cause-specific measures include typhoid, tuberculosis, influenza, diphtheria, maternal deaths, and as a placebo test, suicide deaths.

mining, and limited public health knowledge. That hypothesis is broadly consistent with Anderson et al. (2019), which found that the first major public health campaigns against tuberculosis had limited (though discernible) effects. A second possibility is that health departments organized effective projects, but not more so than cities without full-time health departments. Non-adopting cities may have carried out similar public health endeavors through other public or private channels. A third possibility, intertwined with the second, is that departments were effective only when adequately funded, and the simple existence of a department was a poor proxy for its real capacity. If this third explanation is plausible, then health department capacity may be better measured by funding or staffing rather than binary adoption.

To supplement our main findings suggesting a lack of benefit from opening a health department, we test the validity of these hypothesized explanations with three alternative strategies. First, we show that cities without health departments could sufficiently mobilize vaccination campaigns following the diphtheria vaccine's availability. The evidence suggests that both cities with and without full-time health departments experienced similar declines in diphtheria mortality over the 1920s and 1930s. Based on the similar reductions in diphtheria mortality across early-adopters, late-adopters, and never-adopters, we infer that cities without health departments were able to organize at least some effective health services without reporting a full-time health department. Thus, having an administrative unit branded (and reported) as a health department was not the key factor in health improvements during this era. Instead, a full network of public and private health institutions may have been more important.

Second, we examine city-level budgets to see whether cities with health departments allocated their budget differently than cities without full-time health departments. We find that cities adopting a full-time health department between 1916 and 1933 spent a similar amount on sanitation and child health as never-adopters but spent slightly more on health department administration itself. However, when we formally control for city characteristics, we find that per capita spending on health fails to predict full-time health department status. The failure of per capita expenditure to predict health department status suggests that cities were spending similar amounts on health department administration regardless reporting of full time status (after controlling for observables). The similarity in spending between cities with a full-time or only part-time health departments suggests that our focus on full-time administration may overlook beneficial aspects of part-time public health endeavors or private health investment.

Finally, we directly test whether city-level per capita expenditures on a health department were independently beneficial for mortality improvements. Our analysis shows that infant mortality declined in cities that had higher per capita spending on a health department. These results again indicate that establishing a full-time department may not have been the key initiative in urban public health capacity. Instead, the true gains from the health department may have come from proper funding or management of the health department rather than the full-time activity of the health officer. Further, if health departments gradually organized over time, instead of a binary arrival, our primary methodology may overlook incremental health improvements.

Given the complex determinants of urban mortality across this period, identifying the effects of health departments poses several challenges. First, the category likely describes a very heterogeneous set of organizations. Departments engaged in many different kinds of activities, in different mixes and with differential competence, across place and time. The category of part-time departments, in particular, may be a mixture of established health departments performing many of the same activities as full-time departments and temporary or episodic structures with limited remit. Second, health departments opened and operated in the context of an extraordinary decline in mortality, the causes of which are still matters of deep debate. Our empirical strategy faces a general tension between adjusting for plausible sources of heterogeneity in urban mortality and leaving enough free variation to pick up effects. The latter consideration is of particular concern since we overwhelmingly find null effects. Finally, all of our results reflect a relatively small window of benefit–10 years–which will overlook emerging long-term benefits of the health department. We elaborate on the consequences of this limitation in Section 7.

Our findings add to the existing literature by showing that the organization of full-time public health departments is not nearly as beneficial as specific public health campaigns or infrastructure investments (Troesken, 1999, 2001; Haines, 2001; Cutler and Miller, 2005; Olmstead and Rhode, 2004; Bleakley, 2010; Moehling and Thomasson, 2014; Komisarow, 2017; Anderson et al., 2019; Alsan and Goldin, 2019). A portion of the previous work has linked urban infrastructure investments with declines in typhoid mortality and infant mortality (Troesken, 1999, 2001; Haines, 2001; Cutler and Miller, 2005; Beach et al., 2016; Alsan and Goldin, 2019).[2] Another portion demonstrates that health campaigns can be effective at improving mortality for specific causes of death and infant mortality (Olmstead and Rhode, 2004; Kitchens, 2013; Bleakley, 2010; Moehling and Thomasson, 2014; Komisarow, 2017; Hoehn-Velasco, 2018, 2021). City public health expenditure has also previously been linked to infant mortality declines in Costa and Kahn (2006).

This study also contributes to a body of work that has discovered less of a benefit to public health than might be expected (Anderson et al., Forthcomingb, 2019; Clay et al., 2018). Our present study adds to this literature by demonstrating that the arrival of full-time public health departments did not immediately reduce mortality. The findings from this study also generally align with Hoehn-Velasco (2018), where county-level health departments showed little benefits for overall rural mortality. However, rural infant mortality did decline following the health department's arrival in Hoehn-Velasco (2018). A potential explanation for the null effect observed in the present study is through the heterogeneity in the infant mortality decline discovered in Hoehn-Velasco (2018). Hoehn-Velasco (2018) shows that rural-only counties experienced the largest benefit from public health departments, with little impact on nearby city-level mortality. Put together, these findings suggest that the most significant benefit to public health departments may have occurred in areas with lower existing public health expenditures, limited access to physicians and, perhaps, to basic sanitation knowledge.

[2]Note that Anderson et al. (Forthcomingb) found an error in Cutler and Miller (2005), casting doubt on the magnitude of the effect in the original study. In a reply, Cutler and Miller state the magnitude of the effect on overall mortality is still 38% (Cutler and Miller, Forthcoming). However, Anderson et al. (Forthcominga) show that after correcting the dates, controlling for other interventions, and using the linearly interpolated population numbers, the effect is much smaller and insignificant.

2 Background

2.1 Overview

Boards of health were established in U.S. cities over the late 1700s and throughout the 1800s. Major U.S. cities were the first to set up health administration, and multiple cities claim to have been the very first U.S. city health department. A few of these cities include Baltimore in 1793 (Beilenson, 1993), Boston in 1799, (AJPH, 1940), and Philadelphia in 1794.[3] These initial boards were established to directly combat epidemics, such as yellow fever in Philadelphia, Baltimore, and New York City.[4] Over the 1800s, health departments gained traction in cities, and more part-time boards of health were established. While only five boards were set up between 1800 and 1830, as many as 32 boards were established between 1870 and 1873 (Ravenel, 1921). These city boards predated state and federal control of public health, acting as the primary initial public health system in the United States (Chapin, 1900, 1916).[5]

While cities were the first to adopt public health, initial health boards were still imperfect in their operations.[6] These boards were commonly composed of non-physician members, with only part-time physician consultations. Kramer (1942) notes that in the 1800s, city boards "were composed of the mayor and several aldermen, and only convened when an epidemic knocked at the gates of the city" (Kramer, 1942, p. 6). Further information on early health boards is available from the 1890 *Social Statistics of Cities* (Bureau, 1890). Table A.1 shows the 1890 average health board size, physician composition, and the total expenditure by the board. The median health board in 1890 had five members, one of whom was a physician. However, 28% of cities with health boards did not have a physician on their boards (77 out of 273 cities). 36% of all reporting cities did not have a board of health (123 out of 339). Of the 216 boards reporting any expenditure, the median board in 1890 spent a meager $1,200 ($30,000 in 2020 dollars). We also show the top spending health boards in 1890 in Table A.2. Of these top departments, three of the seven, Boston, Philadelphia, and Brooklyn, still had no physician on the 1890 health board. Over the transition to the early twentieth century, health departments were more consistently headed by a full-time physician and credentialed staff members rather than the laypersons of the 1800s (*City Health Officers: Directory of Those in Cities of 10,000 or More Population*, 1916-1933; Chapin, 1900, 1916; Kramer, 1942; Lancaster, 1937).

As these health departments began to gain traction, they were set up as separate units within the established local government structure.[7] The growing importance of the city health departments as an administrative unit is evident in cities' financial records. The Statistics of Cities (Bu-

[3]Stated history of the Philadelphia department of health `https://www.phila.gov/phils/Docs/Inventor/graphics/agencies/A080.htm` passed in City Act on April 22, 1794.

[4]Beilenson (1993); City of Philadelphia (n.d.) and New York in 1804 Rosen (1958) p. 234

[5]For example, Massachusetts was not organized until the late 1800s and was only predated by Louisiana in 1850 (Chapin, 1900). Chapin in 1916 notes, "In the United States, public health work began in the towns long before it was undertaken by the states. The usual reason for official sanitary activity was the presence of some serious epidemic. Under such conditions it was natural that a committee of prominent citizens should be appointed to take charge of affairs. Usually these committees would be discharged from their duties as soon as the emergency had passed." (Chapin, 1916).

[6]Throughout this article, we use term "health departments" for established health departments that tended to operate full-time and "health boards" for the initial part-time health boards that were set up during the 1800s.

[7]Chapin (1900, 1916); Schneider Jr (1916a); Association (1926); Armstrong et al. (1924)

reau, 1912-1931), as late as 1903, listed health and sanitation as a component of public safety, including police and fire. By 1905, the city financial records listed health and sanitation spending as a separate undertaking from public safety. By 1911, health conservation (including health department administration) was separated from sanitation activities, emphasizing preventive health effects and an expanded role for a local health department.

2.2 The organization of health departments in cities

Municipal health departments were organized first in the largest cities. This observation is reflected in a formal analysis of adoption in Appendix Section B as well as historical records from the early twentieth century. For instance, Chapin (1916) notes that "while the sanitation of our larger cities is far from perfect, it is far superior to what is found in the smaller municipalities where public health is usually sadly neglected" (Chapin, 1916, p. 80). Larger cities had the capacity to fund and operate a full-time health department, where smaller cities did not. In a formal survey of health departments activities from the 1920s, the authors note that majority of notable public health efforts occurred in urban areas with more than 100,000 inhabitants (Armstrong et al., 1924).[8]

After the health departments were initially set up, departments gradually adjusted their size and scope over time, including the organizational shift from part-time to full-time. This transition from part- to full-time involved hiring a full-time health officer to run the public health department. Public health reports define a full-time unit as headed by a dedicated health officer who "does not engage in the practice of medicine or in any other business, but devotes all his time to official business" (USPHS, 1917, p. 1222). In part-time health departments, officers frequently had duties outside of health department administration, such as running a private medical practice. Again, much of the city's ability (and need) to employ a full-time capacity arose from city size. Chapin (1916) reports that "Every city of 50,000 ought to have a full time health officer....Many cities much smaller are cared for efficiently, sometimes remarkably so, by part time men" (Chapin, 1916, p. 80). This historical observation indicates that full-time health departments were most important in the largest cities where they were adopted first.

Unfortunately, the slow growth of health departments over time limited their effectiveness (Chapin, 1917). The haphazard style of organizing health departments led to improper management of time and resources. This fact is highlighted in Chapin (1917), which points to the ad hoc organization of many health departments:

> *One function after another has been grafted on the original duty of nuisance abatement, but the growth has not been well balanced. Healthwork does not extend according to any well thought out plan, but one duty after another is added, now by this person and now by that. Sometimes the health department is expanded at the instance [sic] of a group of earnest reformers having much sympathy for human ills, but little versed in medical and sanitary science. Sometimes a city councilman, getting his knowledge from the syndicated science of his Sunday paper,*

[8]For instance, the surrounding documents note that the "committee at the very outset limited its inquiry to cities of 100,000 population or over, according to the 1920 census. A few cities close to the lower limit were included wherever the health activities appeared to be of sufficient interest to justify the inquiry" (Armstrong et al. (1924) p. 7).

assumes to tell how the health department should be run. Again, it may be the new health officer himself who, in order to justify the political over turn of his office, seeks to reorganize the health work of his city after a few hours' study of some passing book on "sanitation." Rare, indeed, is it that competent advisers are called in to plan a health department so as to utilize most effectively the best scientific knowledge of how to preserve the health of the city, and it is more rare still for the politician to permit such a plan to be put in practice. (Chapin, 1917, p. 204)

Other documents, such as the survey of health departments cited above, also note the limited standardization of health departments (Armstrong et al., 1924). Armstrong et al. (1924) describes, "It is generally known that a great variety of procedures are in effect; that the organization of the health departments differs in different communities; that the amounts spent per capita for any branch of health service vary considerably and that, in other respects, few standards are available to health officers who would pattern their departments after those which predominate in American practice or achieve most satisfactory results" (p. 7). Overall, it appears that city health departments organized gradually over time, adding different functions at different times without necessarily following clear guidelines or settled norms for public health practice. This gradual development of a health department, from initial inception as a part-time department, to an eventual debut in a full-time capacity, appears to have somewhat limited the efficacy of the many city health departments.

2.3 Activities

These newly codified local health departments endeavored to lower the communicable disease burden that permeated urban populations with persistent death and disability (Schneider Jr, 1916a). In 1916 a proponent of public health wrote, "1,400,000 persons die in the continental United States each year. Probably a fourth or a third of these die from preventable causes...[and]... two or three percent of our population are, at any one time, disabled through sickness" (Schneider Jr, 1916a, p. 1)). To control morbidity and mortality, local governments recognized a need to provide preventative efforts. Health departments' initial efforts centered on identifying illness, containing epidemics, preventing outbreaks through sanitation, and expanding health education. As time went on, administrative units took on broader preventative services such as community vaccination, home visits, well-baby clinics, and general clinics to provide medical care (especially for children) (Schneider Jr, 1916a; Ravenel, 1921).

Whereas part-time health boards of the past had focused on epidemic control, health departments of the twentieth century expanded into active prevention of illness. Ravenel (1921) highlights the activities of municipal health departments in 1875 and 1921 (shown above). The activities changed substantially over the 50-year gap in the recording of services.[9] Of the 16 items listed, the last ten activities of health departments had fully transformed. In 1921, health departments took on active prevention of illness, including reducing contagious disease, operating an active laboratory, providing vaccinations, overseeing food and milk hygiene, providing health services through nursing and health centers, actively preventing infant mortality, and distributing

[9] Table from page 139 of Ravenel (1921).

Health Department Activities, 1875 versus 1921

	Schedule of 1875	Schedule of 1921
1	Water Supply	Water Supply
2	Drainage and Sewage	Sewerage, Privies and Comfort Stations
3	Streets and Public Grounds	Street Cleaning
4	Habitation	Housing and Plumbing
5	Garbage	Garbage
6	Slaughter-houses, Manufactories and Trades	Nuisances
7	Public Health Laws	Organization Finances
8	Vital Statistics	Vital Statistics
9	Location, Population, Climate	Contagious Diseases
10	Topography and Geology	Laboratory, Vaccination
11	Gas and Lighting	Infant Hygiene
12	Hospital and Public Charities	Health Centers
13	Police and Prisons	Public Health Nursing
14	Fire Establishments	Food and Drugs
15	Cemeteries and Burial	Milk
16	Quarantine	Education, Publicity

Source: Ravenel (1921).

health education materials (Ravenel, 1921).

For contagious disease control, Chapin, in Ravenel (1921), notes that in the last quarter of the 1800s, contagious disease control became the foremost duty of the health officer. Along similar lines, detecting disease became another essential function of health departments. Public health diagnostic laboratories were set up to identify infectious diseases such as diphtheria. Most major cities had laboratories by 1900, with only eight of the largest cities lacking public health laboratories (Ravenel, 1921). Providing immunization was another essential preventative activity for health departments. Local health authorities were frequently in charge of vaccination for smallpox, diphtheria, and typhoid (Ravenel, 1921).[10]

Health department activities also specifically targeted infant health through milk regulations and providing basic infant health services. Ravenel (1921) notes that the improved handling of milk and the decline in infant mortality were inextricably linked. The handling of milk went further than just local milk regulation and extended into public health education of mothers, with information on the proper storage and heating of milk for infants. Cities targeted infant health directly by providing public health nurses, with many cities setting up home visits for infants, providing prenatal care, and organizing infant welfare stations (Ravenel, 1921; Armstrong et al., 1924).

Schneider Jr (1916b), in a survey of cities on their health department, highlights the essential services performed by health departments in 1916 (the beginning of our study). In this survey, cities were asked whether their programs were in place for various health activities. Table 1 shows the number and percentage of survey cities undertaking the primary activities of a health depart-

[10]Diphtheria vaccination was not introduced until the 1920s, and before that was only a serum antitoxin. Chapin notes that state health boards actively intervened in providing antitoxin because cities failed to provide the serum freely (Ravenel, 1921). However, in some cities, such as New York, serum distribution was one of the board's major activities.(Hammonds, 1999)

Table 1: Health Department Activities, 1916

Activity	**Complete Program (#)**	**Complete Program (%)**
Infant Hygiene Work	89	44
Inspection of School Children	167	79
Health Education Bulletins	53	25
Dispensary Services for Venereal Disease	66	31
Tuberculosis Control Program	50	24
Diagnostic Laboratory	136	62
Bacteriological Service	155	71

Source: Schneider Jr (1916b)

ment in 1916. The survey results suggest that less than half of the cities had ongoing infant health programs in 1916. Moreover, only one-quarter of cities had educational programs and tuberculosis control programs in place as of 1916. Dispensary activities to prevent and treat venereal disease occurred in one-third of cities.[11] Despite these more limited undertakings, most cities had public health laboratories and inspection of school children in place as of 1916. The information partially aligns with *City Health Officers: Directory of Those in Cities of 10,000 or More Population* (1916-1933), which suggests that 70 cities had full-time health departments as of 1916 and more than 200 cities had part-time health departments. The information from Schneider Jr (1916b) suggests that several part-time health departments may have had relatively robust services as of 1916, including laboratories and child health services.

One activity that the majority of municipal health departments did not engage in is water purification. While the largest cities did undertake this task, "it is more properly a function of the state department of health to guard water supplies, though some of the larger cities have resources sufficient for independent action. It is rare that a local health officer has any management in waterworks" (Chapin (1917), p. 204)

2.4 Spending, employment, and salaries

The health officers in charge of running municipal health departments were paid a relatively modest salary that ranged between $1,300 and $10,000 (Association, 1926) with an average salary of $5,000.[12] Health officers were supported by a board of health and other full-time staff members. In a 1923 survey of health departments in the United States, the typical employment was 27 health department employees per 100,000 persons, with 21 of the 27 being full-time. The survey noted that, "The number of employees per 100,000 was remarkably constant in cities of different size... per 100,000 population, 5.3 physicians, 7.3 nurses, 6.7 inspectors, 3.1 clerks, 1.8 laboratory workers, 0.6 dentists, and 2.2 social workers" (Association (1926) pg. 21). While these aggregate numbers of staff illustrated the targets of health departments, these staffing numbers are not

[11] Many of the activities designed or justified to prevent and treat venereal disease may have been unlikely to improve population health, as suggested by the account from Stern (2019).

[12] $5,000 is $76,000 in 2019. The upper bound of $10,000 is $152,000.

broken down by city.[13]

Table 2 shows per capita spending on the primary health initiatives of the health department. The per capita spending on municipal health illustrates the relative weight placed on different types of health work. Based on Schneider Jr (1916a) and Armstrong et al. (1924), the annual spending priorities for the health department were relatively fixed. Table 2 shows that the largest spending item was the health of school children. The primary focus on children is then followed by relatively equal weights on disease control, tuberculosis control, sanitary inspection, and maternal-child health. The higher relative spending on child health suggests a focus of public health towards children, where there was likely a greater benefit to preventative efforts.[14]

Table 2: Health Department Spending Per Capita (in cents)

Service	P.C. Spending
Administration	6.0
Vital statistics	1.8
Disease control	7.4
Tuberculosis	7.3
Venereal disease	2.6
Maternal and child hygiene	5.7
School health service	13.0
Laboratory	4.1
Milk inspection	3.6
Sanitary Inspection	5.7

Source: Association (1926) pg. 39

2.5 Interaction with State Health Departments

At the turn of the twentieth century, health administration was focused at the local level, with states serving in an advisory capacity.[15] While the majority of states had established boards of health before 1900 (see Figure A.1), the influence of state health boards grew over the early twentieth century (Chapin, 1916; Ferrell et al., 1929). By 1916, public health opinion emphasized the importance of state boards in local health affairs. Chapin's 1916 report on state health departments highlights that for local health administration to be successful, "it is now the general and well-founded belief that the sanitary progress of these communities must be stimulated, directed and perhaps controlled by the state" (Chapin (1916) p. 80).

However, merely having a state health department did not necessarily mean that public health systems flourished. State health department quality and spending varied throughout the United States. To emphasis this point, we show Chapin (1916)'s rating of state quality, per capita

[13] The survey used above does have a limitation – it comes from a survey of health departments in urban centers with more than 100,000 persons. The data source that we are using for the majority of the analysis is health services in municipalities with more than 10,000 persons. Thus there may be significant gaps in provision between those population sizes.

[14] In 1913, a report estimated that preventative deaths were broken into "tuberculosis, 25 per cent.; infants' diseases, 25 per cent.; venereal diseases, 20 per cent.; the four common contagious diseases of children, 15 per cent.; typhoid fever, 5 per cent.; other infectious diseases, 8 per cent.; nutritional diseases, 1 per cent.; and poisoning by food, 1 per cent" (Schneider Jr (1916a), pg. 6).

[15] Chapin (1900) p. 3 and Duffy (1992).

spending, and the number of part-time and full-time health departments in each state in Appendix Table A.3. A few observations are notable. First, states with the lowest rating (at the bottom of the table) appear to be the latest adopters of full-time local health departments. Second, per capita spending and quality do not appear to be strongly correlated. Third, the highest quality state health departments generally had the largest number of local health departments. Pennsylvania has 92 health departments (with 80 full time), Massachusetts has 73 (with 60 full time), and New York has 69 (with only 20 full time), while all other states had fewer than 60.[16]

As this table indicates, we expect state health departments to interact with local health departments through larger networks of public health capacity. If higher-quality state health departments provided oversight or funding to local health departments, state systems may have had improved the efficacy of local public health. Especially if high-quality state health departments increased public trust in—and compliance with—public health directives (Burg, 2000). States also had specific ways of intervening in local affairs, including statutes that placed state health departments directly over local health departments (in certain states) (Chapin, 1916). Even in cases where states were not in direct control of local health departments, many states possessed laws for temporary control in cases of improper management (Chapin, 1916). In other cases, states regulated the qualifications for health department office and influenced the appointment (and potential removal) of local health officers (Chapin, 1916). Put together, these factors indicate that the local health department's success may have depended on both state and local affairs.

3 Data

3.1 Municipal health department data

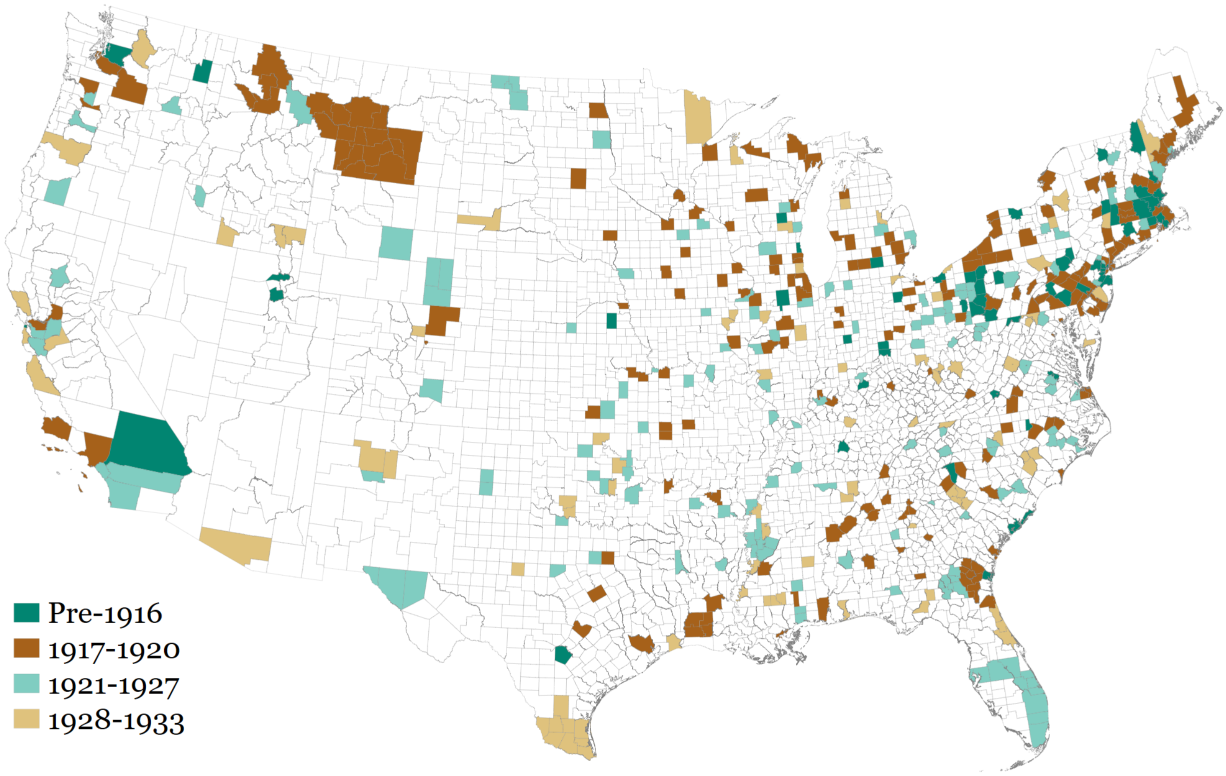
Municipal health departments operated in towns and cities with more than 10,000 persons. To track the spread of these health departments, we use data from *City Health Officers: Directory of Those in Cities of 10,000 or More Population* (1916-1933). This data includes a directory of the city health departments from 1916 to 1933. The source document reports the health officer's name and whether the health department operated full time (beginning in 1917). Appendix Figures A.2 and A.3 show examples of the original directory record.

For the analysis, we measure the binary adoption of a municipal health department. In the main results, we focus on the full-time provision of a health department based on the definition in *City Health Officers: Directory of Those in Cities of 10,000 or More Population* (1916-1933). We take the first instance a health department replied to the survey as full-time for the initial year of operation.

Similarly, this data source also reports municipalities with part-time boards. In the primary analysis, we focus on the full-time health departments due to our focus on preventative public health efforts. Part-time boards offered more limited services were more responsive to negative health shocks such as epidemics (Kramer, 1942). We also suspect that part-time boards were

[16]The correlation coefficient between spending and rating is 0.37. The correlation coefficient between rating and number of full-time health departments is 0.61. Thus, state health department quality is more closely related to the number of cities with a health department rather than the per capita spending.

Figure I: Timing of Full-time Health Departments



SOURCE: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933.

under-reported based on the 1890 survey of health boards described in the Background Section. However, we test the effect of opening a part-time board along with full-time health departments in the main findings.

To illustrate the location of municipal health departments throughout the United States, Figure I maps the timing of full-time health departments. Dark green shows the early adopters of full-time health departments, occurring before 1916. Later adopters, the primary group considered in this study, are shown in dark brown, light green, and light brown. The map suggests little apparent regional clustering of health departments; they appear throughout the United States. We also show the county-level placement of full-time versus part-time health departments in Appendix Figure A.4.

The timing of the health departments, shown in Figure A.5, is key to our empirical strategy. The majority of full-time health departments opened over the 1910s and early 1920s. As a control group, we include the cities that never adopted a full-time health department; however, the vast majority of cities had adopted at least a part-time health department by 1933. Thus, the counter-factual to opening a health department, in our preferred specification, is against cities that (i) already had a health department in 1916 and (ii) cities that operated a part-time health department.

There are several limitations to the municipal health department data that are worth noting. First, the data begin in 1916, with two gap years in the data. Therefore, we are unable to track the full rollout of city health departments in the United States. The scope of this study is limited to health departments that arrived between 1916 and 1933. Along similar lines, the full-time data is only available beginning in 1917 and is not reported in 1918 and 1916.[17] We fill in the missing full-time information based on 1917. We take the earliest year the health department arrived as the base year. For 1916, if a health department was full-time in 1917 and the city appeared in the 1916 survey, then we assume it was full-time in 1916. For 1918, if the health officer had the same name in 1919, we assume the health department arrived in 1918.

Second, as mentioned above, the data are based on a survey of health departments. The survey format requires health departments to report their operation to the USPHS. This self-reporting has the potential to bias the findings towards the health departments with the best administrative capabilities. While there may be concern about part-time health departments underreporting their presence, well-functioning health boards should properly self-report. Thus, we assume, if anything, the survey response will overestimate the effectiveness of public health measures. However, we explore survey misreporting more systematically in Section 6.3.

Table 3: Summary Statistics–Mortality and City Composition by Health Department Entry Year

	Pre-1917	1917-1920	1921-1924	1925-1933	Never
	1916 Mean	1916 Mean	1916 Mean	1916 Mean	1916 Mean
Composition					
Populations (1,000)	171.826	81.969	35.583	41.465	25.084
Share Under 5	0.101	0.099	0.098	0.096	0.099
Share Over 65	0.038	0.041	0.042	0.044	0.045
Physicians per 10,000	14.621	14.240	15.472	15.093	12.943
Share White	0.940	0.933	0.936	0.918	0.972
Mortality					
Overall Mortality Rate	154.506	159.036	162.983	162.025	158.493
Age-Adjusted Mortality Rate	1.672	1.673	1.780	1.652	1.631
Infectious Mortality Rate	52.851	52.309	55.955	51.851	51.778
Non-Infectious Mortality Rate	101.656	106.727	107.029	110.174	106.715
Infant Mortality Rate	110.392	101.585	110.827	106.464	105.521
Birth Rate	14.039	15.404	9.660	10.926	12.822
By-Cause					
Tuberculosis Mortality Rate	13.682	14.201	15.294	15.912	14.731
Influenza/Pneumonia Mortality Rate	18.928	18.023	18.808	17.176	17.891
Typhoid Mortality Rate	1.404	1.807	1.996	1.700	1.678
Diphtheria Mortality Rate	1.531	1.460	1.064	1.371	1.210
Whooping Cough Mortality Rate	1.351	1.124	1.348	0.830	1.107
Maternal Deaths Per 1,000 Births	7.453	6.853	7.744	5.855	6.413
Suicide Mortality Rate	1.524	1.692	1.522	1.652	1.727
Observations	90	160	48	47	147

NOTES: Table shows the summary statistics across cities in 1916. Alternative version with 1936 is shown in Appendix Table A.5.
SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

[17] Another gap year appeared in 1932, which we fill in with 1931 and 1933, but this gap is less critical than the earlier gap.

3.2 Mortality data

To measure the health effects of health departments, we construct an unbalanced panel of city-level mortality data from the *US Vital Statistics (1890-1938)*. These data were used in previous work (Hoehn-Velasco, 2018; Feigenbaum et al., 2019) and discussed in detail in these studies. The data include cause-specific mortality, overall mortality, and infant mortality. At the outset, we are most interested in infant mortality, due to the findings in Hoehn-Velasco (2018), the fact that one-third of preventable deaths occurred among infants (Schneider Jr, 1916a), and the investment of cities towards infant health services and milk regulations (Ravenel, 1921; Armstrong et al., 1924). However, we also explore other measures of cause-specific mortality, as cities spent significant amounts towards child mortality (diphtheria), tuberculosis prevention, sanitation (typhoid), as well as public health nursing, which may have impacted both infant health and maternal mortality through proper prenatal care (Bureau, 1912-1931; Ravenel, 1921; Armstrong et al., 1924; Albanesi and Olivetti, 2014). We further aggregate these by-cause mortality measures as "infectious" disease mortality (reflecting 19 causes, described in Feigenbaum et al. (2019)) and non-infectious mortality.

We show several versions of the summary statistics for our main measures of mortality in Table 3, Table A.4, and Table A.5. Each of these tables captures different aspects of the data nuances and limitations. In Table 3, we show the demographic composition and mortality measures of cities with a health department by the health department adoption year. Table 3 illustrates that the earliest health departments appeared in the largest cities. The later-arriving health departments have populations that are a fraction of the earlier health department cities.

Next, Table A.4 shows the differences across cities that had full-time versus part-time health departments in Panel A and the early versus later-treated in Panel B. Cities with full-time health departments are much larger, have a higher non-white population, more physicians, and have higher mortality rates. Early- versus later-adopting cities are more comparable across characteristics than part- versus full-time cities, but early-adopting cities are still larger. Based on the summary statistics, the largest cities appear to have received health departments first, with smaller cities then opening health departments next, and small towns and cities only operating part-time health departments.

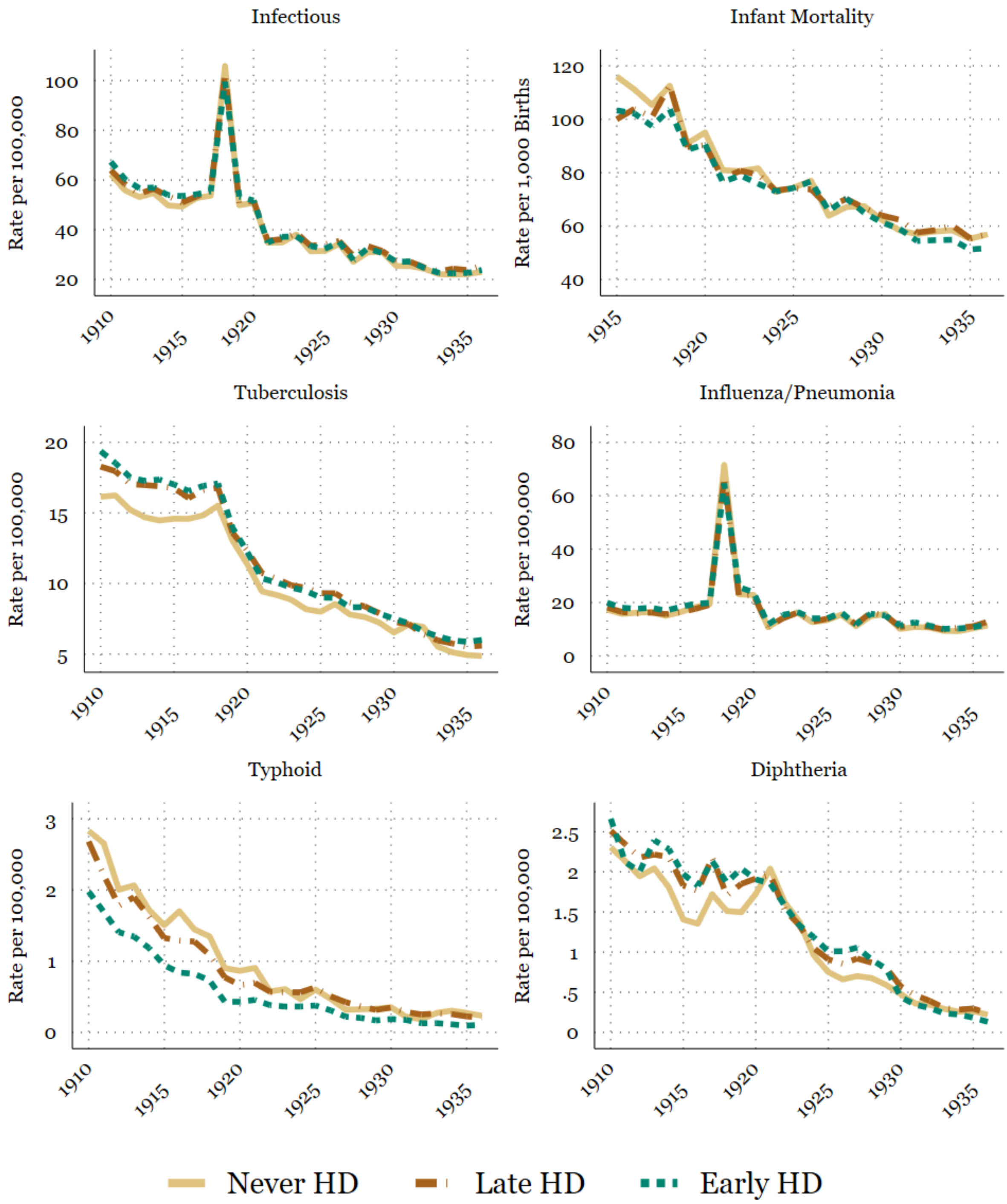
In Figure II we consider the trends in mortality by health department status: early full-time health departments (before-1916, green short dashed lines), late full-time health departments (1917-1933, brown dashed lines), and cities that never adopted full-time health departments (light solid brown lines). Only typhoid mortality appears different across city types.[18]

3.3 Census controls and per capita expenditures

Controls for city characteristics are added from census microdata over 1910-1940 from the IPUMS Restricted Complete-Count Census Data (Minnesota Population Center and Ancestry.com (2013); Ruggles et al. (2020)). An issue worth noting in this data is that the "stdcity" variable does not perfectly align with the population numbers provided in the mortality data or census

[18] Figure A.6 shows influenza and pneumonia mortality without 1918.

Figure II: Mortality by City Health Department Status, 1910-1936



NOTES: Never having a health department refers to no adoption by 1933, and includes part-time boards. Late adoption is defined as adoption between 1917 and 1933. Early adoption is defined as having a health department before 1917.
SOURCE: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data.

publications.[19] We use both the minor civil divisions (mcd) and the city variable in the full count

[19]For instance, for Greenwich, CT, in 1910, if we use the IPUMs city, we would obtain a population count of 3,886. Yet, the correct census population is 16,463. Using the combined minor civil division and stdcity we get a population of

census to construct city controls. However, even when using these two variables, there are cases where the population numbers differ from the published population counts. When we compute mortality rates, we use the population counts published as Census population totals for the cities. We fill in years between census years with linearly interpolated population counts, following (Feigenbaum et al., 2019).

For the controls, we use city characteristics from the earliest census year in our data (1910) interacted with year indicators. Using the 1910 covariates provides pre-treatment controls, ensuring that the control variables are not affected by treatment. Still, the results are robust to alternative inclusion of covariates, including the linearly interpolated controls over 1910-1940 census years (Figures C.7 and C.8).

For Section 7, we also explore the city-level budget of health departments, which we collected from the Financial Statistics of Cities (Bureau, 1912-1931). These financial details are available over select years from 1912 to 1931. These records report the total budget and the health and spending budget of cities with over 30,000 persons. We summarize the budget data in Section 7. An important caveat for this data is the limitation to cities of 30,000 or more and therefore does not reflect the full sample from the primary analysis. A second caveat is the data are missing for 1913-1914 and 1920-1922.

4 Event-Study Specification

Our primary empirical strategy exploits variation in health department timing and health department location. We test the validity of using the year of establishment as an exogenous source of variation in Section B. We are especially concerned about factors that predict the timing of establishment and less so about time-invariant characteristics that influence city-level adoption as we include city-level fixed effects n the analysis. In Table B.1, population size is the main significant predictor of adoption. Pre-existing infectious mortality conditions and other observable demographic characteristics fail to predict adoption timing. We address the predictive population size similar to Bailey and Goodman-Bacon (2015), by including population-group-by-year fixed effects (described below).

To measure whether urban health departments improved population health, we take the first year that each city reported operating a full-time health department. We track the mortality changes following the arrival of the municipal health department using a flexible event-study design. The event-study approach helps account for changes in mortality before and after establishing a health department, which would not be observable in the difference-in-differences approach (see Table A.6). Particularly concerning, in this case, is whether pre-treatment epidemic conditions pushed administrators to set up health departments, which would tend to produce a spurious decline in mortality (as the epidemic ran its course) coincident with the health department's founding.

More formally, we test the following specification:

16,464.

$$M_{jst} = a_j + \eta_{st} + \pi_{hjt} + \sum_{m=-23}^{23} \beta_m HD_{jm} + \mathbf{X}'_{jt}\gamma + \epsilon_{jst} \tag{1}$$

where M_{jst} is the mortality rate in city j, state s, and year t.[20] We consider separate results for M_{jst} that cover overall, infant, and by-cause mortality. a_j captures the city fixed effects, which account for time-invariant city-level characteristics. η_{st} accounts for state-by-year fixed effects, which address annual state-level changes in mortality that may be correlated with the operation of a city health department but are, in fact, administered at the state level. These state-by-year fixed effects should address confounding programs run by the state boards of health. π_{hjt} are the population-group-by-year fixed effects, which control for the relative size of the city.[21] We control for the city size as it is the main factor predicting the timing of the health department (see Section B). $\mathbf{X}_{jt}$ are city-level controls. ϵ_{jst} is the regression error, which we cluster at the city level.

Health department operation is captured by the event-study indicator variable, HD_{jm}. HD_{jm} represents the entry of an urban health department into city j at period $m = 0$. Period m represents the year of operation relative to the entry period. In our case, m ranges from 23 years prior and 23 years after a health department arrives, a fully saturated model that avoids binning the endpoints (Borusyak and Jaravel, 2018; Schmidheiny and Siegloch, 2019).[22] The treatment effect of the health departments is captured by the dummy variables, $m = 0, 1, 2, ..., 23$, and this treatment effect is relative to the year before the health department opened, $m = -1$, the omitted period.

One notable issue with the event-study specification above is our reliance on staggered treatment timing in a two-way fixed effects estimator. To deal with issues related to the two-way fixed effects estimator, we also present the Interaction Weighted (IW) estimator from Sun and Abraham (2020) alongside the main findings.[23] The IW estimator creates the cohort-specific average treatment effect and weights each cohort by their sample shares. In the IW specification, we focus on the cities that ever adopted between 1916 and 1933 versus those that never adopted health departments (mostly part-time cities). We also include the results without the covariates. We only include the covariates in the full two-way fixed effects specification.

In our main preferred specification, we add controls for a number of other pre-treatment levels of controls (from 1910) interacted with year fixed effects. First, we directly control for the 1910 city-level share female, the share white, and the share under five and over 65. These factors address the differing population distributions between cities, especially the high mortality populations. We then include the 1910 average occupational scores to control for average income. Finally, we control for the fact that public health successes may be affected by outside private health alternatives. To account for the availability of private health care, we include the 1910 number of physicians per 10,000. A concern about this method of adding controls is that the year

[20]For infant mortality $t = 1915, ..., 1936$ and for the remainder of mortality measures $t = 1910, ..., 1940$.

[21]Each group dummy variable represents the percentile ranking of the size of the (urban) population relative to other cities. The groups include percentiles h from 0-20, 20-40, 40-60, 60-80, 80-100. These dummy variables are then interacted with year dummy variables. We use 1920 population totals for this calculation because more cities reported population in 1920 than in 1910.

[22]For infant mortality, the series does not start until 1915; thus our event study runs from 18 years to 19 years after a health department arrives.

[23]Based on Baker et al. (2021), the Sun and Abraham IW estimator performs similarly to Callaway and Sant'Anna (2020).

fixed effects may absorb too much of the variation in our specification. Accordingly, we also show alternative sets of controls in Section 6.

5 Main Results

5.1 Full-time health departments

Figure III: Event Study: Full-time Health Department Entry and Mortality

NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. The dark green diamonds show the two-way fixed effects specification with controls. The lighter green circles show the main specification, excluding controls (light green). The brown squares show the Interaction-Weighted estimator from Sun and Abraham (2020) relative to the never-treated group (excluding controls). Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Figure III shows the effect of full-time health department arrival on overall mortality, non-infectious mortality, infectious mortality, and infant mortality. The vertical line depicts the excluded pre-treatment period, which includes control cities (mostly part-time health departments). The plotted points represent the coefficients on event-study dummy variables (see Equation 1). Though only a 16-year span is shown in the graph window, the event study performs the analysis on a fully saturated estimation of event-study style dummy variables, from 23 years before to 23 years after health department arrival. In each graph, we show three different specifications. The diamond dark green points display our preferred two-way fixed effects (TWFE) estimator with controls. The lighter green circles show the TWFE specification, excluding controls. The brown squares display the IW estimator from Sun and Abraham (2020).[24]

In the first plot, the city-level overall mortality rate remains stagnant following health department entry. Similarly, non-infectious mortality in the top right graph remains flat after health department arrival. The failure of non-infectious mortality to decline is not surprising. Health departments should primarily reduce infectious disease mortality over the short run. We anticipate the strongest response in infant and infectious disease mortality over the bottom two graphs. Despite this expectation, health departments still have little impact on infectious or infant mortality. Both infectious mortality and infant mortality fail to decline, with infant mortality potentially increasing after the health department's arrival.

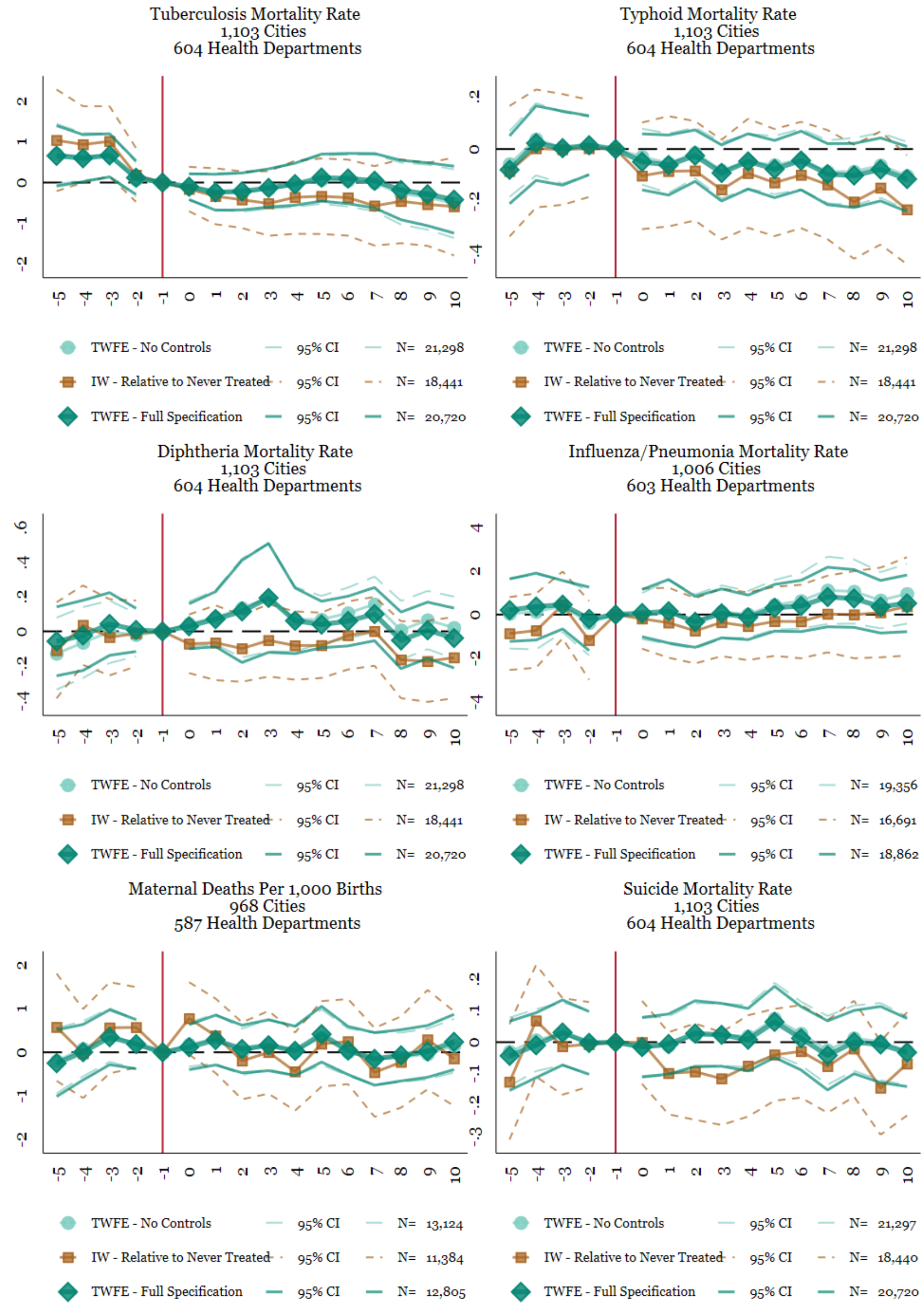
Of these null effects, the infant mortality findings are the most surprising. Infant mortality should be relatively sensitive to public health investment as infant deaths composed the majority of preventative deaths in the early twentieth century (Schneider Jr, 1916a). Further, the measures instituted to prevent infant deaths should deliver a noticeable response relatively quickly. For instance, public health efforts to increase breastfeeding rates or changes in sanitation practices should create a prompt decline in infant mortality. Despite this expectation, infant mortality fails to decline following health department arrival in any of the three specifications.

Next, we consider finer measures of mortality that may be more sensitive to specific public health practices. Figure IV shows the impact on deaths from tuberculosis, typhoid, diphtheria, influenza & pneumonia, maternal causes, and suicide deaths (as a placebo test). Only tuberculosis declines slightly, but tuberculosis mortality appears to have been on a clear preexisting decline before the health department arrived. The establishment of health departments in the wake of a downward trend in tuberculosis deaths aligns with Anderson et al. (2019)'s finding that declines in tuberculosis predated the establishment of major campaigns designed to eradicate it.

These cause-specific results again suggest that health departments were ineffective at reducing mortality for any of the major categories, including areas where we might expect an impact, such as infant, typhoid, and tuberculosis mortality. Our findings align with anecdotal evidence of the period suggesting the ineffectiveness of the majority of health departments. For instance, Chapin (1916) writes of local health organizations, "It would be difficult to find any one who would claim that existing agencies outside of the larger cities, if left to themselves, are capable of accomplishing very much. They have been tried and have failed." (Chapin (1916) p. 82)

[24]The IW estimator is also shown without controls and is most comparable to the light green circles. The IW results also exclude the always (or already) treated cities.

Figure IV: Event Study: Full-time Health Department Entry and By-Cause Mortality



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. The dark green diamonds show the two-way fixed effects specification with controls. The lighter green circles show the main specification, excluding controls (light green). The brown squares show the Interaction-Weighted estimator from Sun and Abraham (2020) relative to the never-treated group (excluding controls). Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

5.2 Part-time boards of health

Next, we consider whether the part-time departments produced more noticeable health improvements than full-time health departments fail to display. For example, part-time health departments may show a more apparent mortality decline if most of the gains from a health department originate from having any administrative capacity rather than full-time administration. Further, if full-time health departments under-report their status, then the part-time administration may be a preferred measure of health department existence. (We explore the possibility of under-reporting more fully below, in Section 6.3.) And even in cases of proper reporting, part-time health departments potentially could operate close to full-time capacity, absorbing much of the benefit from having full-time administration. Still, we caution that the part-time health department may have organized in response to epidemic illness rather than administering preventative programs (discussed in Section 2). This claim is partially illustrated by the number of boards that were organized in the wake of the 1918 pandemic (see Figure A.5).

Figure A.7 presents the event-study results for part-time health departments.[25] We focus on infectious causes and exclude infant mortality. Infant mortality is excluded due to our limited series of infant mortality (only 1915 and onward) and the substantial number of health departments that arrived in 1917/1918. The part-time health departments show slightly noisier estimates than full-time departments. However, generally, the results suggest no clear change in the majority of mortality rates. The only decline in mortality occurs for typhoid mortality, which shows a clear drop after health department entry, with little evidence of pre-trends.

A notable benefit of examining part-time health departments, in addition to our full-time findings, is that these part-time boards should capture any benefit of having public health administration, even if the health department does not report full-time capacity. In our case, typhoid mortality shows some evidence of declining upon arrival of the part-time health department, but not the full-time health department, indicating differences between part-time and full-time health departments. The importance of part-time status may capture part-time boards that practically operated at full-time capacity, representing effective under-reporting of full-time administration. Another potential explanation is that full-time health departments no longer had easily actionable interventions upon organizing from the part-time boards. Despite these hypotheses, given our data source, it is difficult to disentangle these two potential explanations, though we attempt some explanation in Section 7.

6 Robustness

To test the robustness of the main findings, we perform a battery of robustness checks on the full-time health department results. First, we present the results from a difference-in-differences specification and perform a Goodman-Bacon decomposition (Goodman-Bacon, 2021) (Tables A.6 and A.7). Second, we consider whether health spillovers between cities pollute the control group in the main findings (Figures C.1 and C.2). Third, we test whether under-reporting or over-reporting appears likely with the data we have available (Figures C.3 and C.4). Fourth, we confirm

[25] The results are shown without the IW estimator as there are very few never-treated cities for comparison.

null results over log of the mortality rates (Figures C.5 and C.6). Fifth, we show two alternative specifications of the covariates included in the event study (Figures C.7 and C.8). Sixth, we show the findings over the balanced panel (Figures C.9 and C.10). Seventh, we exclude 1918 and show the results without population weights (Figures C.11 and C.12). Eighth, we present the effects in small cities (less than 100,000) (Figures C.13 and C.14). Ninth, we show the findings across quality measures, including the best state health department states (Figures C.13 and C.14) and the highest quality boards (Figures C.15 and C.16). Tenth, we show the nonwhite mortality separately (Figure C.17). Finally, in Appendix Section D we also show the findings for alternative grouped event study results, including presenting additional heterogeneity analyses in Tables D.1-D.8.

6.1 The null results hold in the difference-in-differences specification

First, we test a difference-in-differences approach as an alternative to the main event study. We choose an event study as our main specification because the event study captures the dynamic treatment effect over the post period. Difference-in-differences does not capture this time-varying effect (Wolfers, 2006; Goodman-Bacon, 2021), and instead, the difference-in-difference strategy yields the average effect over the post-period. This average effect potentially yields inconsistent results as it heavily depends on the chosen endpoints (Wolfers, 2006).

Despite these limitations with a difference-in-differences approach, our preferred event study may remove too much variation from the mortality estimates. To test whether this is the case, we present the estimates from a difference-in-difference specification in Table A.6. The null results hold across the difference-in-difference results presented in Table A.6. Still, the interpretation of the difference-in-difference estimates are not entirely clear, as the effect may be biased downward due to comparisons between early and later-treated groups as controls. To show the degree to which this issue is occurring in our primary analysis, we present the results from a Goodman-Bacon decomposition in Table A.7 for the balanced panel of cities.[26] The results in Table A.7 show difference-in-differences estimates and the associated weights split by early versus later treated, treated versus never treated, and treated versus already treated. The results indicate the presence of heterogeneous treatment effects–where some estimates suggest that the health department reduced mortality upon arrival and other estimates suggesting an increase in mortality after the health department arrived.

Over all measures of mortality, the main comparison of interest, the treated-versus-never-treated group receives the largest weight in the specification. This comparison group also shows a positive coefficient across all specifications (except typhoid), indicating that cities adopting a full-time health department had higher mortality upon arrival than never adopters. In the case of typhoid, the coefficient is negative, but it is still quite small.

For the remainder of the groups, the effect is mixed and depends on the comparison group and the mortality measure. First, the earlier-treated versus later-treated as control in each specification shows a negative coefficient, indicating that early-adopting cities experienced mortality declines upon arrival of the full-time health department when compared against the later treated group. This specific comparison receives a minimal weight in the average difference-in-difference

[26] Goodman-Bacon et al. (2019) required a strongly balanced panel. The findings are also presented without controls.

estimate, likely due to the small number of time periods that this comparison occurs over. Then, the effect of the later-treated versus earlier-treated as control displays a negative coefficient in the majority of specifications, excluding for overall and infant mortality. In these cases, later-treated cities appear to have higher mortality with the health department's arrival. Finally, the treated versus already-treated displays a positive coefficient in the majority of mortality measures. The treated versus already treated against suggests higher mortality in cities that adopted a health department during our sample. Only typhoid and tuberculosis mortality show negative effects in the treated versus already-treated specification.

Based on Table A.7 the most compelling results are for tuberculosis and typhoid. The findings indicate health departments may reduce tuberculosis and typhoid mortality in most of the specifications (and on average). However, the results still suggest higher tuberculosis mortality in the treated versus never-treated specification. This treated versus never-treated specification is also the specification with the clearest counterfactual for full-time health department adoption over the study period. Based on these heterogeneous treatment effects by comparison group, we emphasize that our results are null even when we implement the Interaction-Weighted estimator (Sun and Abraham, 2020). The IW estimator provides the average dynamic effect (even in cases of heterogeneous treatment effects) relative to the never-treated group.

6.2 Are spillovers polluting the control group?

Second, we test whether public health benefits from the health department create spillovers to untreated cities nearby. These spillovers may pollute the control group in the main specification, where never-treated cities receive some level of treatment from health departments in close proximity. We test this possibility with two alternative specifications. First, we omit never-treated cities within 30 miles of health department cities. Second, we consider a specification with multiple treatments, where a city is treated each time a full-time health department opens within 30 miles.[27]

Figures C.1 and C.2 present the main findings while accounting for nearby health departments. The brown circles display the estimates while omitting nearby cities from the control group. These point estimates suggest little impact of the health department, indicating that spillovers are not contaminating the control group. The case of multiple treatments, in green squares, shows slightly smoother results over the pre and post-period. Still, there is no clear decline in most measures of mortality, except for overall mortality, which is mainly driven by declines in non-infectious mortality, and typhoid mortality. However, in the case of typhoid, mortality is also significantly lower before arrival. These results suggest that cities surrounding by other local health departments (a network of public health systems) may have experienced certain mortality declines.

[27]For this second specification, we follow the process of applying multiple treatments in event studies outlined in Schmidheiny and Siegloch (2019).

6.3 The results are robust to our best estimates of under- and over-reporting

A concern throughout our analyses is that health departments may be misreported in the data. Such underreporting may have occurred in any combination of three forms, with different implications for our specifications. Cities with full-time (or part-time) health departments may have failed to respond to the health department survey, leading them to be treated as cities lacking a health department in our main (or part-time) specification. Cities also may have been able to operate at full-time capacity without reporting a full-time health department and may be erroneously classified as part-time in our data—a possibility raised by our analysis of expenditures, reported in Section 7.2 below. Conversely, cities with part-time departments may also have been erroneously classified as full time. While we cannot fully check any of these possibilities, we provide alternative robustness checks in order to partially explore each of them.

First, we test whether the results change when using 1917 and 1916 as the base year for "early-treated" (rather than just 1916). Based on visual inspection of the surveys, 1916 appears the most inconsistent across 1916-1917 (versus 1917-1918, 1918-1919, etc...). 1916 also has clear omissions of large cities that would have been likely to have a full-time board. Thus, we take cities that health departments that reported in either 1916 or 1917 as the "early treated." Despite this change in methodology, the brown plotted squares in Figures C.3 and C.4 show similar results to the baseline for all measures of infectious causes of death. The results do show some evidence of a declining trend in non-infectious and overall mortality, the measures of mortality that health departments are unlikely to affect.

Second, we exclude never-treated cities (a relatively small group in our sample) and compare full-time health departments against the part-time departments. This specification is shown in light green circles in Figure C.3, C.4, and in Table D.1 (Columns 4-6). This specification excludes any cities that simply did not respond to the survey (but may have had a health department) from erroneously appearing in the control group. This specification also produces null results.

Third, we also adjust for potential over-reporting, as there are a few cases of transient health departments who only report one year and then drop out. Figures C.3 and C.4 present these findings in light green circles, where we exclude health departments that only appeared for one year in the survey. The plotted point here again suggests null results similar to the baseline.

And as already reported, in Section 5.2, we also find few clear benefits to opening a part-time health department (aside from typhoid). If full-time departments are underreported as part-time departments, then "part-time" departments in our data will be a heterogeneous mix of organizations ranging from fully-staffed departments to episodic, epidemic-focused operations. To the extent that departments that operated only sporadically would be less likely to fill out the health departments survey than any that actually operated with full-time capacity, survey non-response would increase our ability to identify health benefits of the latter group.

Overall, while we cannot confirm the validity of the survey data, these various findings help to check for evidence of under- or over-reporting. Our main results, suggesting few identifiable benefits of health administration in this era, persist across these specifications.

6.4 There is no effect across the remaining robustness checks

Third, we present the findings with the log of mortality rates instead of linear rates. Figures C.5 and C.6 repeat the main findings with the log of each mortality rate. These findings suggest that the tuberculosis rate declined before the health department arrived, with a small dip after the health department opened (similar to the baseline). The remaining measures of mortality show similarly null results to the baseline findings. Fourth, we show the specification with alternative controls, including 1910 controls interacted with linear trends and 1910-1940 linearly interpolated controls. Figures C.7 and C.8 shows similar results regardless of the method of adding covariates.

Fifth, a significant limitation of this study is the unbalanced panel of mortality rates. Not all states appeared in the death registration area in 1910, and the U.S. did not mandate reporting until 1933 (Haines, 2001). This staggered entry during the analysis may bias the coefficients, with the direction of the bias not immediately apparent. Prior work has suggested that the unbalanced panel may produce an upward bias in rural areas (Hoehn-Velasco, 2019). However, urban areas' bias may be fundamentally different due to high mortality in Southern cities (Feigenbaum et al., 2019). To test whether the unbalanced panel limits our ability to detect an effect, we show two alternative panels. First, we show the balanced panel based on entry (some cities exited the data). Second, we show the findings over a truly balanced panel of cities (also omitting exiting cities). Figures C.9 and C.10 present both specifications. The balanced panels generally reflect the null impact demonstrated in the baseline findings.

Sixth, we show the results excluding 1918 and without weights. Figures C.11 and C.12 shows each result. The results suggest slightly less decline in tuberculosis mortality in the specification without 1918. For the unweighted results, shown in green squares, the findings do suggest a small dip in infectious mortality after arrival. However, there is also a spike before the health department arrived. Thus, the dip after arrival may be due to the higher pre-treatment mortality, such as the preexisting decline in tuberculosis mortality shown in Figure C.12. Sixth, due to the unweighted results showing the largest coefficient (but still not significant), we present the main results without the largest cities in Figures C.13 and C.14. The results for smaller cities are again null.

Eighth, we test whether there were differences across health department quality. To begin, we show cities in the best state health department states in Figures C.13 and C.14. We choose states with a health department rating of higher than five, as measured by Chapin (1916) (seven states in total, shown in Appendix Table A.3). After health departments in these states arrive, there is a slight dip in infant mortality (also reflected in Table D.5). However, the decline only lasts for one or two periods. Then, we test the effectiveness of specific high-quality health departments, measured by an early board of health (as of 1890) and a long tenure of the health officer (greater than seven years). Figures C.15 and C.16 with high quality health departments again show no impact on mortality conditions.

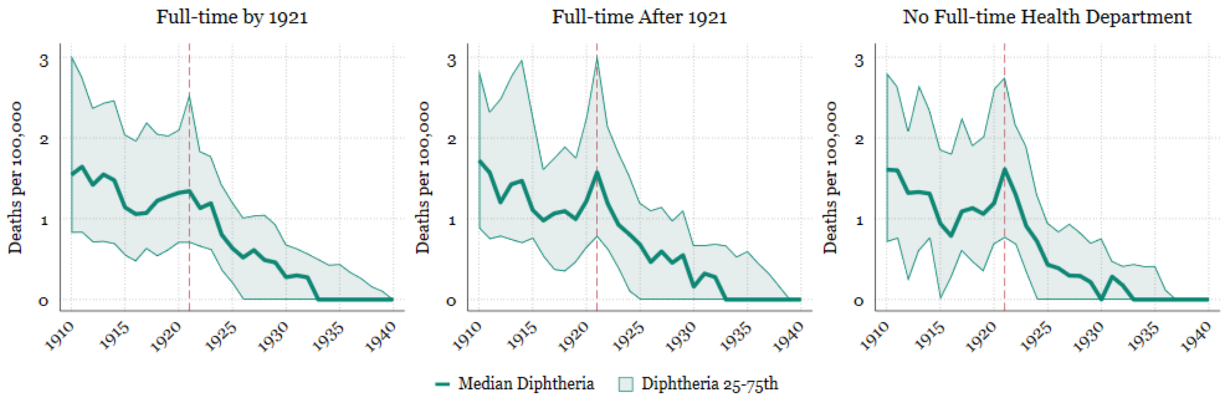
Ninth, we show the findings for nonwhite mortality separately from the total mortality rate. Nonwhite mortality was higher than white mortality, and disadvantaged nonwhites may benefit the most from public services. Despite this expectation, the findings in Figure C.17 continue to show little benefit from the health department. However, we caution that the nonwhite deaths are only reported in cities with more than 10% of the population is nonwhite, which is only a fraction of the main sample of cities.

7 Explanations for the Null Effect

Why did urban health departments appear to have so little effect? Several alternative hypotheses stand out. One possibility is that health departments were entirely ineffective at improving health. In other words, their initiatives did not work. A second possibility is that health departments may have organized productive projects, but no more so than cities that lacked health departments, where non-adopting cities carried out such projects through other public (state or local) or private means (physicians and donors). A third potential is that the binary adoption of a health department is too coarse of a measure of health administrative capacity. In this case, health department functions may be better captured by the intensity of services (budget or staff). Finally, health departments may have provided unobserved benefits over the long run that we fail to capture in our analysis.

7.1 Vaccine-preventable mortality improved in never-adopting cities

Figure V: Mechanism–Diphtheria Mortality by Full-time Health Department Presence



SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data.

Diphtheria was "the paradigmatic disease of the so-called bacteriological revolution and the symbol of the triumph of scientific medicine in the control of infectious disease" (Hammonds (1999) p. 7). A diphtheria antitoxin that improved survival began to be used in the United States as early as 1894-5, but a vaccine was not developed until 1914; used widely in campaigns beginning around 1921, with notable improvements in 1926; and expanded access through the 1930s. The prevention of childhood illnesses such as diphtheria became popular in the context of expanded public health focus on young children (older than infants) in the wake of World War I. The war brought public sympathies to the plight of refugee children and expert attention to the long-term consequences of early childhood infections for young adults' military readiness (Meckel (1990) p. 201).

We explore whether cities with and without full-time health departments experienced declines in diphtheria mortality after 1921, when the vaccine first became widely available. 1921 also marked the passage of the Sheppard-Towner Act, which provided federal resources for child and maternal health (Moehling and Thomasson, 2012, 2014). Figure II (in Section 3, above) shows that diphtheria's decline accelerated dramatically after 1921 in both cities with and without a health department. Figure V presents an adjusted version of Figure II, with the 25th, 50th, and 75th percentile added. The figure splits diphtheria mortality across cities that had a full-time health department before 1921, cities with a full-time health department by 1933 (but without one in 1921), and cities that did not adopt a full-time health department before 1933. All three city types show sharp declines in diphtheria mortality, confirming that—at least in the context of the federal funding and national focus on child health following the war—the vaccine's discovery was associated with sharp reductions in diphtheria mortality regardless of whether a city had a health department.

These results imply that cities were able to coordinate vaccination campaigns even in the absence of a formal, full-time health department. There are three main ways these health activities could have been organized. First, never-adopting and late-adopting cities may have allocated similar public resources toward public health with distinctive administrative structures. Second, never-adopting and late-adopting cities may have had robust private health infrastructure that cities with public health departments lacked. Indeed, even in cities with health departments, the ability to organize effective campaigns often depended on mobilizing private funding, and the boundaries between public and private campaigns were often blurry (Hammonds, 1999, p. 89). Third, part-time and never-adopting cities may have effectively set up a full-time health department without reporting this level of capacity. We test these alternative possibilities by turning to city expenditures and physician access.

7.2 Never-adopters and late-adopters allocated similar public funds to public health

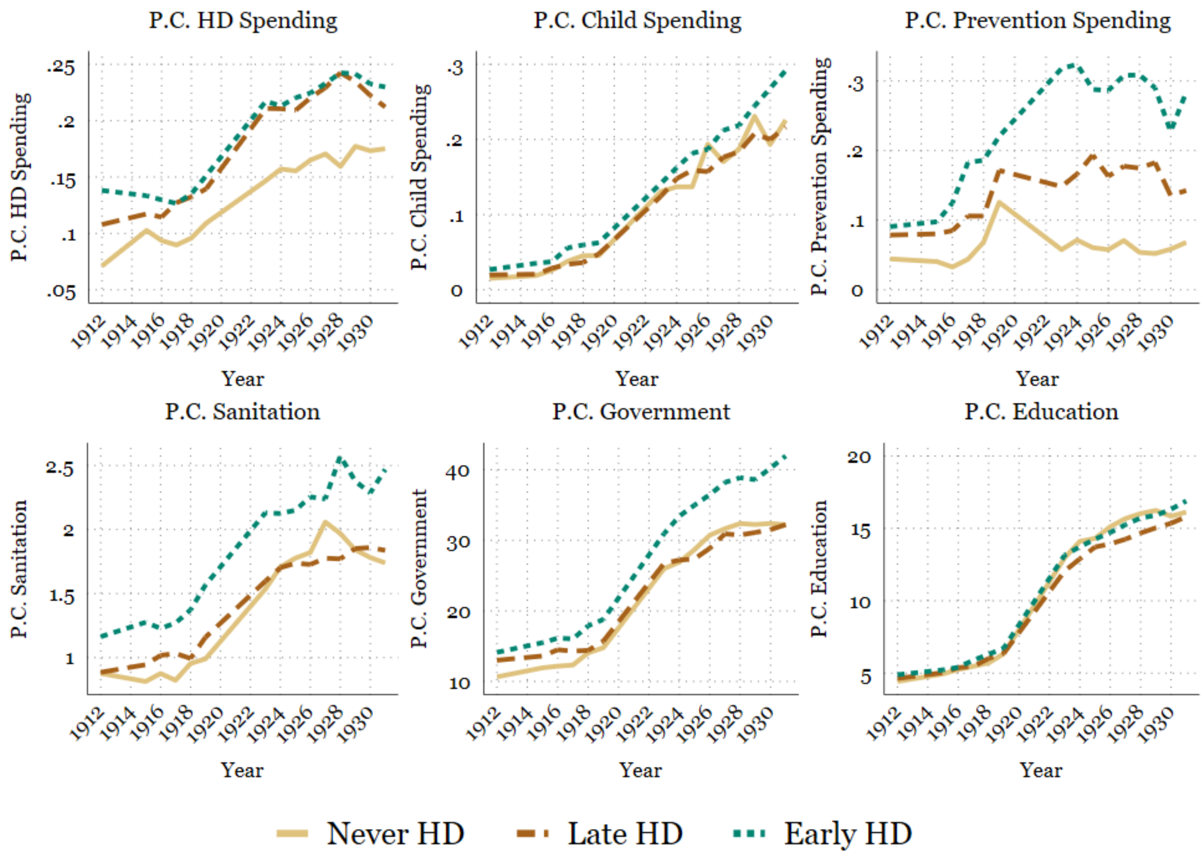
We next consider spending at the city level to test whether city-level health expenditures can help us interpret the non-effect of health departments. Ideally, we would like to determine whether cities that had health departments spent more on health, which would indicate both a larger investment in public health and proper reporting of 'full time.'

To start, Figure VI shows the evolution of spending from 1912 to 1931 from the Financial Statistics of Cities.[28] Cities that adopted a health department early (before 1916, plotted in short green dashes) consistently have higher child health, prevention, sanitation, and general government expenditure. Cities that adopted a full-time health department after 1916 (later-adopting health departments, plotted in brown dashes) spent more on prevention and health department administration relative to never-adopters but spent a similar amount on other activities relative to never-adopters.

Despite the deficit in administrative health department expenditures, never-adopting cities put similar per capita funds towards other types of health initiatives and general government

[28] Note that these expenditure data are only available for the largest cities, meaning our analysis with expenditures is a smaller sample than our primary health department analysis. All cities in this sample have either a full-time or a part-time health department.

Figure VI: Mechanism–Median Per Capita Spending by Adoption of a Health Department



NOTES: Never having a health department refers to no adoption by 1933, and includes part-time boards. Late adoption is defined as adoption between 1917 and 1933. Early adoption is defined as having a health department before 1917.
SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31. City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933.

and education expenditures. While never-adopters did not invest in health departments, they allocated public funds to specific health programs, such as child health initiatives. The similar growth of city budgets across health department status indicates that cities with and without health departments followed similar local government expenditure patterns over time, irrespective of the bureaucratic apparatus. To illustrate this further, Figure E.2 displays the median percentage breakdown by health department status. The funding of local government activities is similar in percentage breakdown between the late-adopting and never adopting cities. Only education expenditures are a notably higher share of the government budget in never-adopting cities.

In Appendix Table E.2, we next test whether spending predicts whether a city has a full-time health department (in a given year) controlling for city characteristics. The results suggest that per capita spending on health *fails* to predict whether a city operates a full-time health department. Table E.2 demonstrates that even in years where the health department was active, cities without health departments were allocating their budgets similarly (with an exception for lower general spending). These results affirm the hypothesis that health departments failed to reduce mortality because health activities occurred irrespective of reporting a full-time health department. The similarity in spending between adopting and non-adopting cities also explains why there are similar declines in diphtheria in Figure V. Cities that did not administratively report having a full-time department still engaged in health activities. It seems highly likely that cities that never reported having a full-time health department were already fulfilling similar health functions by alternative means, such as through part-time health departments or private alternatives.

We conclude this section by showing the private alternative to public health, physician access per 10,000. Figure E.3 plots physician access over 1910-1931 and suggests that cities with full-time health departments had the highest per capita physician access. The lack of public administration combined with lower private access in never-adopting cities indicates that these cities had historical differences in all health access, rather than merely facing a trade-off between investing in public and private services.

7.3 Health department spending is correlated with declines in infant mortality

We next directly test whether higher per capita expenditure on the health department is associated with infant mortality reductions. We focus our expenditure analysis on infant mortality for two reasons. First, rural health departments primarily reduced infant mortality and had no noticeable effect on overall mortality (Hoehn-Velasco, 2018). Second, one-third of preventable deaths in urban areas (at the time) occurred amongst infants (Schneider Jr, 1916a). While the results presented here are merely a correlation between per capita public expenditure at the city level, we do account for city fixed effects and control for pre-treatment city characteristics in the specification. Our specification focuses on whether last year's spending can be associated with lower infant mortality in the subsequent year. We choose the lag of expenditure to capture the fact that public health programs may take time to produce an effect.[29]

More formally, we estimate the following:

$$M_{jt} = a_j + \eta_{st} + \pi_{hjt} + \beta_m E_{j,t-1} + \mathbf{X}'_{jt}\gamma + \epsilon_{jt} \tag{2}$$

where M_{jst} is the mortality rate in city j and time t. $E_{j,t-1}$ is the per capita city-level expenditures on the health department from the prior year.[30] As in Equation 1, a_j captures the city fixed effects, η_{st} accounts for state-by-year fixed effects, π_{hjt} are the population-group-by-year fixed effects, $\mathbf{X}_{jt}$ are city-level controls, and ϵ_{jst} is the regression error (clustered at the city level).

Table 4 shows the baseline relationship between per capita expenditure in 1912-1931 (with gap years) and the infant mortality in the subsequent year.[31] The findings reveal that cities with higher per capita health department expenditures experienced reductions in infant mortality. The results hold for the specification without controls (Column (1)), with controls (Column (2)), the specification with linear trends (Column (3)), and the log of infant mortality (Column (4)). In Columns (5)-(8), we show the relationship between reporting a full-time health department and declines in infant mortality. Full-time health department arrival again fails to be correlated with infant mortality declines.

We also perform two checks on this per capita expenditure analysis in Table E.3 and Table E.4.

[29] Hoehn-Velasco (2018) also used the lag of health department presence and the lag of expenditure.

[30] Note that expenditure is only available for 1912, 1915-1919, 1923-1931. We do, however, have total expenditure for 1921, but not health expenditure.

[31] We are missing 1913-1914, 1920-1922. While we have the breakdown of expenditure in 1921, we do not have health expenditures for 1921.

Table 4: Mechanism–Infant Mortality Rate (IMR), Per Capita Expenditures, and Health Department Entry

	Infant Mortality Rate			Log IMR	Infant Mortality Rate			Log IMR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.P.C. HD Expenditures	-18.837**	-17.722**	-14.021**	-0.168*				
	(7.839)	(7.570)	(6.892)	(0.085)				
L.1(Health Department)					2.104**	1.045	0.162	-0.004
					(0.962)	(0.906)	(0.866)	(0.011)
Observations	2,700	2,684	2,684	2,682	12,172	11,923	11,923	11,874
Health Departments	587	587	587	587	587	587	587	587
Number of Cities	968	968	968	968	968	968	968	968
Adjusted R-sq.	0.87	0.88	0.90	0.89	0.81	0.83	0.87	0.85
F-statistic	5.77	5.48	4.14	3.87	4.79	1.33	0.03	0.14
Baseline FE	X	X	X	X	X	X	X	X
Controls		X	X	X		X	X	X
Time Trends			X	X			X	X

NOTES: Results from Equation 2. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Infant mortality results are weighted by the number of births. Per capita expenditure are the dollars spent over the population of the city. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31. City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table E.3 shows the lags and leads of city-level per capita health department expenditure. While present and future spending appear unrelated to infant mortality declines, higher past spending is associated with reductions in infant mortality. These findings suggest a potential causal link–as past spending should be predictive of future mortality declines–while future spending should have no impact on today's mortality. Next, in Table E.4, we present the results for sanitation spending, child health spending, prevention spending, general spending (courts and administration), and education spending. Aside from the importance of health department spending, per capita prevention expenditures are also tied to declines in infant mortality. Prevention spending is plausibly associated with infant mortality declines, as it is a component of health conservation spending. The lack of significant relationship with other spending categories suggests that the relationship is not primarily through general city-level wealth and public good provision.

Then, in Table 5 we try to pinpoint where the largest declines in infant mortality occur. Here the main impact of higher spending appears in states with the best state health departments, the Northeast, and specifically, in New York and Massachusetts. Thus, the majority of the correlation appears in states with long histories of public health achievements. There are less noticeable declines in the remaining states, including the South, Midwest, and West. In the South and the West, the coefficient is positive, indicating that higher per capita expenditures are associated with elevated levels of infant mortality.

Here we caution that our expenditures results only provide speculative evidence and are far from causal. Cities that spent more on health departments may have had higher provision of

Table 5: Mechanism–Health Department Expenditures and Infant Mortality 1912-1931, Heterogeneous Effects

	Infant Mortality Rate						
	(1) Best States	(2) Other States	(3) Midwest	(4) South & West	(5) North-east	(6) NY	(7) MA
L.P.C. HD Expenditures	-31.257***	5.479	-0.821	14.606	-33.284***	-26.709	-59.750***
	(8.379)	(7.633)	(7.977)	(14.348)	(8.243)	(17.571)	(17.345)
Observations	1,202	1,482	927	566	1,182	267	358
Health Departments	587	587	587	587	587	587	587
Number of Cities	968	968	968	968	968	968	968
Adjusted R-sq.	0.92	0.87	0.87	0.87	0.91	0.93	0.92
F-statistic	13.92	0.52	0.01	1.04	16.30	2.31	11.87
Baseline FE	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X
Time Trends	X	X	X	X	X	X	X

NOTES: Results from Equation 2. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Infant mortality results are weighted by the number of births. Per capita expenditure are the dollars spent over the population of the city. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31. City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

health generally through both private and public means. For instance, in the survey of municipal health departments in the early 1920s, it is noted that "Infant hygiene work is also done in all of the cities studied, though less than half the health departments have a distinct division of child hygiene. Private agencies are of course doing notable work in this field" (Armstrong et al. (1924) p. 10). Cities may have also made substantial infrastructure investments, which could create simultaneous effects but go unnoticed in the annual spending records.

However, these results still add to our overall null results by suggesting that organizing and reporting full-time health administration is insufficient to improve mortality conditions. The per capita expenditure results instead suggest several explanations for the null effect, including inadequate funding of health departments and the general importance of the network of public health systems in the state. Our results also leave open questions into whether city expenditures on public health (and proper allocation of that spending) can be effectively applied to improve mortality conditions. These funds may play a larger role in determining effectiveness than the binary adoption of a full-time health department.

The words of public health reformer Charles V. Chapin appear appropriate in light of these findings. Of local public health departments, he wrote, "It is often said that all public health problems lead back to just one thing, and that is money. We can generally, 'within natural limitations,' get what we want to pay for in health as in commodities. If communities were willing to pay for efficient health service they could get it." (Chapin (1916) p. 83)

7.4 Health department benefits may have occurred over the long run

Finally, we conclude by noting that the health department's benefits may have occurred over the long run. While initial health departments may have been too ambitious in their undertakings and poorly funded, health departments with proper staffing and funding may have had unobserved health benefits over the longer term. While we do not formally examine the impact past a decade, we note this possibility for long-run achievements with a capsule history of a public hospital in Milwaukee. In Milwaukee, the first attempt at opening a city hospital in 1879 was so poorly provisioned—lacking water, sewage, or much heat—that "because of its physical deficiencies, the hospital rarely admitted patients" (Leavitt, 1982, p. 69). This city hospital had been opened under health department administration despite the strong objections of the health commissioner. Yet, the city revamped the public hospital, completing its work in 1916. This reattempt at a modern hospital, whose design emphasized access to fresh air for patients with respiratory illness, became an important institution in the city's provision of care. In a similar fashion over the short term, health departments may have been intermittently effective or successful in particular campaigns without being consistently successful in reducing mortality when they first opened.

More broadly, our results here are limited to medium-term effects: mortality reductions in the first decade of establishing a health department. Nevertheless, some of the health departments' activities may have needed many years to come to fruition—for example, one account (Leavitt, 1982, p. 214-227) argues that Milwaukee's health department had substantial lifesaving effects for children only after its commissioner successfully built a broad political coalition that would support its work on an ongoing basis—nearly half a century after it was founded. By the same account, this work depended heavily on public trust that necessarily could be built only slowly (Leavitt, 1982, p. 236-238) (Burg, 2000). Accounts of New York's landmark campaigns against diphtheria similarly suggest the necessity of painstaking work to assemble political power and credibility before ambitious campaigns could succeed (Hammonds, 1999, p. 88-119). These anecdotal observations suggest that our analysis may be too focused on health department openings as opposed to other factors that may have made them sometimes effective and other times not. Therefore, we caution that our findings are limited to the period after the health department opened and that this narrow focus leaves open questions about whether health departments helped to carry out public health campaigns over the long run. Finally, to the extent that the federal Sheppard-Towner Act that provided resources for diphtheria vaccination arose in part out of New York City's diphtheria campaigns, our results fail to capture how individual cities' health departments may have influenced health by creating national (or state), rather than localized, spillovers over a relatively long time frame.

8 Conclusion

This study tracks the expansion of urban health departments throughout the United States over 1916-1933. Our results show no clear mortality benefit from the adoption of a public health department. These findings hold across multiple robustness checks and subsamples, with two exceptions. First, in states with the best state health departments, infant mortality declined over the initial years of the health department's operation. Second, in certain specifications, we also note small reductions in typhoid and tuberculosis mortality. However, the event study suggests that tuberculosis was on a preexisting downward trend before the health department arrived, mirroring the findings in Anderson et al. (2019). Typhoid mortality declines appear only in the part-time results and may reflect changes in sewage systems and water treatment (Cutler and Miller, 2005; Beach et al., 2016; Anderson et al., Forthcomingb; Phillips and Pitzer, 2020; Beach, 2021).

Our findings indicate that upon arrival, health departments were generally ineffective at improving mortality in cities. While the results may initially seem surprising, historical evidence from the period suggests that health departments often targeted the wrong problems, operated with too little funding, and lacked standards and training (Chapin, 1900, 1916, 1917; Hammonds, 1999). For instance, New York's Dr. S. Josephine Baker, who led the city's first Bureau of Child Hygiene, described the city's first efforts to vaccinate schoolchildren (in 1902) as "a pathetic farce" (Hammonds, 1999, p. 172-173). Further, few health department inspectors carried out their work in any rigorous fashion (Hammonds, 1999). The successful campaigns that did occur were often undermined by the deep distrust of health departments among immigrant populations in whom infectious diseases were particularly prevalent (Hammonds, 1999, p. 173-175) (Leavitt, 1982, p. 67). These factors combined led to nuances in health department quality and effectiveness that our binary measure of a full-time health department may graze over.

Still, we try to determine why health departments were ineffective and find several potential explanations. First, we find a decline in diphtheria mortality after the appearance of a vaccine, regardless of health department status. Thus, having a full-time health department is unnecessary for effective public health campaigns in the proper context (such as the availability of medical technologies and federal funding). Second, per capita expenditures allocated toward a health department cannot predict whether a city has a health department (after controlling for city characteristics). The similarity in funding across health department status indicates that either part-time health departments underreported their full-time health status, or instead, operated at a similar capacity to full-time health departments—or, perhaps, that full-time health departments were so under-resourced that they had no greater capacity than part-time departments. Third, we conclude by showing suggestive evidence of infant mortality declines in cities with higher per capita public expenditures on a health department. Put together, the results indicate that certain intensive measures of a health department, such as per capita expenditures, may be preferred in order to capture the nuances of health department quality.

We also see several limitations of the present study that open the field to future research. First, our results leave remaining questions over whether cities with higher public health expenditures experienced reductions in infant mortality. Future studies could exploit shocks to city budgets, occurring through inter-governmental grants or ballot achievements, to examine the causal impact of city spending on health. Second, more could be said about state health departments and their ability to influence local health. State health departments may have enacted notable benefits for public health through either public health campaigns or through regulatory changes, such as the occupational licensing of midwives (Anderson et al., 2020). Third, while broad health department activities may have provided little benefit in the infectious disease era, this same characteristic may be a strength later on, as mortality shifted toward more complex, chronic causes of death. Similarly, for infectious diseases such as tuberculosis, tactics such as large-scale epidemiological surveys may have been uniquely suited to public health departments. These initiatives may have grown in importance as the medical understanding of the disease gradually increased options for effective campaigns (Roberts, 2009, p. 61) or provided a basis for targeted action when epidemics began (Leavitt (1982) p. 60-61, 67). Future work could investigate the evolution of public health tactics as causes of death shifted and consider whether health departments become more effective as medical knowledge grew (Colgrove, 2011). Fourth, because we focused on the period when health departments first opened, we captured their operations only before many federal public health efforts, such as establishing the Centers for Disease Control. Yet, our diphtheria results suggestively raise the possibility that federal funding may have affected the evolution of health department operations—and may itself have followed in part from pioneering local health department initiatives such as New York City's anti-diphtheria campaigns (Hammonds, 1999). Put together, our results present the potential for a more complex interplay between local, state, and national initiatives as well as spillover effects that unfolded over a long period and at the state and federal level instead of the localized scales. We leave these several areas of investigation for future work.

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A Additional Background and Data Information

Table A.1: Staffing of 1890 Boards

	Mean	Std. Dev.	50th Pct	Min	Max	Count
Board Members	5.01	2.5	5.0	0.0	15.0	273.0
Physicians on Board	1.22	1.2	1.0	0.0	6.0	273.0
Share Physician	0.27	0.3	0.2	0.0	1.0	271.0
Expenditures (1,000s)	9.65	38.7	1.2	0.0	374.9	216.0
No Physicians 1890	0.28	0.5	0.0	0.0	1.0	273.0
No Board 1890	0.36	0.5	0.0	0.0	1.0	339.0

SOURCES: 1890 Social Statistics of Cities.

Table A.2: Highest Expenditure Health Departments - 1890

City	(1) Board Members	(2) Physicians on Board	(3) Expenditures (1,000s)
New York	8	2	375
St Louis	6	2	335
Chicago	3	1	207
Boston	3	0	105
Philadelphia	6	0	97
Baltimore	3	2	80
Brooklyn	1	0	77

SOURCES: 1890 Social Statistics of Cities.

Table A.3: State Health Departments - Chapin (1916)

State	(1) Part-Time HD	(2) Full-Time HD	(3) State HD Rating	(4) P.C. Expen-diture	(5) 1st Part-Time HD	(6) 1st Full-Time HD
MA	72	59	745	4.95	1916	1916
NY	68	23	730	2.87	1916	1916
PA	92	79	716	12.7	1916	1916
MN	14	8	574	3.25	1916	1918
NJ	55	35	555	4.47	1916	1916
IN	34	9	526	2.32	1916	1916
MD	6	5	507	10.54	1916	1916
KS	20	7	499	2.6	1916	1916
VT	3	3	486	9.27	1916	1916
OH	59	40	462	1.8	1916	1916
RI	14	4	432	3.14	1916	1916
NC	21	17	411	2.6	1916	1916
VA	14	12	397	2.09	1916	1916
KY	12	7	393	1.27	1916	1916
CT	24	11	393	2.24	1916	1916
WI	27	15	392	1.56	1916	1916
MI	40	19	370	1.48	1916	1916
IL	58	32	346	1.78	1916	1916
CA	47	32	342	3.96	1916	1916
NH	10	7	320	4.81	1916	1916
LA	8	5	315	4.93	1916	1918
MS	13	11	297	1.2	1916	1918
ME	9	7	280	1.95	1916	1918
WA	15	7	262	1.08	1916	1916
FL	14	8	253	15.21	1916	1916
MT	6	4	246	5.45	1916	1919
OR	6	4	227	1.78	1916	1916
IA	21	10	225	1.46	1916	1916
SC	9	8	165	2.27	1916	1916
UT	3	2	161	2.93	1916	1916
GA	15	14	156	1.21	1916	1916
MO	16	9	152	.86	1916	1916
ND	4	3	139	1.48	1916	1920
DE	1	1	131	4.04	1918	1919
ID	2	2	127	5.22	1918	1922
TN	8	7	122	.73	1916	1916
TX	8	6	116	1.13	1916	1916
WV	10	10	113	1.02	1916	1920
CO	8	4	106	2.19	1916	1916
AL	14	12	105	1.11	1916	1917
SD	6	3	101	1.43	1916	1916
OK	16	10	97	1.61	1916	1921
NV	1	0	94	7.59	1916	
AR	9	4	74	.53	1916	1919
NE	8	3	66	.85	1916	1916
AZ	2	1	39	3.76	1916	1931
WY	2	2	10	1.24	1918	1921
NM	3	2	0	0	1918	1922

Figure A.1: Dates of State Boards of Health

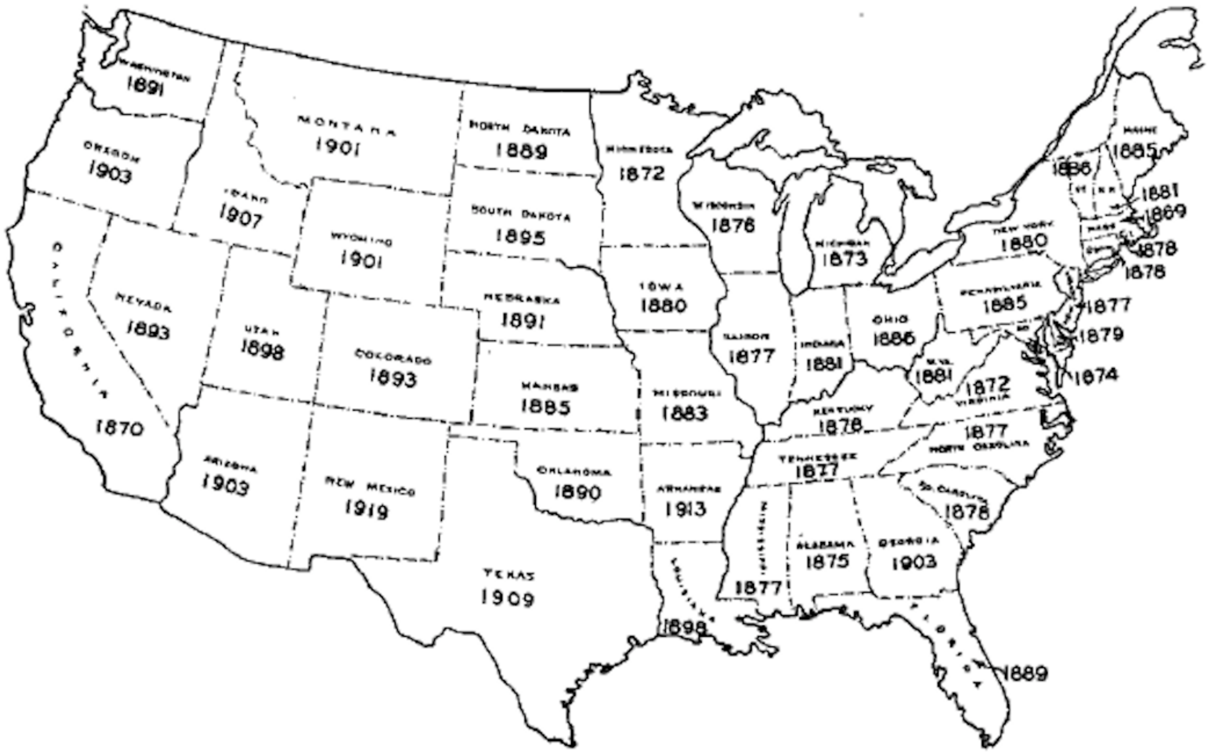


FIGURE 1.—Date of creation of each State board of health for the purpose of promoting public health work

SOURCE: Ferrell et al. (1929)

Figure A.2: Original City-Level Health Department Record

June 13, 1924 1444

CITY HEALTH OFFICERS, 1924.

Directory of Those in Cities of 10,000 or More Population.

Directories of the city health officers in the cities of the United States having a population of 10,000 or more have been published in the Public Health Reports [1] for each year from 1916 to 1923, for the information of health officers and others interested in public health activities. These directories have been compiled from data furnished by the health officers. The cities included in this directory are those having 10,000 population or more on July 1, 1923, as estimated by the Bureau of the Census.

The asterisk (*) indicates that the officer so designated has been reported to be a "whole-time" health officer. For this purpose a "whole-time" officer is defined as "one who does not engage in the practice of medicine or in any other business, but devotes all his time to official duties."

City.	Name of health officer.	Official title.
Alabama:		
Anniston		
Bessemer		
Birmingham	*J. D. Dowling, M. D	County health officer.
Dothan	*T. E. Tucker, M. D	City and county health officer.
Florence	*W. D. Hubbard, M. D	Field agent, U. S. P. H. S.
Gadsden	*Claude L. Murphree, M. D	County health officer.
Mobile	*C. A. Mohr, M. D	Do.
Montgomery	*J. L. Bowman, M. D	Health officer, Montgomery County, unit No. 3.
Selma	*L. T. Lee, M. D	County health officer.
Tuscaloosa	*Arthur A. Kirk, M. D	City health officer.
Arizona:		
Douglas	Z. Causey, M. D	Do.
Phoenix	L. D. Dameron, M. D	Do.
Tucson	A. G. Schnabel, M. D	Do.
Arkansas:		
Fort Smith		
Hot Springs		
Jonesboro	Walter C. Overstreet, M. D	Do.

SOURCE: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933.

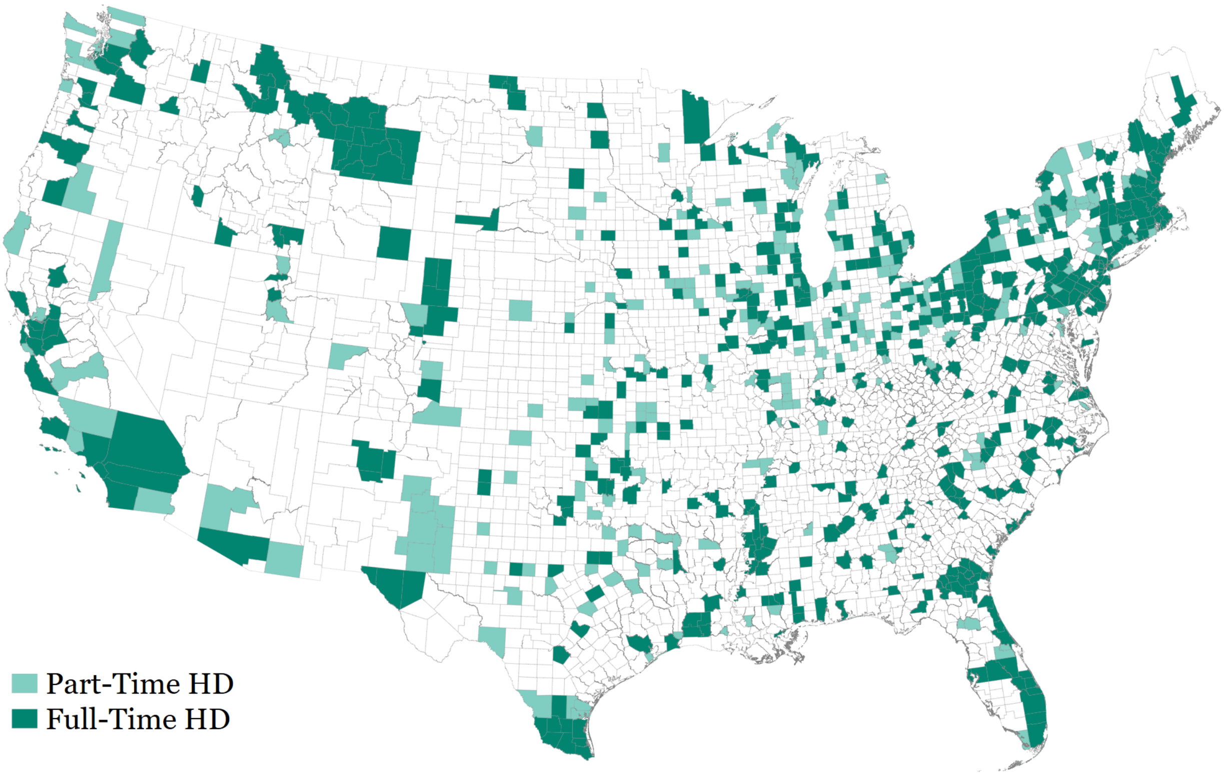
Figure A.3: Original City-Level Health Department Record - Additional Details

1449 June 13, 1924

City.	Name of health officer.	Official title.
Minnesota—Continued.		
Minneapolis	*F. E. Harrington, M. D	Commissioner of health.
Rochester	C. H. Mayo, M. D.[1]	Health officer.
St. Cloud	P. E. Stangl, M. D	City physician.
St. Paul	*Benjamin F. Simon, M. D	Chief health officer.
Virginia		
Winona	William Vardaman Lindsay, M. D	Health officer.
Mississippi:		
Biloxi	Geo. F. Carroll, M. D	City health officer.
Columbus	Thomas Toxey Box, M. D	Do.
Greenville	*A. J. Ware, M. D	City and county health officer.
Hattiesburg	J. D. Donald, M. D	Do.
Jackson	T. P. Sparks, Jr., M. D	City health officer.
Laurel	P. C. Risher, M. D	Do.
Meridian	T. J. Houston, M. D	Do.
Natchez	W. H. Aikman, M. D	County and city health officer.
Vicksburg	Sylvan Myers, M. D	County health officer.
Missouri:		
Cape Girardeau	*Robert Wilson	Health officer.
Carthage	Lloyd B. Clinton, M. D	Deputy State health commissioner
Columbia	W. A. Norris, M. D	Do.
Hannibal	*E. E. Waldo, M. D	City physician.
Independence	Calvin Atkins, M. D	City health officer.
Jefferson City	Hugh Granville Dallas, M. D	City physician.
Joplin	*M. B. Harutun, M. D	Commissioner of health.
Kansas City	*Eugune H. Bullock, M. D	Health commissioner.
Moberly	C. H. Dixon, M. D	Do.
St. Joseph	Leroi Beck, M. D	City health officer.
St. Louis	*Mac C. Starkloff, M. D	Health commissioner.
Sedalia	*C. T. Robinson	Sanitary officer.
Springfield	*Lon Sharp	Commissioner of health.
Webster Grove	Arthur W. Westrup, M. D	Health commissioner.
Montana:		
Anaconda		
Billings	James I. Wernham, M. D	Health officer.
Butte	J. B. Freund, M. D	Do.
Great Falls	*William H. Pickett, M. D	City-county health officer.
Helena	*Arthur Jordan, M. D	Field agent, U. S. P. H. S.
Missoula	*F. D. Pease, M. D	Health officer.
Nebraska:		
Grand Island	Frank D. Ryder, M. D	City physician.
Hastings	James V. Beghtol, M. D	Do.
Lincoln	*Chauncey F. Chapman, M. D	Superintendent of health.
North Platte		
Omaha	A. S. Pinto, M. D	Health commissioner.
Nevada:		
Reno	Albert F Adams, M. D	Secretary board of health.
New Hampshire:		
Berlin		
Claremont	William P. Prescott	Health officer.
Concord	*Charles E. Palmer	Sanitary officer.

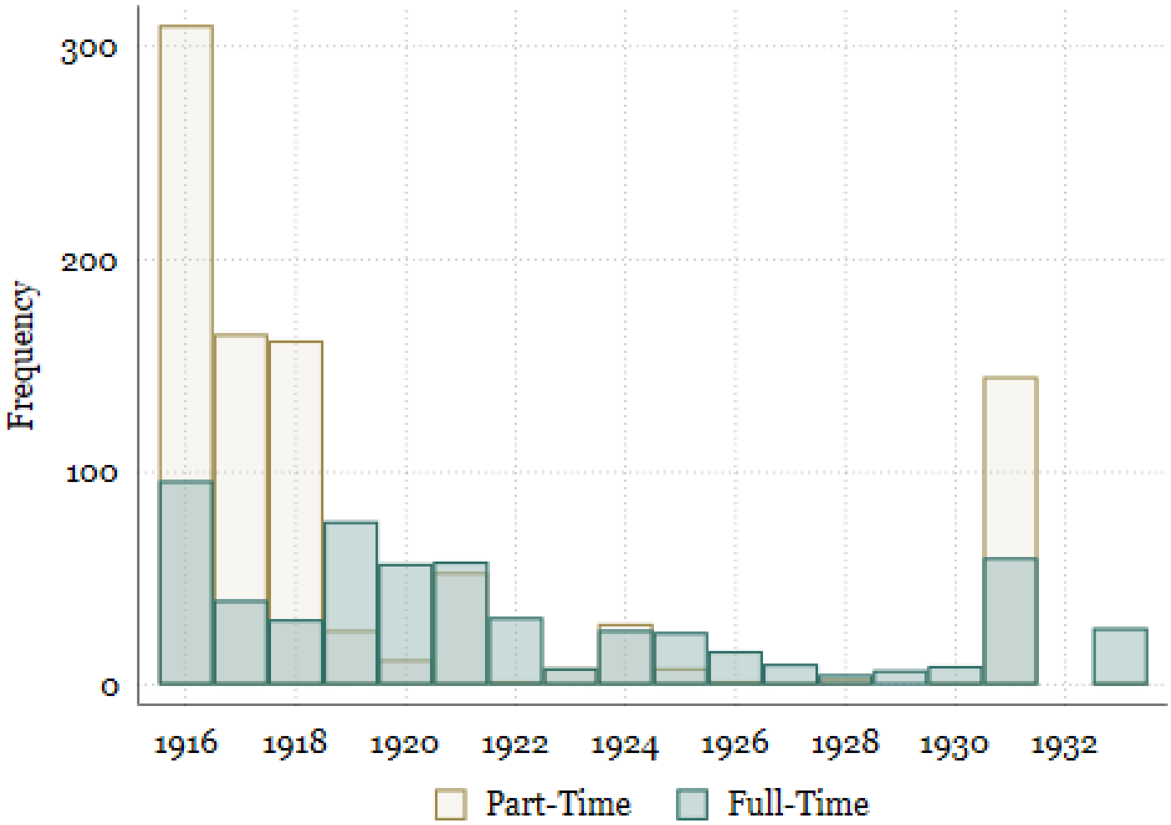
SOURCE: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933.

Figure A.4: Map of Full-time v. Part-time Health Departments



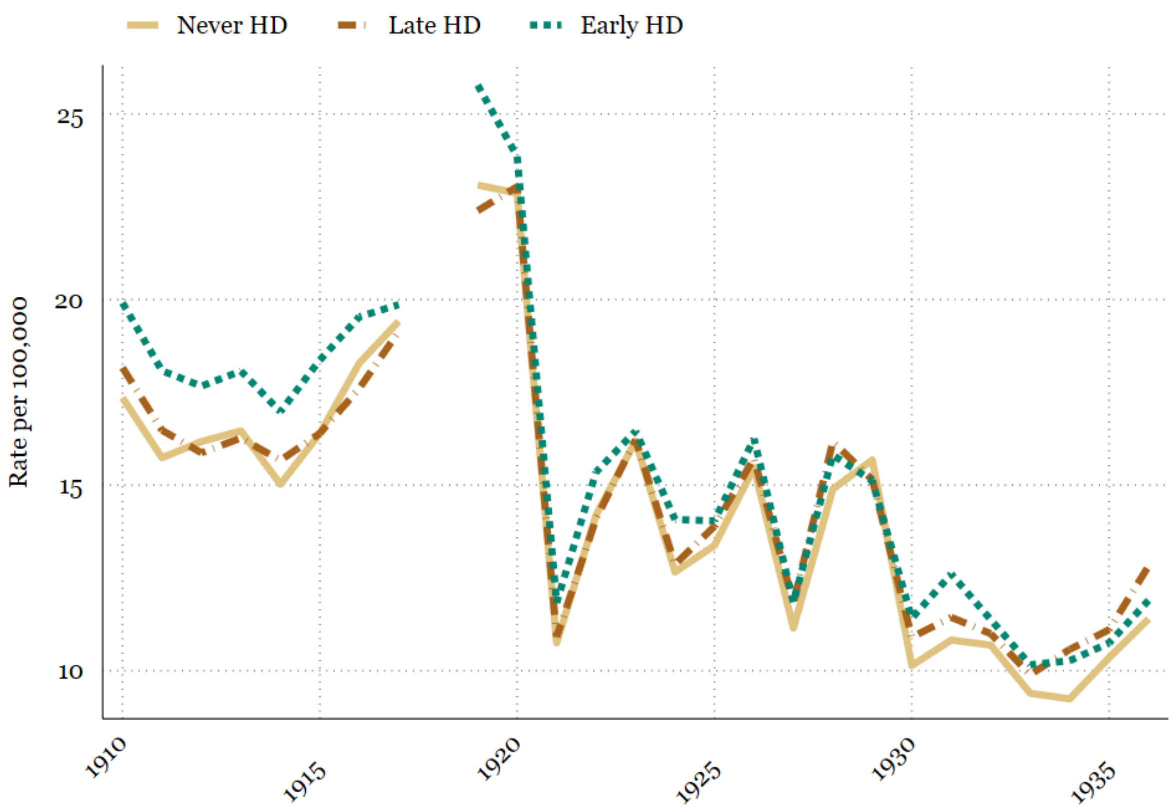
SOURCE: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933.

Figure A.5: Timing of Part-time versus Full-time Health Department Arrival



SOURCE: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933.
NOTES: Green bars represent the number of full-time health departments that opened in each year. Brown bars show the number of part-time health departments that opened in each year.

Figure A.6: Influenza and Pneumonia Mortality by City Health Department Status, Excluding 1918



SOURCE: The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data.
NOTES: Never having a health department refers to no adoption by 1933, and includes part-time boards. Late adoption is defined as adoption between 1917 and 1933. Early adoption is defined as having a health department before 1917. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births.

Table A.4: Summary Statistics–Differences Across Health Department Type

Panel A: Full v. Part-Time

	FULL-TIME		PART-TIME		DIFF.
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Est.*
Mortality					
Overall Mortality Rate	133.527	49.127	123.685	51.903	9.843**
Age-Adjusted Mortality Rate	0.951	0.523	0.844	0.552	0.107**
Infectious Mortality Rate	29.285	15.675	26.272	16.982	3.013**
Non-Infectious Mortality Rate	104.243	37.937	97.413	39.826	6.830*
Infant Mortality Rate	66.989	31.289	64.142	28.934	2.847
Birth Rate	20.331	7.515	19.152	8.289	1.179*
By-Cause					
Tuberculosis Mortality Rate	6.748	6.939	6.143	6.332	0.605
Influenza/Pneumonia Mortality Rate	11.763	5.749	10.284	6.021	1.479***
Typhoid Mortality Rate	0.508	0.848	0.436	0.946	0.072
Diphtheria Mortality Rate	0.533	1.084	0.500	0.878	0.032
Whooping Cough Mortality Rate	0.470	0.644	0.427	0.700	0.043
Maternal Deaths Per 1,000 Births	8.844	7.335	7.518	6.835	1.326**
Suicide Mortality Rate	1.744	1.174	1.590	1.231	0.154
Characteristics					
Population (10,000's)	8.495	35.049	2.251	2.160	6.243***
Share White	0.906	0.133	0.943	0.094	-0.037***
Share Under 1	0.016	0.003	0.016	0.003	-0.000
Share Under 5	0.085	0.012	0.086	0.014	-0.001
Share Over 65	0.048	0.018	0.051	0.019	-0.003*
Share Females	0.509	0.019	0.502	0.022	0.007***
Physicians per 10,000	13.305	8.864	11.801	6.921	1.505**
Average Occscore	8.390	0.720	8.326	0.860	0.064
N	584		344		928

Panel B: Early Versus Later-Treated

	BEFORE 1916		AFTER 1916		DIFF.
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Est.*
Mortality					
Overall Mortality Rate	126.586	35.876	134.893	51.252	-8.306
Age-Adjusted Mortality Rate	0.855	0.367	0.970	0.546	-0.114*
Infectious Mortality Rate	26.410	10.963	29.850	16.394	-3.441*
Non-Infectious Mortality Rate	100.177	27.570	105.043	39.632	-4.866
Infant Mortality Rate	62.333	16.953	67.901	33.319	-5.567*
Birth Rate	20.174	7.162	20.362	7.589	-0.188
By-Cause					
Tuberculosis Mortality Rate	5.856	3.731	6.924	7.398	-1.068*
Influenza/Pneumonia Mortality Rate	11.185	4.358	11.877	5.982	-0.693
Typhoid Mortality Rate	0.380	0.605	0.533	0.886	-0.153*
Diphtheria Mortality Rate	0.539	0.614	0.532	1.155	0.007
Whooping Cough Mortality Rate	0.472	0.571	0.470	0.658	0.002
Maternal Deaths Per 1,000 Births	7.240	4.353	9.158	7.750	-1.918***
Suicide Mortality Rate	1.699	1.037	1.753	1.200	-0.055
Characteristics					
Population (10,000's)	21.537	72.973	5.929	19.791	15.608*
Share White	0.926	0.107	0.902	0.137	0.024
Share Under 1	0.016	0.002	0.016	0.003	-0.000
Share Under 5	0.084	0.012	0.086	0.013	-0.002
Share Over 65	0.047	0.015	0.048	0.018	-0.000
Share Females	0.509	0.017	0.509	0.020	-0.000
Physicians per 10,000	12.804	4.650	13.404	9.475	-0.600
Average Occscore	8.584	0.672	8.352	0.723	0.233**
N	96		488		584

NOTES: Table shows the summary statistics across cities in 1930.
SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table A.5: Summary Statistics–Mortality and City Composition by Health Department Entry Year, 1936

	Pre-1917	1917-1920	1921-1924	1925-1933	Never
	1936 Mean	1936 Mean	1936 Mean	1936 Mean	1936 Mean
Composition					
Populations (1,000)	221.240	97.668	34.495	34.904	23.265
Share Under 5	0.073	0.075	0.078	0.076	0.077
Share Over 65	0.057	0.057	0.053	0.057	0.059
Physicians per 10,000	15.551	14.638	14.683	17.308	14.906
Share White	0.928	0.913	0.886	0.902	0.936
Mortality					
Overall Mortality Rate	133.273	139.899	138.889	137.383	131.853
Age-Adjusted Mortality Rate	0.762	0.831	0.906	0.902	0.766
Infectious Mortality Rate	23.926	25.796	27.923	27.984	24.013
Non-Infectious Mortality Rate	109.345	114.103	110.966	109.359	107.842
Infant Mortality Rate	52.443	57.489	63.498	63.344	58.482
Birth Rate	18.084	19.072	18.763	17.993	17.518
By-Cause					
Tuberculosis Mortality Rate	4.429	4.398	5.033	5.167	4.326
Influenza/Pneumonia Mortality Rate	12.794	13.782	14.165	14.240	12.290
Typhoid Mortality Rate	0.210	0.259	0.357	0.362	0.286
Diphtheria Mortality Rate	0.205	0.229	0.343	0.280	0.245
Whooping Cough Mortality Rate	0.197	0.196	0.213	0.215	0.168
Maternal Deaths Per 1,000 Births	6.333	6.559	9.378	7.807	6.690
Suicide Mortality Rate	1.589	1.464	1.487	1.687	1.642
Observations	96	207	125	163	388

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table A.6: Difference-in-Differences Specification

Panel A: All Cities

	Mortality Rate				Infectious Mortality				Infant Mortality				Typhoid Mortality			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1(Post x HD)	-0.47	0.36	-0.31	-0.31	-0.90*	-0.10	-0.37	-0.37	2.05*	0.35	0.38	0.38	-0.08	0.02	0.02	0.02
	(1.08)	(0.93)	(0.87)	(0.89)	(0.53)	(0.54)	(0.52)	(0.53)	(1.06)	(0.80)	(0.86)	(0.90)	(0.07)	(0.04)	(0.05)	(0.05)
N	21,297	21,297	20,719	20,719	21,297	21,297	20,719	20,719	13,124	13,124	12,806	12,806	21,298	21,298	20,720	20,720
Health Departments	604	604	604	604	604	604	604	604	587	587	587	587	604	604	604	604
Number of Cities	1,103	1,103	1,103	1,103	1,103	1,103	1,103	1,103	968	968	968	968	1,103	1,103	1,103	1,103
Mean Dependent	140.2	140.2	140.2	140.2	36.6	36.6	36.6	36.6	73.3	73.3	73.3	73.3	0.9	0.9	0.9	0.9
Adjusted R-squared	0.86	0.90	0.91	0.91	0.89	0.94	0.95	0.94	0.68	0.86	0.86	0.85	0.59	0.69	0.69	0.67
Baseline FE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Weights		X	X	X		X	X	X		X	X	X		X	X	X
Controls			X	X			X	X			X	X			X	X
Linear Time Trends				X				X				X				X

Panel B: Excluding Early Treated Health Departments (1916 or Before)

	Mortality Rate				Infectious Mortality				Infant Mortality				Typhoid Mortality			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1(Post x HD)	-0.35	0.45	-1.16	-1.16	-0.79	-0.31	-0.92*	-0.92	1.53	0.34	0.31	0.31	-0.02	0.03	0.02	0.02
	(1.26)	(1.20)	(1.12)	(1.15)	(0.58)	(0.58)	(0.56)	(0.57)	(1.08)	(0.90)	(0.91)	(0.96)	(0.07)	(0.04)	(0.04)	(0.04)
N	18,440	18,440	17,918	17,918	18,440	18,440	17,918	17,918	11,384	11,384	11,104	11,104	18,441	18,441	17,919	17,919
Health Departments	508	508	508	508	508	508	508	508	492	492	492	492	508	508	508	508
Number of Cities	1,007	1,007	1,007	1,007	1,007	1,007	1,007	1,007	873	873	873	873	1,007	1,007	1,007	1,007
Mean Dependent	140.9	140.9	140.9	140.9	36.3	36.3	36.3	36.3	73.1	73.1	73.1	73.1	0.9	0.9	0.9	0.9
Adjusted R-squared	0.86	0.89	0.90	0.89	0.88	0.93	0.94	0.93	0.66	0.82	0.82	0.81	0.57	0.65	0.66	0.63
Baseline FE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Weights		X	X	X		X	X	X		X	X	X		X	X	X
Controls			X	X			X	X			X	X			X	X
Linear Time Trends				X				X				X				X

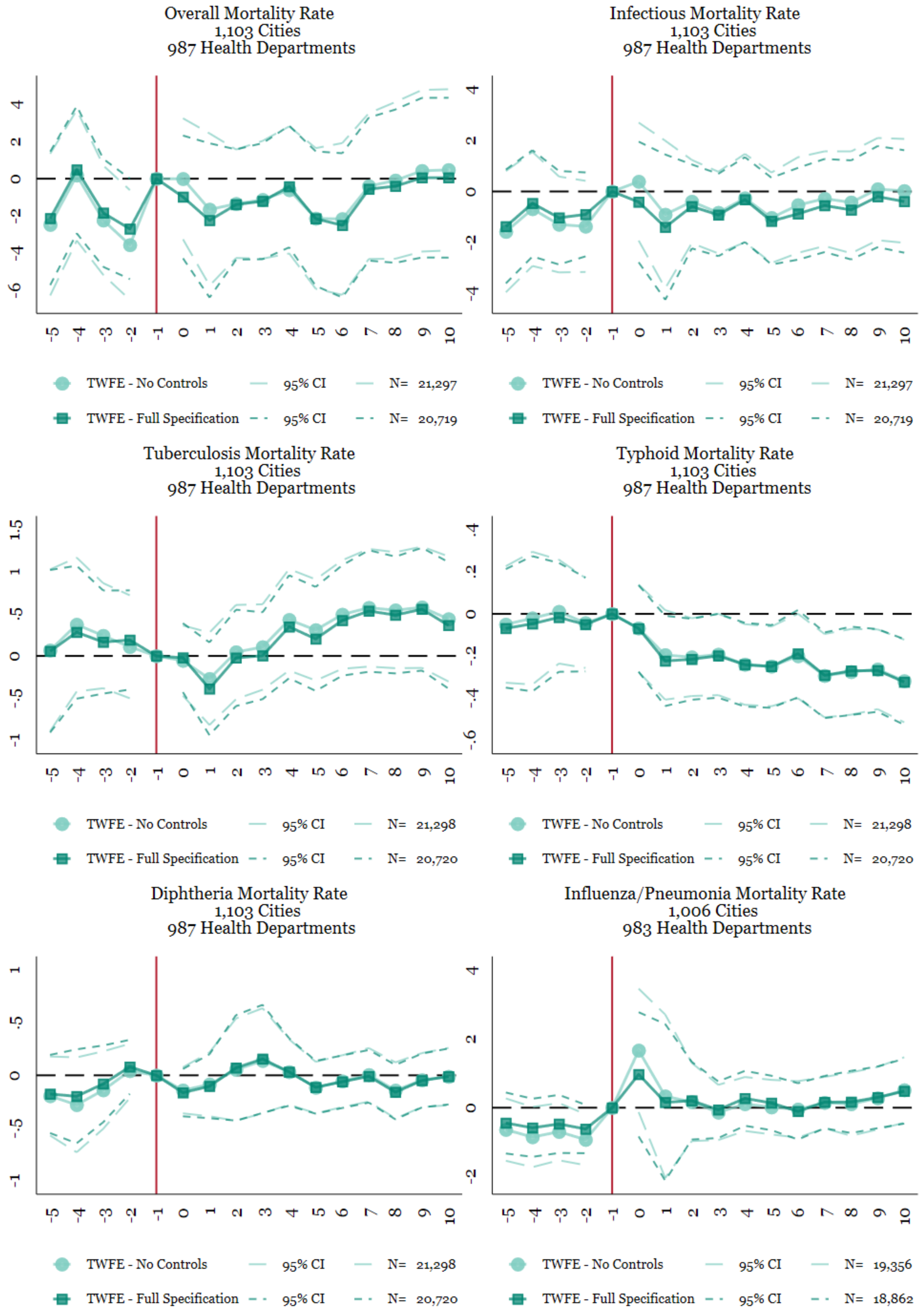
NOTES: Columns (1), (6), (11) show the specification with only year fixed effects. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table A.7: Bacon Decomposition

	(1)	(2)
DD Comparison	**Weight**	**DD Estimate**
Overall Mortality Rate		
Earlier Treated v. Later Control	0.056	-2.729
Later Treated v. Earlier Control	0.276	1.247
Treated vs. Never Teated	0.326	1.843
Treated vs. Already Treated	0.341	0.472
Average DD Estimate		0.954
Infectious Mortality Rate		
Earlier Treated v. Later Control	0.056	-2.356
Later Treated v. Earlier Control	0.276	-1.449
Treated vs. Never Teated	0.326	2.701
Treated vs. Already Treated	0.341	0.738
Average DD Estimate		0.601
Infant Mortality Rate		
Earlier Treated v. Later Control	0.085	-2.119
Later Treated v. Earlier Control	0.269	0.944
Treated vs. Never Teated	0.286	3.365
Treated vs. Already Treated	0.361	8.084
Average DD Estimate		3.951
Tuberculosis Mortality Rate		
Earlier Treated v. Later Control	0.056	-0.448
Later Treated v. Earlier Control	0.276	-0.596
Treated vs. Never Teated	0.326	0.346
Treated vs. Already Treated	0.341	-1.080
Average DD Estimate		-0.446
Typhoid Mortality Rate		
Earlier Treated v. Later Control	0.056	-0.272
Later Treated v. Earlier Control	0.276	-0.075
Treated vs. Never Teated	0.326	-0.004
Treated vs. Already Treated	0.341	-0.266
Average DD Estimate		-0.128
Diphtheria Mortality Rate		
Earlier Treated v. Later Control	0.056	-0.081
Later Treated v. Earlier Control	0.276	-0.072
Treated vs. Never Teated	0.326	0.047
Treated vs. Already Treated	0.341	0.087
Average DD Estimate		0.021
Influenza/Pneumonia Mortality Rate		
Earlier Treated v. Later Control	0.064	-1.438
Later Treated v. Earlier Control	0.268	-0.668
Treated vs. Never Teated	0.329	1.167
Treated vs. Already Treated	0.339	1.076
Average DD Estimate		0.479

Figure A.7: Event Study–Part-time Health Department Entry



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

B What Factors Predict the Timing of City-level Adoption?

To test the effect of preventative public health, we exploit the timing of the health department and test whether mortality declines in the wake of health department operation. To ensure the timing is exogeneous, in this section, we briefly test whether a city's characteristics influence the timing. In particular, we test whether the 1910 census characteristics predict the *arrival year* of both full-time and part-time health departments.

More formally, we test whether the arrival year of the health department in city j is predicted by a set of demographic controls:

$$HD_{js} = \beta_0 + \mathbf{X}_j'\gamma + \eta_s + \epsilon_{js} \tag{3}$$

where the timing (year) of a health department in city j and state s is considered over a set of demographic characteristics from the census years, $\mathbf{X}_j'$, and state fixed effects, η_s.

Table B.1 shows the OLS estimates along with the F-statistic, the R-squared, and the number of observations for each regression. Columns (1) and (2) show the timing of part-time health departments, and Columns (3) and (4) show the timing of full-time health departments. Aside from the size of the city, no other factors predict the adoption of the full-time health department, including the infectious disease mortality rate.

Over Columns (5)-(6), we also show the results across the binary adoption of a full-time health department. The estimates suggest that the existing physician base appears to predict adoption, as does having a lower share over 65. No other factors consistently predict adoption.

Despite these factors predicting treatment, these results should not affect the identification strategy as city fixed effects are included in the analysis. The sole factor that predicts the timing of the health department is the population size. To address the correlation of the timing of adoption with population size, we add city-size fixed effects to the main analysis, which is discussed in the empirical analysis (Section 4).

Table B.1: Timing of Health Department and City Characteristics

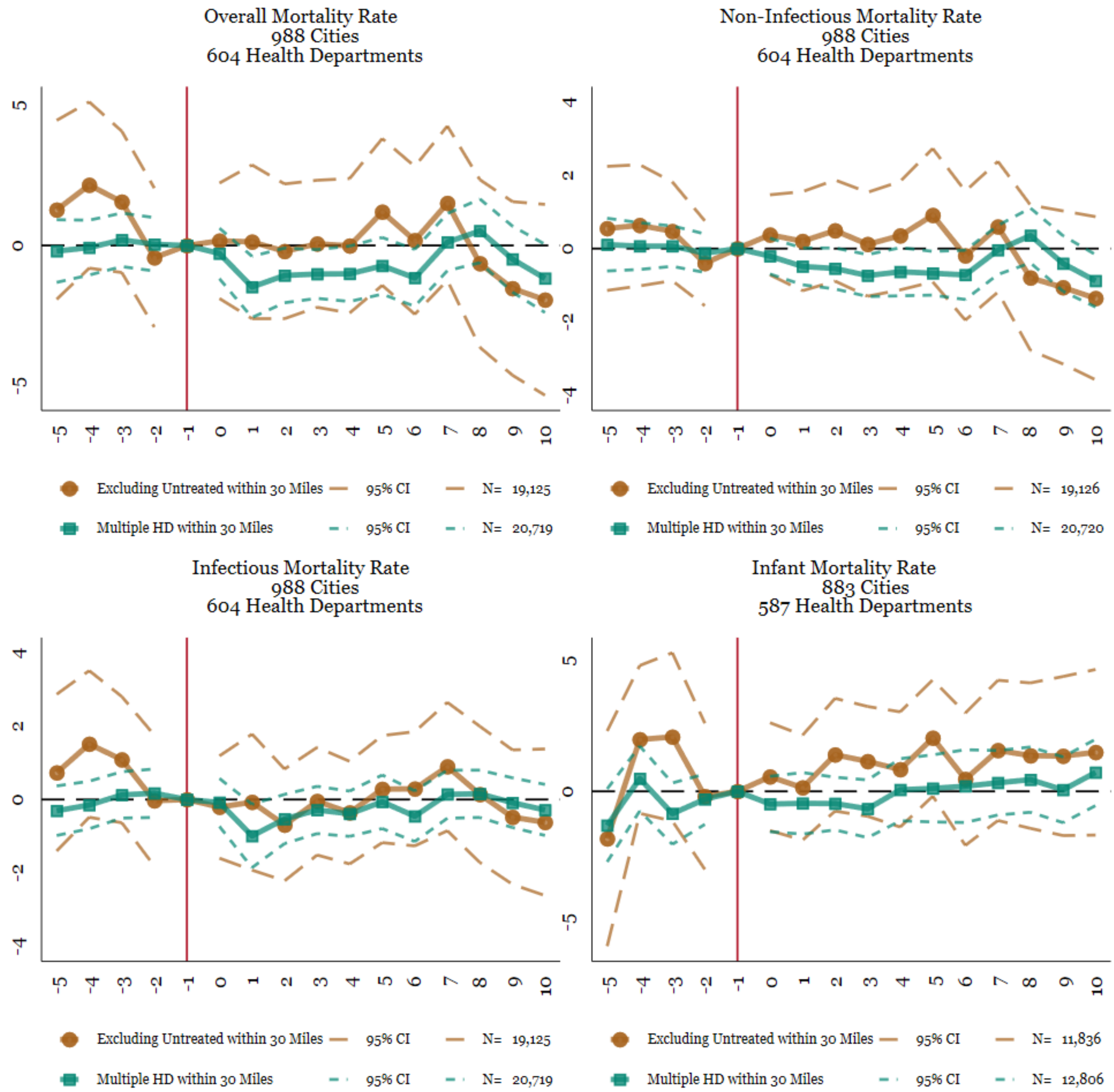
	Part-Time HD		Full-Time HD			
	(1)	(2)	(3)	(4)	(5)	(6)
	Timing	Timing	Timing	Timing	Treat -ment	Treat -ment
Log of Population	-0.164***	-0.149***	-0.754**	-0.714**	0.123***	0.095***
	(0.038)	(0.031)	(0.286)	(0.315)	(0.031)	(0.030)
Infectious Mortality Rate	0.000	0.001	0.015	0.022	-0.002*	-0.001
	(0.001)	(0.001)	(0.016)	(0.021)	(0.001)	(0.001)
Share White		-0.793		3.978		-1.087
		(0.773)		(7.784)		(0.685)
Share Under 5		1.578		2.446		-2.952
		(4.843)		(28.685)		(3.626)
Share Females		0.291		3.632		-0.163
		(1.715)		(12.810)		(0.841)
Physicians per 10,000		-0.013*		-0.010		0.010**
		(0.007)		(0.046)		(0.004)
Average Occscore		0.034		-0.098		-0.027
		(0.058)		(0.378)		(0.024)
Share Over 65		4.462		13.202		-5.366*
		(6.196)		(31.059)		(2.799)
N	452	449	320	318	456	451
Adjusted R-sq.	0.05	0.05	0.05	0.04	0.22	0.24
F-statistic	10.70	8.05	3.85	8.15	7.89	4.57
State FE	X	X	X	X	X	X

NOTES: The table displays the timing of full-time and part-time health departments based on population controls in a multivariate OLS regression model. Columns (1)-(2) show part-time and Columns (3)-(6) show the full-time timing. State fixed effects are included. Robust standard errors are clustered at the state level with significance levels at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

C Event Study and Full-Time Health Department Entry, Additional Specifications of Figures III and IV

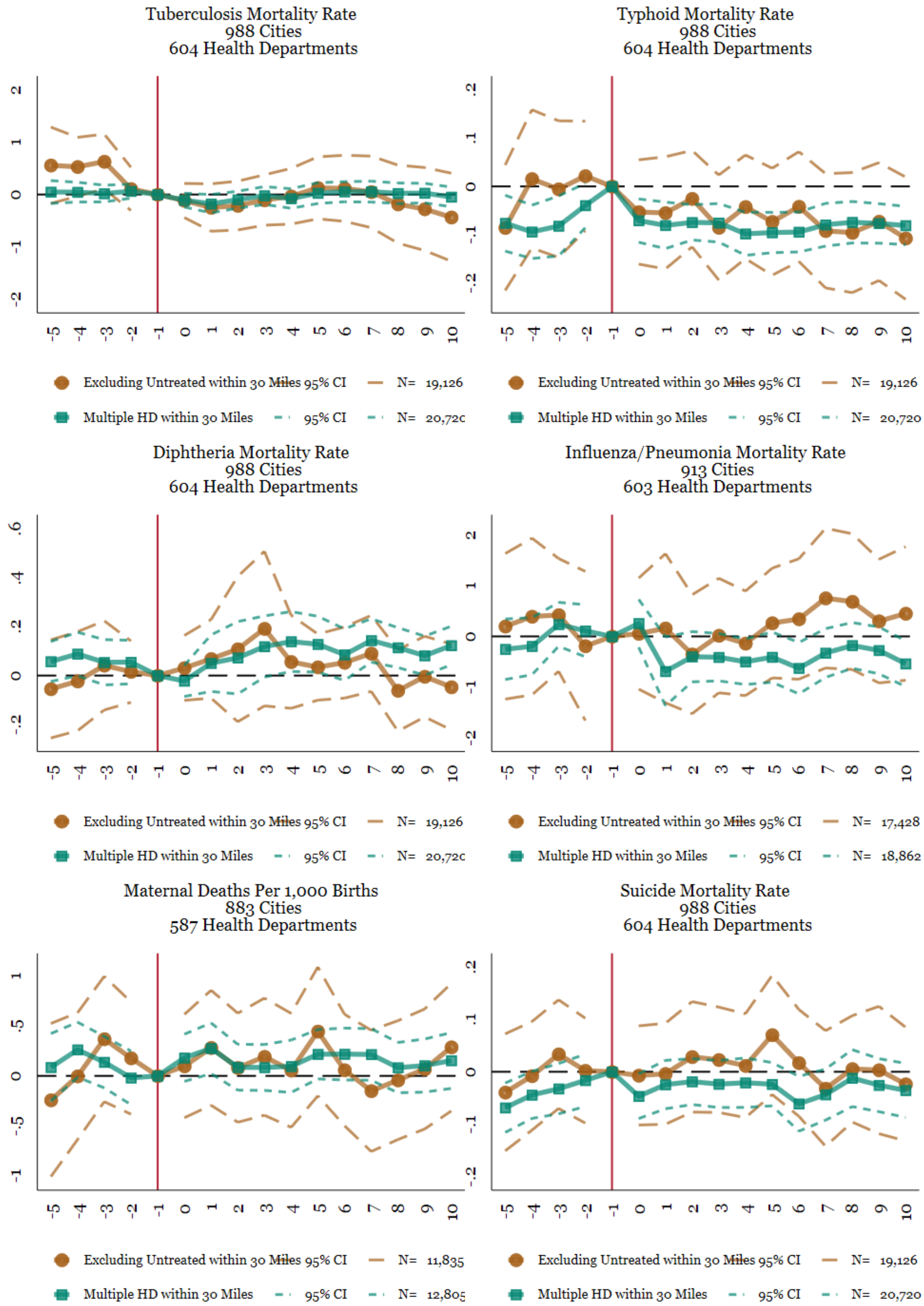
Figure C.1: Event Study: Accounting for Spillovers



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Figure C.2: Event Study: Accounting for Spillover, By-Cause Mortality



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

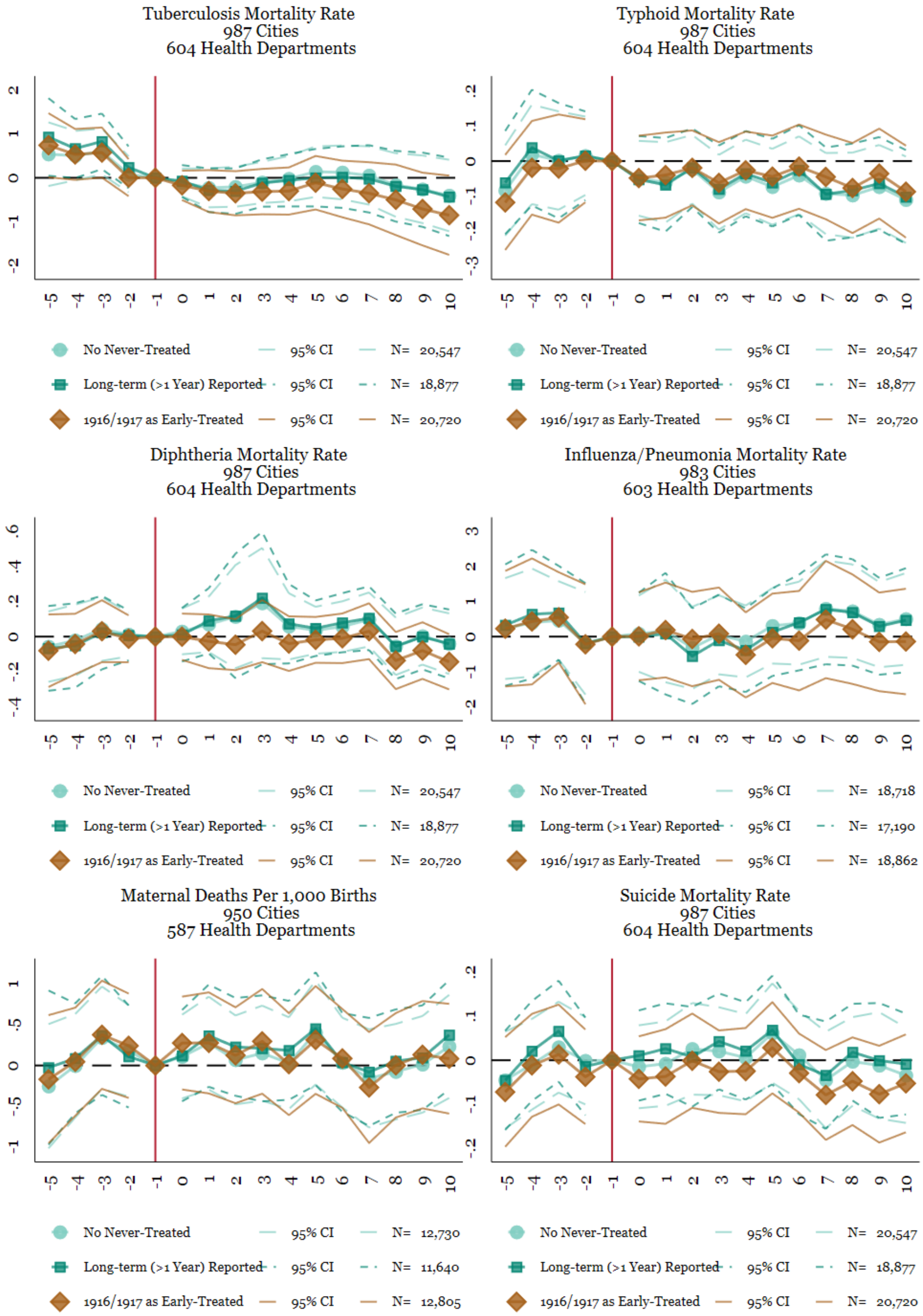
SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Figure C.3: Event Study: Long-Term Health Departments and using both 1916/1917 as Base Year for Early Treated

NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. The dark green diamonds show the two-way fixed effects specification with controls. The lighter green circles show the main specification, excluding controls (light green). The brown squares show the Interaction-Weighted estimator from Sun and Abraham (2020) relative to the never-treated group (excluding controls). Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. For the specification with long-term health departments, only part-time boards are included in the control group. Full-time boards that only reported full-time status in a single year are dropped. For the base year as 1916 and 1917, we replace 1917 as the first year for the early/always treated as the 1916 survey is the most suspect.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Figure C.4: Event Study: Long-Term Health Departments and using both 1916/1917 as Base Year for Early Treated, By-Cause Mortality



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. The dark green diamonds show the two-way fixed effects specification with controls. The lighter green circles show the main specification, excluding controls (light green). The brown squares show the Interaction-Weighted estimator from Sun and Abraham (2020) relative to the never-treated group (excluding controls). Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. For the specification with long-term health departments, only part-time boards are included in the control group. Full-time boards that only reported full-time status in a single year are dropped. For the base year as 1916 and 1917, we replace 1917 as the first year for the early/always treated as the 1916 survey is the most suspect.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Figure C.5: Event Study: Log of Mortality

NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. The dark green diamonds show the two-way fixed effects specification with controls. The lighter green circles show the main specification, excluding controls (light green). The brown squares show the Interaction-Weighted estimator from Sun and Abraham (2020) relative to the never-treated group (excluding controls). Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

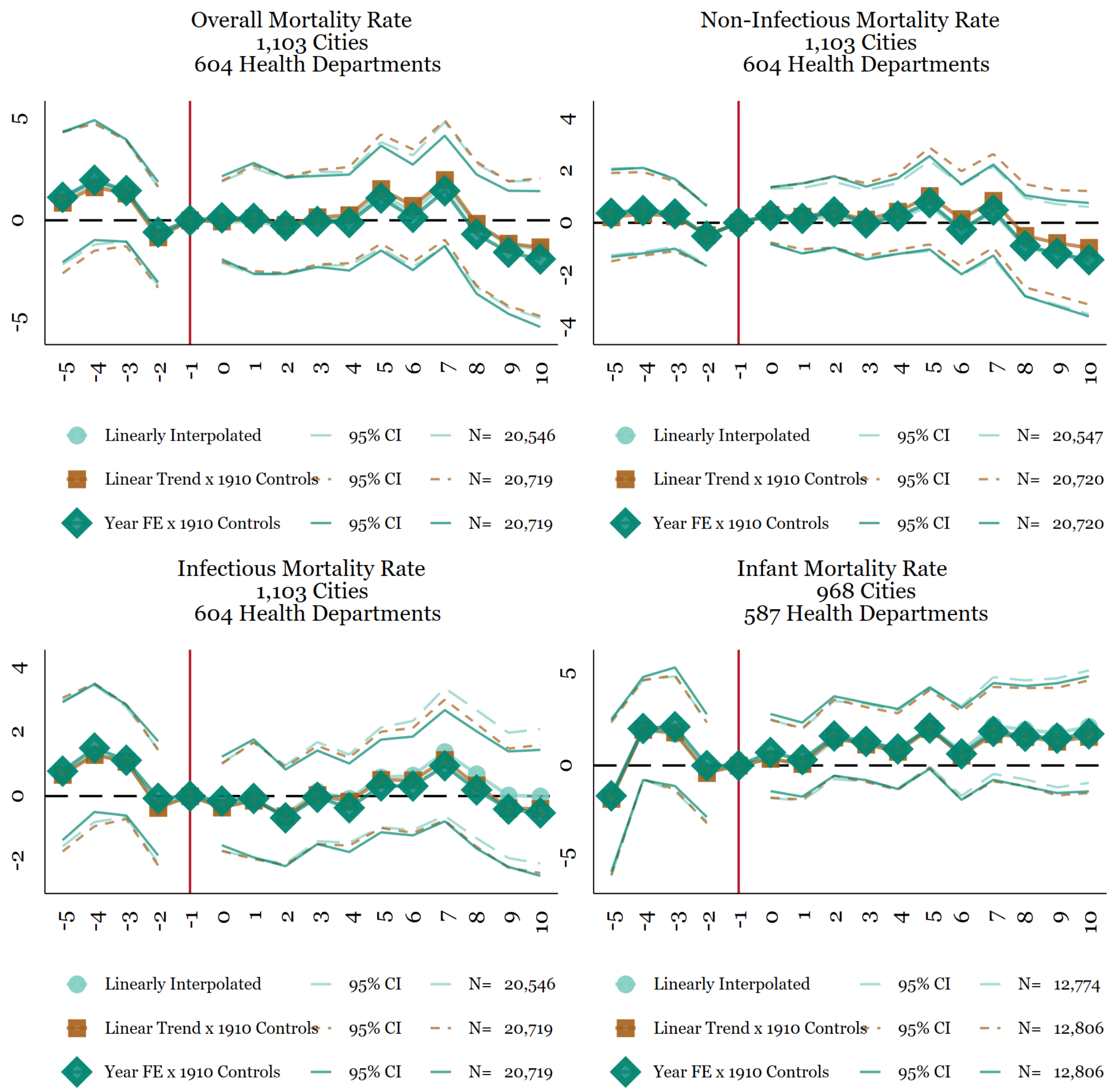
SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Figure C.6: Event Study: Log of Mortality, By-Cause Mortality

Notes: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. The dark green diamonds show the two-way fixed effects specification with controls. The lighter green circles show the main specification, excluding controls (light green). The brown squares show the Interaction-Weighted estimator from Sun and Abraham (2020) relative to the never-treated group (excluding controls). Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

Sources: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

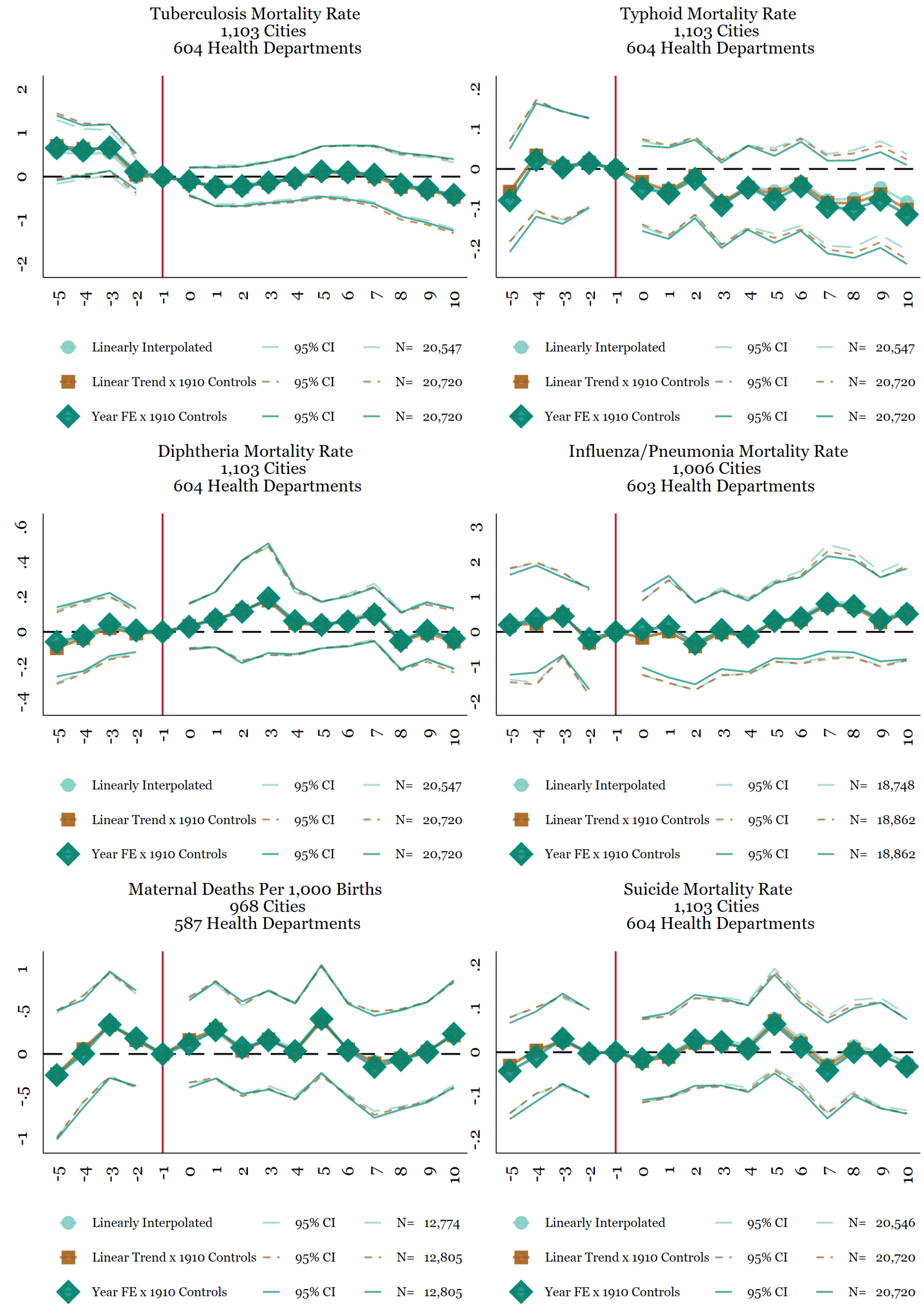
Figure C.7: Event Study: Alternative Controls



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

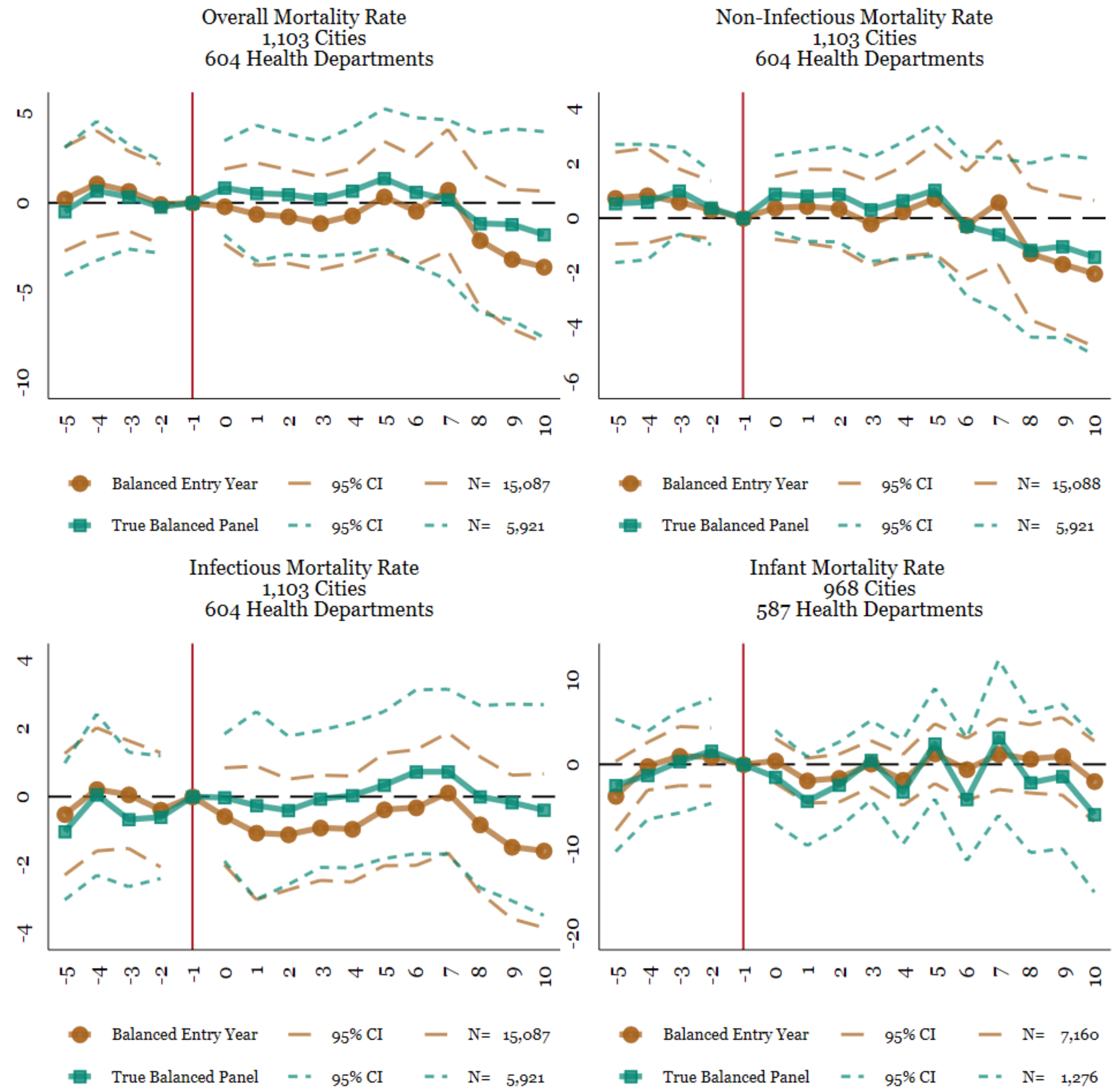
Figure C.8: Event Study: Alternative Controls, By-Cause Mortality



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

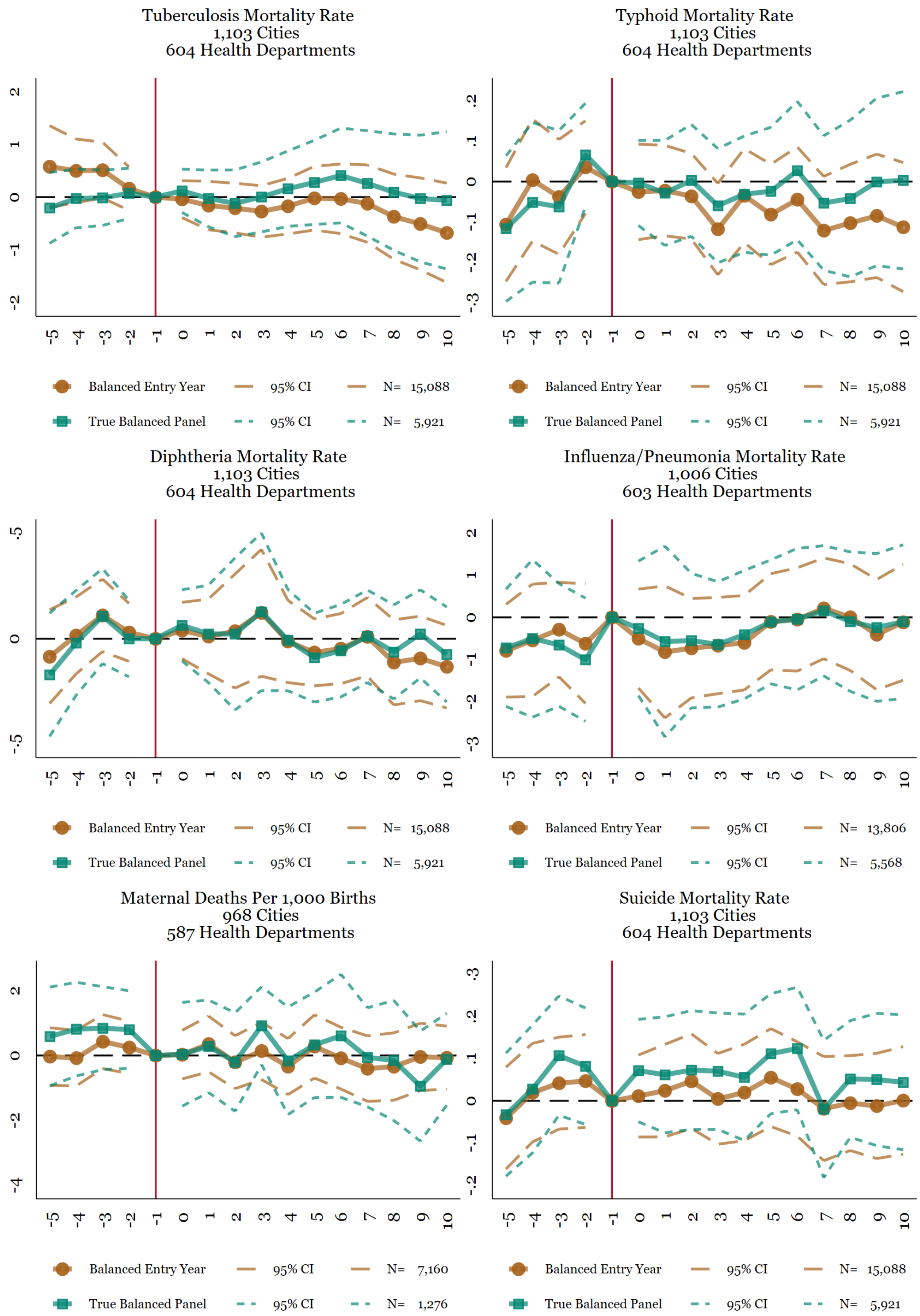
Figure C.9: Event Study: Balanced Panel



Notes: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

Sources: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

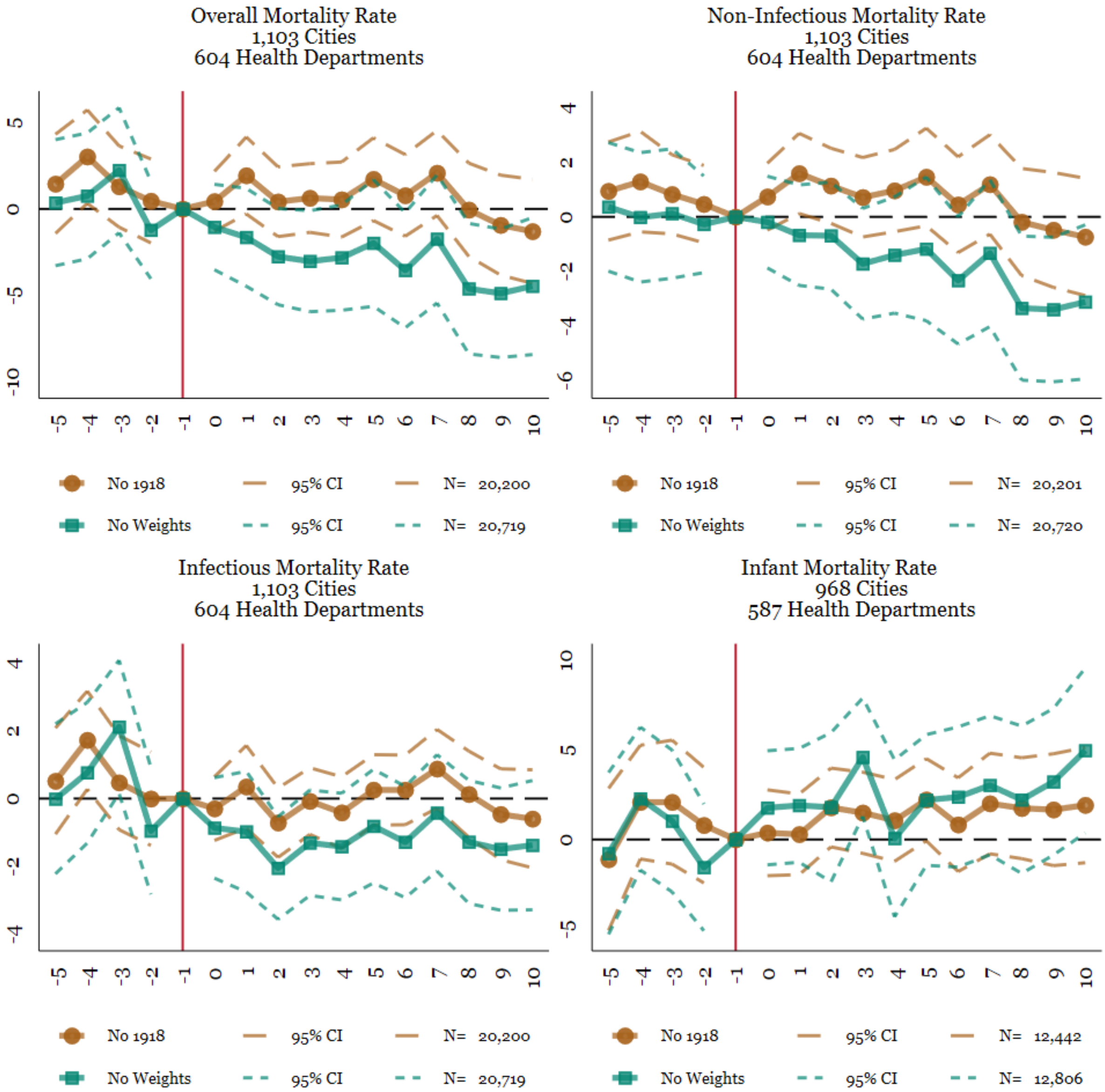
Figure C.10: Event Study: Balanced Panel, By-Cause Mortality



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

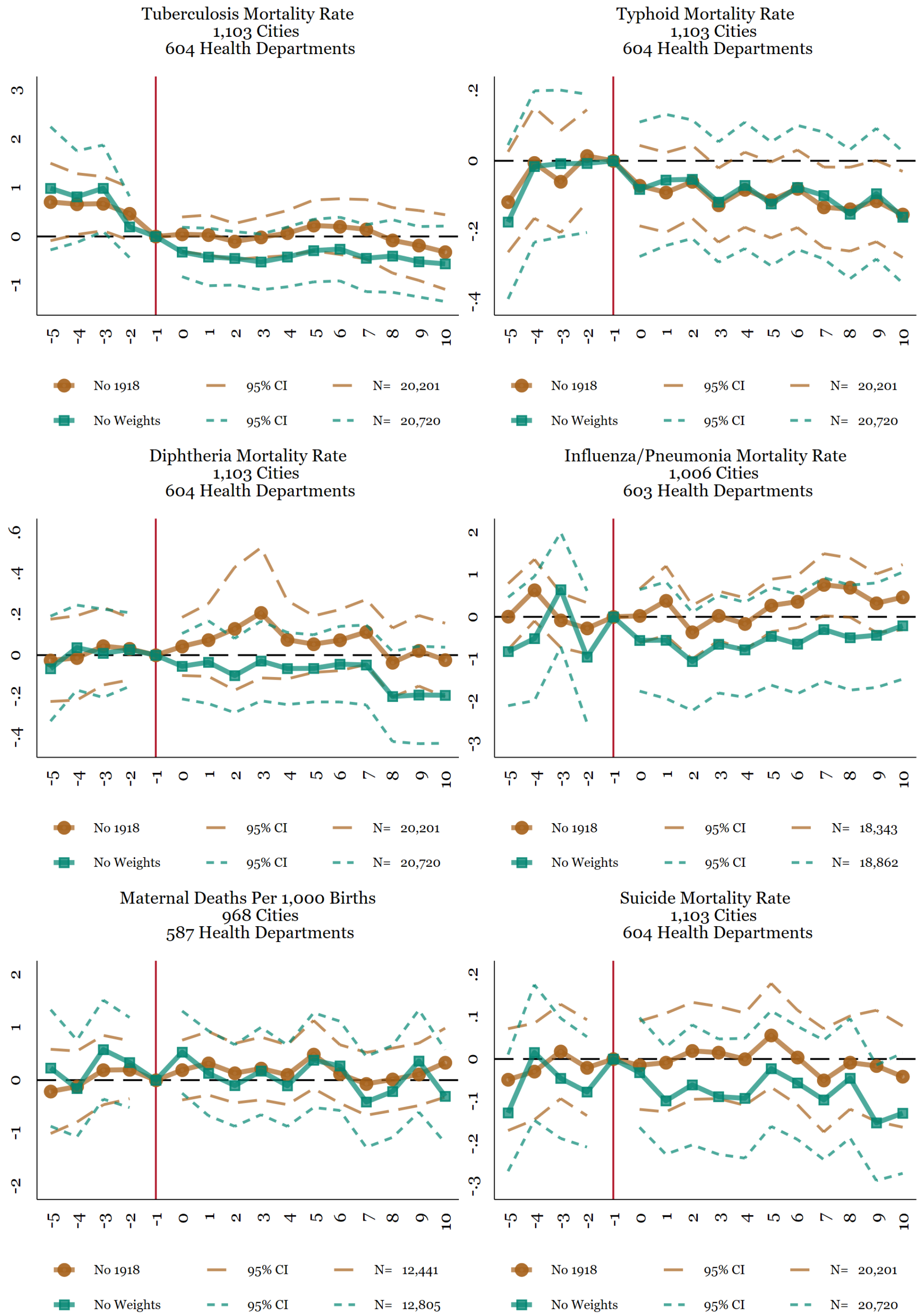
Figure C.11: Event Study: No Weights and Excluding 1918



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

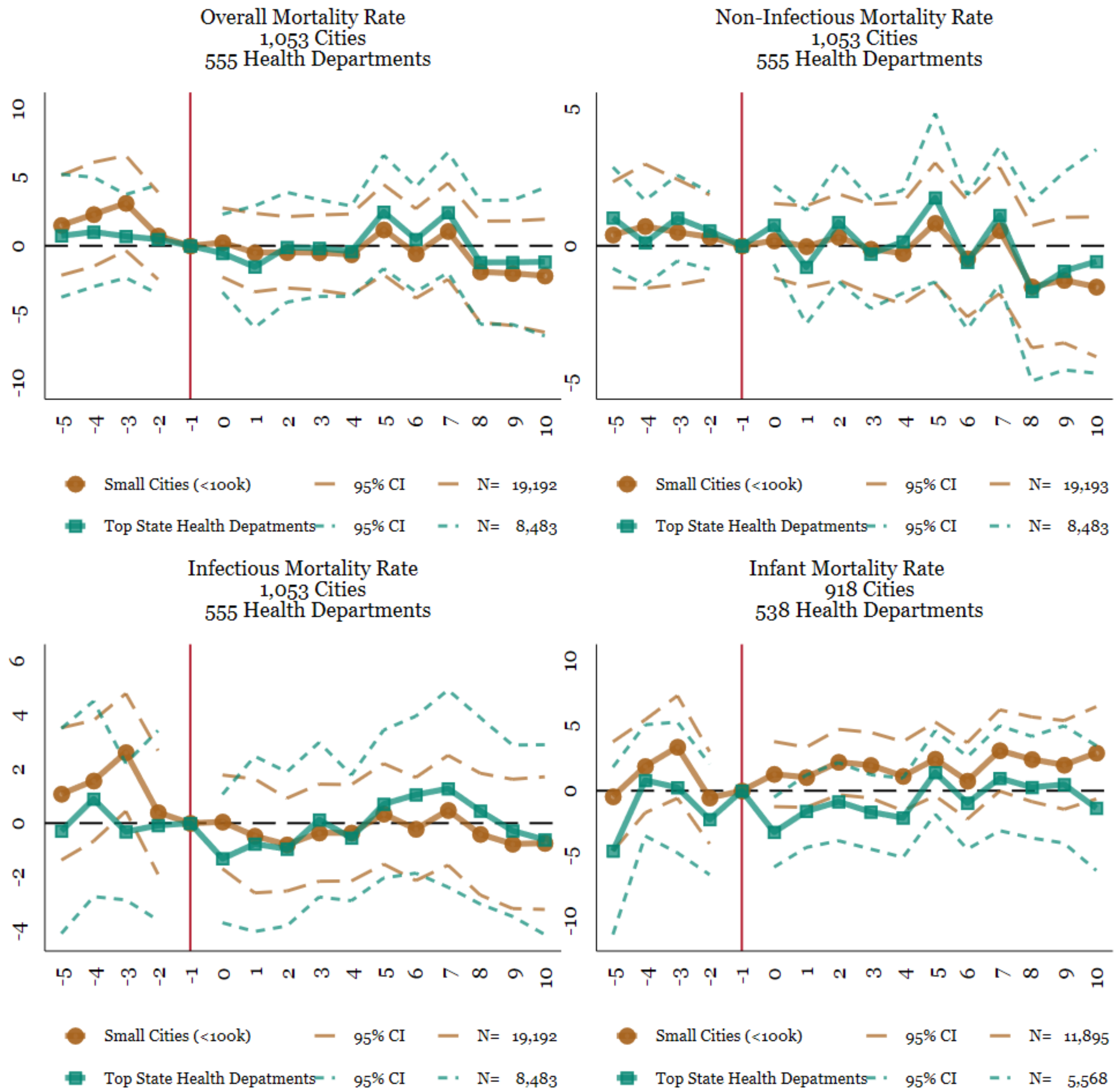
Figure C.12: Event Study: No Weights and Excluding 1918, By-Cause Mortality



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

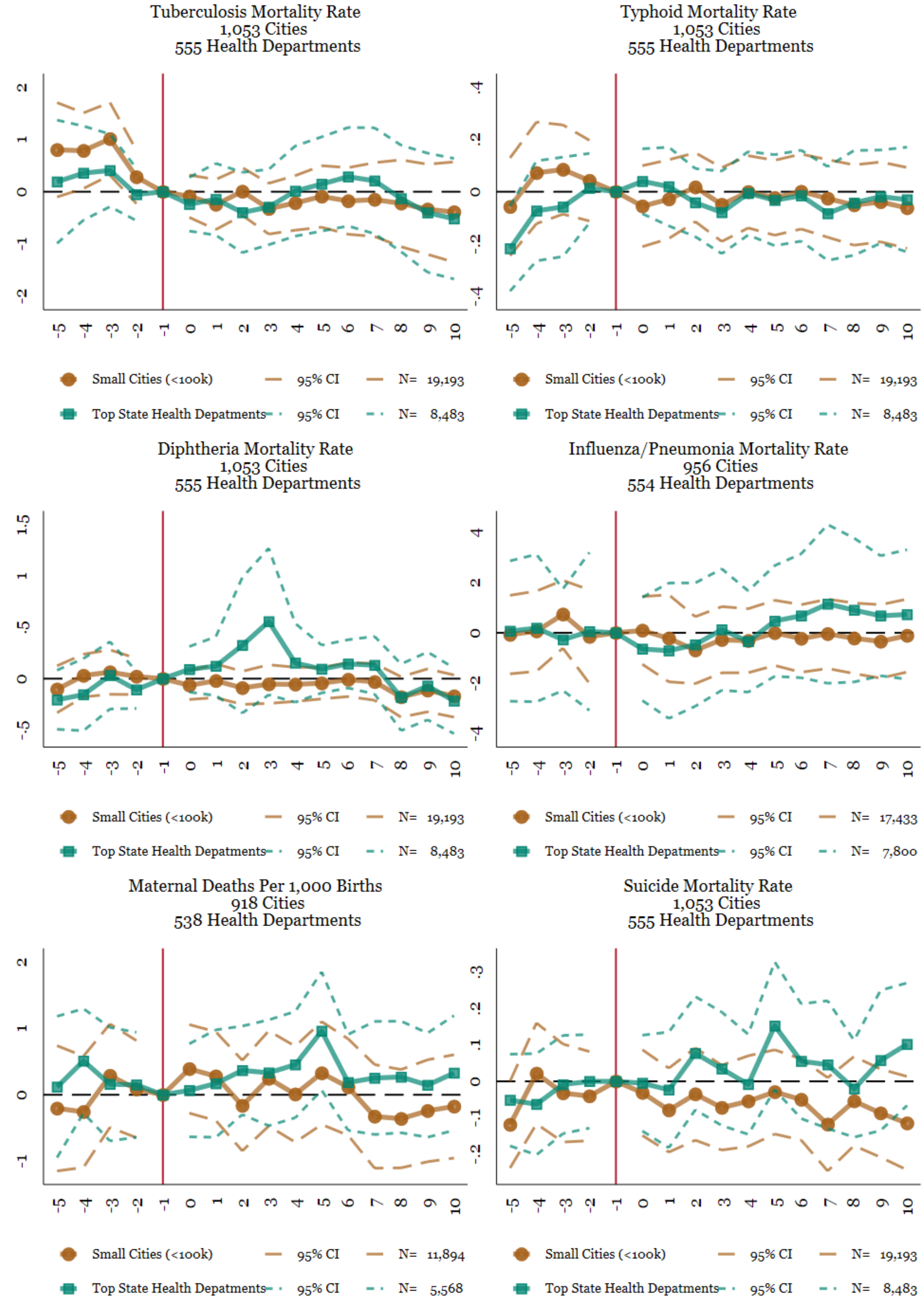
Figure C.13: Event Study: Small Cities and Best State Health Departments



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

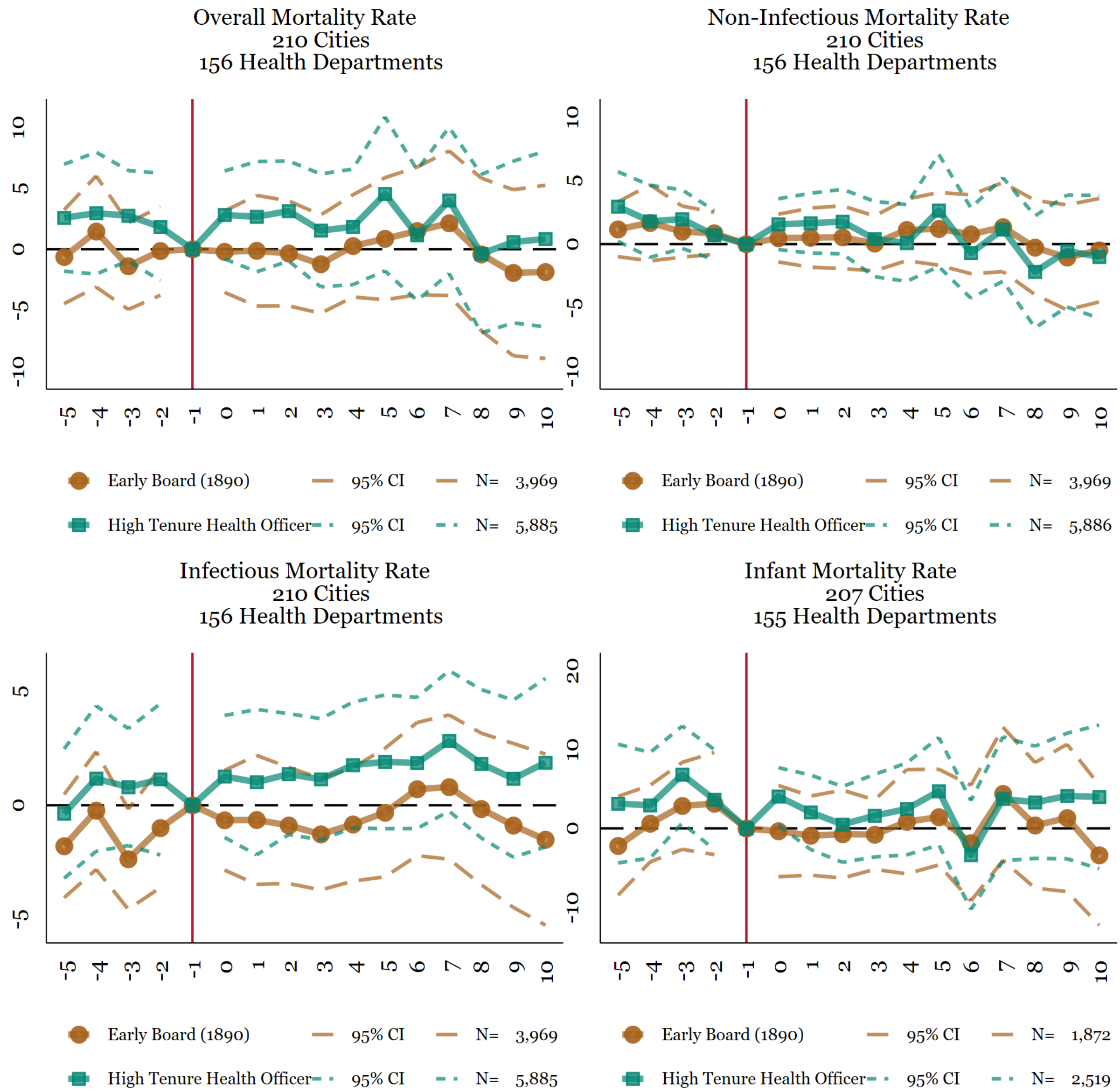
Figure C.14: Event Study: Small Cities and Best State Health Departments, By-Cause Mortality



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

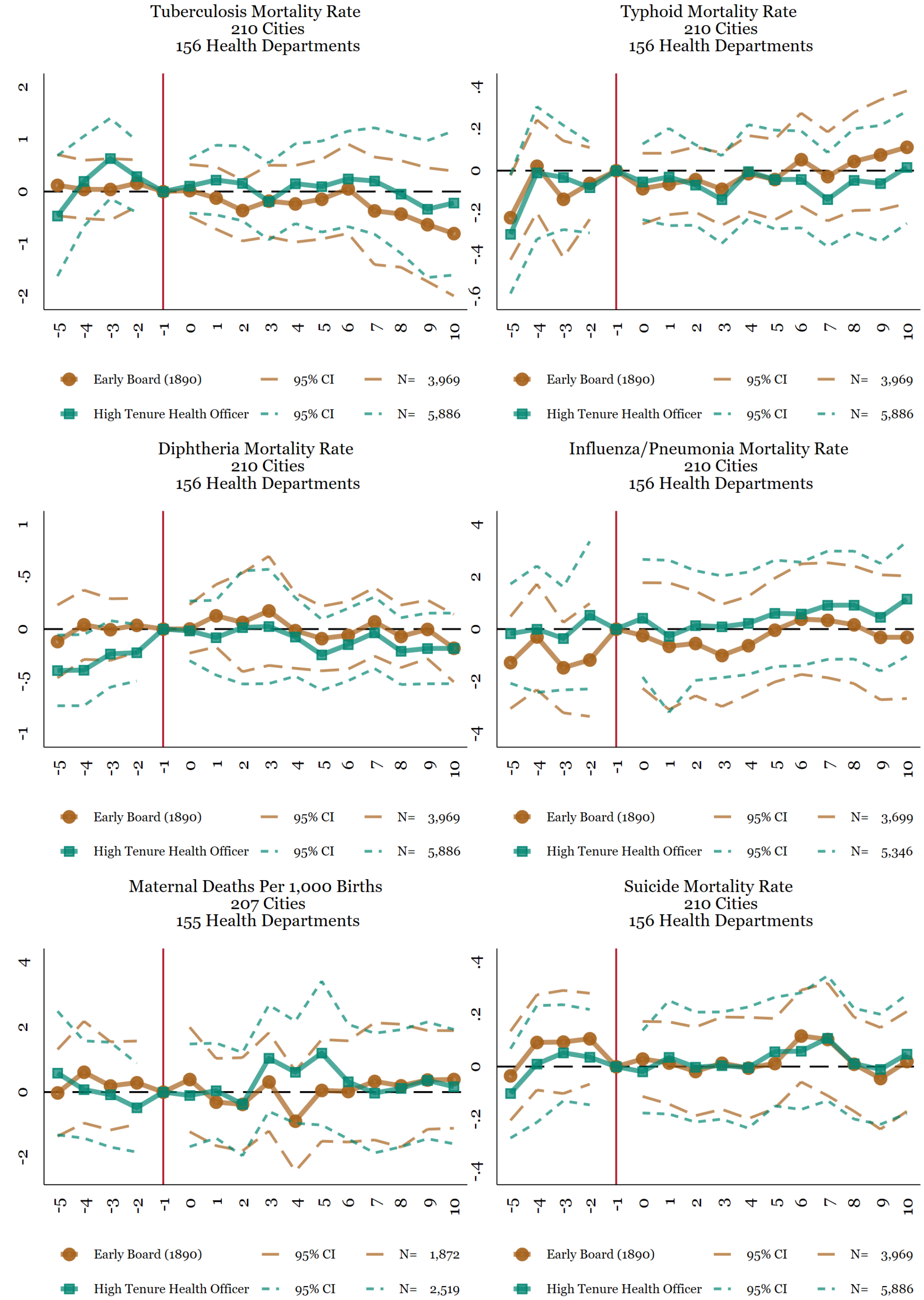
Figure C.15: Event Study: Quality Measures



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

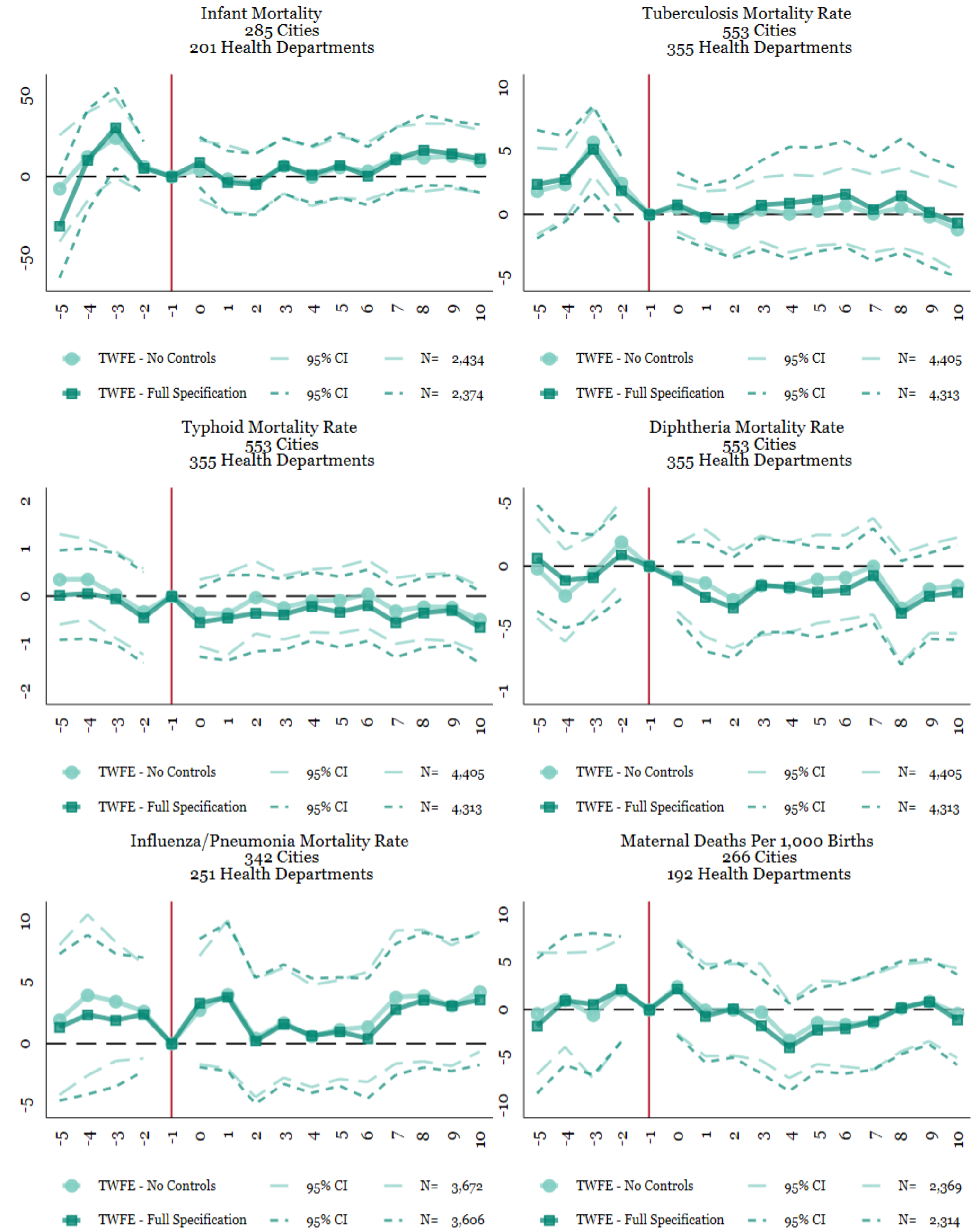
Figure C.16: Event Study: Quality Measures, By-Cause Mortality



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Figure C.17: Event Study: Full-time Health Department Entry–Non-white Mortality



NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. We only show the coefficients from the event window, however, the specification includes all lags and leads on health department entry. Dashed and dotted lines display the 95 percent confidence intervals. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. (In this case weights of population and births are for the non-white population) Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

D Grouped Event-time Specification

D.1 The null effect holds in alternative control groups and subsamples

Next, we test an alternative specification where we group the event-study indicators and employ alternative control groups for the main findings. The groupings that we examine are periods up to -4; the two periods before the excluded period, -3 and -2; then post-treatment periods 0 and 1; periods 2 and 3; periods 4 and 5; and periods 6 or more. Table D.1 shows the results using the grouped event-study indicators. All reported results focus on city-level overall mortality, infant mortality, and infectious disease mortality.

Beginning with Columns (1)-(3), we repeat the baseline estimation with the grouped indicators and add a linear city-specific time trend. The findings show no significant decline in urban mortality after the health department opens. Then, over Columns (4)-(12), we test whether the health departments' impact over alternative control groups. In Columns (4)-(6), we examine the effect relative to the pre-treatment year and part-time boards of health. In Columns (7)-(9), we omit all cities that never operated a full-time health department, where the control group is cities that already had a full-time health department. In Columns (10)-(12), we show the results for cities that adopted full-time health departments after 1916, where there is no control group, only the omitted period. The findings still generally show no effect of the health department with the alternative omitted groups.

We also test different subsamples of the treated group over city-level mortality in Table D.2. In Table D.2 we only show the primary measures most likely affected by public health measures– infant mortality and infectious disease mortality. Over Columns (1)-(8), we drop each region one at a time to see whether any particular regions of the country are driving the null results. Over Columns (1)-(8), the health department has no consistent effect. Finally, in Columns (9)-(12), we compare the findings over early and areas that adopted a health department between 1917 and 1926; and those that adopted 1926 onward. The findings are again null in the specifications.

D.2 There is a decline in infant mortality only in the best state health department states

In addition to the main robustness checks we consider additional heterogeneous effects across in Appendix Tables D.5, D.6, D.7, and D.8. Two declines appear. First in Table D.5, where we limit the sample to states with the best state health departments, measured by a rating of higher than five in Chapin (1916) (seven states in total) (shown in Appendix Table A.3). Cities with the best state health departments show reductions in infant mortality for the two years after the health department arrives. After the initial decline, the coefficient remains negative but is no longer statistically significant. The observed decline in infant mortality is similar in magnitude to Hoehn-Velasco (2018), and suggests that the most effective health departments may have been successful at targeting infant mortality (initially). Second, tuberculosis also declines in cities of smaller size (Table D.6).

Table D.5 Columns (7)-(12) also shows the findings for cities with a sizeable nonwhite population, with again no effect. Similarly, the results in Table D.7 suggest no difference in effect across areas with high or low-physician access or high and low foreign-born populations in Table D.8.

Table D.1: Grouped Event Study–Alternative Control Groups

	County Trends			Relative to Part-Time			Only Full-Time			No Control Group		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	All	Infect.	Infant	All	Infect.	Infant	All	Infect.	Infant	All	Infect.	Infant
Years up to -4	1.25	0.80	1.33	1.34	0.82	1.33	1.40	0.82	1.81	-0.76	-0.29	0.15
	(1.70)	(1.06)	(1.48)	(1.69)	(1.06)	(1.48)	(1.76)	(1.10)	(1.50)	(1.52)	(0.83)	(1.44)
Year -2 and -3	0.60	0.44	1.15	0.63	0.43	1.16	1.03	0.67	1.44	0.82	0.43	0.87
	(1.09)	(0.78)	(1.37)	(1.09)	(0.78)	(1.37)	(1.13)	(0.81)	(1.38)	(1.09)	(0.72)	(1.37)
Years 0 and 1	0.20	-0.07	0.39	0.27	-0.05	0.40	0.47	-0.03	0.11	-0.44	-0.77	0.19
	(1.16)	(0.76)	(0.92)	(1.15)	(0.76)	(0.92)	(1.19)	(0.80)	(0.89)	(1.18)	(0.81)	(0.91)
Years 2 and 3	-0.23	-0.52	0.85	-0.14	-0.50	0.86	0.14	-0.42	0.55	-0.92	-1.12	0.98
	(1.15)	(0.69)	(1.09)	(1.15)	(0.69)	(1.09)	(1.16)	(0.70)	(1.07)	(1.17)	(0.71)	(1.19)
Years 4 and 5	0.12	-0.36	0.95	0.18	-0.37	0.96	0.71	-0.25	0.68	-0.26	-0.80	1.36
	(1.37)	(0.66)	(1.33)	(1.38)	(0.66)	(1.33)	(1.41)	(0.67)	(1.30)	(1.33)	(0.68)	(1.41)
Years 6-9	-1.05	-0.39	0.67	-1.01	-0.40	0.67	-0.58	-0.28	0.18	-1.41	-0.87	0.74
	(1.72)	(0.76)	(1.42)	(1.73)	(0.76)	(1.42)	(1.74)	(0.76)	(1.40)	(1.77)	(0.77)	(1.57)
N	20,719	20,719	12,806	20,546	20,546	12,731	13,859	13,859	8,599	11,061	11,061	6,906
Health Departments	604	604	587	604	604	587	604	604	587	508	508	492
Number of Cities	1,103	1,103	968	987	987	950	604	604	587	508	508	492
Mean Dependent	140.2	36.6	73.3	140.2	36.6	73.3	140.2	36.6	73.3	140.9	36.3	73.1
Adjusted R-squared	0.91	0.95	0.86	0.91	0.95	0.86	0.92	0.95	0.88	0.91	0.94	0.84
Year FE and City FE	X	X	X	X	X	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X	X	X	X	X	X
Linear Time Trends	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Coefficients are grouped event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. The first row represents the coefficient four periods before treatment, the second row represents the coefficient two and three periods before treatment. The third row is one and two periods after treatment, and so on. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table D.2: Grouped Event Study– Alternative Subsamples

	No Northeast		No Midwest		No South		No West		Treated Pre-1926		Treated 1926+	
	(1) Infant	(2) Infect.	(3) Infant	(4) Infect.	(5) Infant	(6) Infect.	(7) Infant	(8) Infect.	(9) Infant	(10) Infect.	(11) Infant	(12) Infect.
Years up to -4	1.96	1.72*	1.93	0.60	0.63	0.53	1.41	0.72	1.21	1.34	3.80	-0.12
	(1.81)	(0.95)	(1.83)	(1.48)	(1.53)	(1.14)	(1.58)	(1.21)	(2.43)	(1.53)	(5.23)	(1.38)
Year -2 and -3	2.86	0.97	0.55	0.59	0.49	-0.24	1.36	0.65	1.05	0.86	7.24*	-0.73
	(1.76)	(0.86)	(1.73)	(1.05)	(1.43)	(0.84)	(1.44)	(0.86)	(1.81)	(1.06)	(4.23)	(1.04)
Years 0 and 1	2.43*	1.21	-0.05	-0.61	-0.10	-0.19	0.20	-0.31	-0.72	-1.40	2.21	-1.03
	(1.33)	(0.93)	(1.06)	(1.03)	(0.93)	(0.75)	(0.96)	(0.82)	(1.31)	(1.19)	(3.87)	(0.89)
Years 2 and 3	1.46	-0.32	1.30	-0.53	0.19	-0.71	0.87	-0.46	0.31	-1.31	-2.64	-1.55
	(1.53)	(0.79)	(1.28)	(0.94)	(1.12)	(0.71)	(1.15)	(0.75)	(1.84)	(1.11)	(4.31)	(1.18)
Years 4 and 5	0.27	-0.35	1.97	-0.39	0.32	-0.62	1.08	-0.20	0.82	-0.53	-7.27	-1.39
	(1.80)	(0.76)	(1.63)	(0.89)	(1.38)	(0.67)	(1.40)	(0.72)	(2.36)	(1.13)	(5.68)	(1.46)
Years 6-9	0.08	-0.52	1.99	-0.06	-0.10	-0.59	0.85	-0.39	0.33	-0.24	-10.34	-2.11
	(2.00)	(0.84)	(1.73)	(1.03)	(1.45)	(0.78)	(1.51)	(0.84)	(2.73)	(1.23)	(7.53)	(1.83)
N	7,093	11,963	8,638	14,011	10,951	17,319	11,734	18,864	5,477	8,723	1,188	1,921
Health Departments	359	367	432	443	443	460	527	542	355	367	137	141
Number of Cities	605	705	665	767	762	854	873	983	355	367	137	141
Mean Dependent	73.5	38.1	75.4	38.3	69.4	33.6	74.9	36.9	73.4	37.1	72.0	33.3
Adjusted R-squared	0.84	0.94	0.87	0.95	0.87	0.95	0.86	0.95	0.85	0.95	0.76	0.94
Year FE and City FE	X	X	X	X	X	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X	X	X	X	X	X
Linear Time Trends	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Coefficients are grouped event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. The first row represents the coefficient four periods before treatment, the second row represents the coefficient two and three periods before treatment. The third row is one and two periods after treatment, and so on. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table D.3: Grouped Event Study–Heterogeneity by Early v. Later-Treated

	Treated Before 1926						Treated 1926+					
	(1) Infant	(2) Infect	(3) Flu	(4) TB	(5) Typh	(6) Diph	(7) Infant	(8) Infect	(9) Flu	(10) TB	(11) Typh	(12) Diph
Years up to -4	1.21	1.34	-0.12	0.52	0.01	-0.11	3.80	-0.12	1.03	-0.58	-0.18	0.12
	(2.43)	(1.53)	(1.03)	(0.54)	(0.12)	(0.14)	(5.23)	(1.38)	(0.92)	(0.70)	(0.19)	(0.20)
Year -2 and -3	1.05	0.86	-0.02	0.32	0.05	0.04	7.24*	-0.73	-0.52	-0.41	0.05	0.29**
	(1.81)	(1.06)	(0.86)	(0.31)	(0.08)	(0.09)	(4.23)	(1.04)	(0.57)	(0.57)	(0.15)	(0.13)
Years 0 and 1	-0.72	-1.40	-1.26	-0.12	-0.06	0.01	2.21	-1.03	-0.29	-0.08	-0.05	-0.04
	(1.31)	(1.19)	(0.95)	(0.24)	(0.07)	(0.10)	(3.87)	(0.89)	(0.53)	(0.41)	(0.10)	(0.14)
Years 2 and 3	0.31	-1.31	-1.54*	-0.03	-0.07	0.15	-2.64	-1.55	-0.58	-0.04	-0.02	-0.03
	(1.84)	(1.11)	(0.81)	(0.30)	(0.09)	(0.17)	(4.31)	(1.18)	(0.73)	(0.42)	(0.11)	(0.19)
Years 4 and 5	0.82	-0.53	-1.02	0.19	-0.12	0.12	-7.27	-1.39	-0.60	0.08	0.06	-0.16
	(2.36)	(1.13)	(0.78)	(0.38)	(0.10)	(0.16)	(5.68)	(1.46)	(0.82)	(0.49)	(0.11)	(0.23)
Years 6-9	0.33	-0.24	-0.88	0.32	-0.17	0.06	-10.34	-2.11	-0.09	-0.23	0.10	-0.22
	(2.73)	(1.23)	(0.83)	(0.53)	(0.13)	(0.17)	(7.53)	(1.83)	(1.15)	(0.58)	(0.13)	(0.25)
N	5,477	8,723	8,025	8,723	8,723	8,723	1,188	1,921	1,683	1,921	1,921	1,921
Health Departments	355	367	367	367	367	367	137	141	140	141	141	141
Number of Cities	355	367	367	367	367	367	137	141	140	141	141	141
Mean Dependent	73.4	37.1	16.4	9.0	0.9	0.9	72.0	33.3	14.7	8.4	0.8	0.7
Adjusted R-squared	0.85	0.95	0.91	0.93	0.69	0.72	0.76	0.94	0.87	0.89	0.75	0.70
Year FE and City FE	X	X	X	X	X	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X	X	X	X	X	X
Linear Time Trends	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Coefficients are grouped event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. The first row represents the coefficient four periods before treatment, the second row represents the coefficient two and three periods before treatment. The third row is one and two periods after treatment, and so on. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table D.4: Grouped Event Study–Heterogeneity by Early v. Later-Treated, Excluding 1918

	Treated Before 1926						Treated 1926+					
	(1) Infant	(2) Infect	(3) Flu	(4) TB	(5) Typh	(6) Diph	(7) Infant	(8) Infect	(9) Flu	(10) TB	(11) Typh	(12) Diph
Years up to -4	2.57	2.62**	0.66	0.72	0.01	-0.08	3.57	-0.95	0.22	-0.59	-0.19	0.11
	(2.66)	(1.25)	(0.60)	(0.60)	(0.13)	(0.15)	(5.15)	(1.40)	(0.79)	(0.68)	(0.20)	(0.21)
Year -2 and -3	2.60	1.47*	0.10	0.57	0.06	0.07	7.15*	-0.90	-0.68	-0.41	0.05	0.28**
	(1.85)	(0.85)	(0.50)	(0.35)	(0.09)	(0.11)	(4.22)	(1.04)	(0.55)	(0.56)	(0.15)	(0.13)
Years 0 and 1	-0.70	0.02	-0.08	-0.04	-0.03	-0.01	2.22	-0.83	-0.12	-0.08	-0.05	-0.04
	(1.57)	(0.76)	(0.49)	(0.25)	(0.08)	(0.12)	(3.85)	(0.88)	(0.52)	(0.41)	(0.10)	(0.14)
Years 2 and 3	0.29	-0.46	-0.90*	0.03	-0.05	0.14	-2.53	-1.16	-0.22	-0.03	-0.01	-0.02
	(1.96)	(0.85)	(0.49)	(0.30)	(0.08)	(0.18)	(4.34)	(1.19)	(0.68)	(0.42)	(0.11)	(0.18)
Years 4 and 5	0.61	0.22	-0.47	0.23	-0.10	0.11	-7.03	-0.84	-0.09	0.09	0.07	-0.15
	(2.47)	(0.97)	(0.50)	(0.39)	(0.10)	(0.17)	(5.74)	(1.49)	(0.77)	(0.49)	(0.11)	(0.22)
Years 6-9	-0.06	0.41	-0.38	0.35	-0.16	0.05	-9.99	-1.43	0.54	-0.22	0.11	-0.21
	(2.87)	(1.12)	(0.54)	(0.54)	(0.13)	(0.18)	(7.63)	(1.91)	(1.02)	(0.58)	(0.13)	(0.25)
N	5,314	8,494	7,796	8,494	8,494	8,494	1,170	1,889	1,651	1,889	1,889	1,889
Health Departments	355	367	367	367	367	367	137	141	140	141	141	141
Number of Cities	355	367	367	367	367	367	137	141	140	141	141	141
Mean Dependent	72.4	35.2	14.7	8.8	0.9	0.9	71.2	31.9	13.5	8.2	0.8	0.7
Adjusted R-squared	0.84	0.94	0.85	0.93	0.70	0.72	0.75	0.93	0.82	0.89	0.75	0.70
Year FE and City FE	X	X	X	X	X	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X	X	X	X	X	X
Linear Time Trends	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Coefficients are grouped event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. The first row represents the coefficient four periods before treatment, the second row represents the coefficient two and three periods before treatment. The third row is one and two periods after treatment, and so on. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table D.5: Grouped Event Study–Heterogeneity by Best State Health Departments and High Non-white Population

	Best State HD						Less than 90% White					
	(1) Infant	(2) Infect	(3) Flu	(4) TB	(5) Typh	(6) Diph	(7) Infant	(8) Infect	(9) Flu	(10) TB	(11) Typh	(12) Diph
Years up to -4	-0.01	0.14	0.18	0.00	-0.12	-0.08	3.97	2.15	0.77	0.05	0.06	0.19
	(2.10)	(2.11)	(1.49)	(0.54)	(0.08)	(0.13)	(3.47)	(1.93)	(1.25)	(1.01)	(0.19)	(0.13)
Year -2 and -3	-0.47	-0.04	0.08	0.11	-0.01	-0.06	5.10*	3.98***	1.54	1.09*	0.13	0.03
	(2.07)	(1.52)	(1.29)	(0.28)	(0.06)	(0.12)	(2.68)	(1.43)	(1.02)	(0.57)	(0.16)	(0.10)
Years 0 and 1	-2.70**	-1.08	-0.82	-0.11	0.04	0.14	5.18**	0.04	0.46	-0.65*	-0.08	-0.16*
	(1.20)	(1.29)	(1.13)	(0.28)	(0.06)	(0.12)	(2.40)	(1.48)	(1.09)	(0.37)	(0.14)	(0.10)
Years 2 and 3	-1.88	-0.61	-0.58	-0.15	-0.04	0.52	6.98**	-0.49	-0.32	-0.40	-0.09	0.10
	(1.47)	(1.31)	(1.20)	(0.37)	(0.07)	(0.36)	(2.88)	(1.31)	(0.95)	(0.41)	(0.14)	(0.13)
Years 4 and 5	-1.07	-0.37	-0.61	0.35	0.00	0.23	6.24*	-0.01	-0.40	-0.17	-0.10	0.05
	(1.90)	(1.11)	(1.01)	(0.46)	(0.07)	(0.16)	(3.54)	(1.39)	(0.92)	(0.46)	(0.15)	(0.12)
Years 6-9	-1.19	-0.37	-0.21	0.28	-0.02	0.21	6.79	-0.26	-0.13	-0.45	-0.16	-0.09
	(1.99)	(1.37)	(1.26)	(0.54)	(0.08)	(0.14)	(4.34)	(1.66)	(0.95)	(0.55)	(0.17)	(0.11)
N	5,568	8,483	7,800	8,483	8,483	8,483	5,061	8,543	7,484	8,544	8,544	8,544
Health Departments	217	221	221	221	221	221	313	327	326	327	327	327
Number of Cities	356	387	370	387	387	387	572	696	599	696	696	696
Mean Dependent	71.9	34.3	16.1	7.4	0.6	1.1	76.4	38.3	16.4	10.0	1.0	0.8
Adjusted R-squared	0.89	0.96	0.93	0.93	0.66	0.71	0.77	0.94	0.88	0.93	0.71	0.57
Year FE and City FE	X	X	X	X	X	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X	X	X	X	X	X
Linear Time Trends	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Coefficients are grouped event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. The first row represents the coefficient four periods before treatment, the second row represents the coefficient two and three periods before treatment. The third row is one and two periods after treatment, and so on. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table D.6: Grouped Event Study–Heterogeneity by Size of City

	Small City						Large City					
	(1) Infant	(2) Infect	(3) Flu	(4) TB	(5) Typh	(6) Diph	(7) Infant	(8) Infect	(9) Flu	(10) TB	(11) Typh	(12) Diph
Years up to -4	-0.82	-1.43	-1.69	0.71	-0.11	-0.12	2.04	1.17	0.73	-0.02	-0.12	0.05
	(2.53)	(1.47)	(1.13)	(0.70)	(0.14)	(0.16)	(1.81)	(1.35)	(0.97)	(0.39)	(0.08)	(0.11)
Year -2 and -3	0.71	-0.24	-0.40	0.35	0.00	-0.05	1.40	0.85	0.53	0.15	-0.04	0.03
	(2.12)	(1.26)	(1.11)	(0.45)	(0.13)	(0.15)	(1.83)	(1.06)	(0.82)	(0.22)	(0.06)	(0.09)
Years 0 and 1	3.13	-1.26	-0.61	-0.50*	0.04	-0.09	-0.36	0.13	0.32	-0.05	-0.09*	0.12
	(1.92)	(1.10)	(0.94)	(0.30)	(0.12)	(0.12)	(1.05)	(1.08)	(0.87)	(0.22)	(0.06)	(0.09)
Years 2 and 3	3.21	-2.23**	-1.01	-0.68**	-0.05	-0.01	0.24	-0.12	-0.20	0.02	-0.05	0.28
	(2.23)	(1.11)	(0.91)	(0.32)	(0.11)	(0.16)	(1.33)	(0.96)	(0.78)	(0.28)	(0.05)	(0.24)
Years 4 and 5	3.28	-1.82	-0.98	-0.36	-0.09	-0.02	0.74	0.03	-0.05	0.30	-0.02	0.13
	(2.43)	(1.26)	(0.93)	(0.40)	(0.13)	(0.15)	(1.64)	(0.85)	(0.66)	(0.34)	(0.06)	(0.11)
Years 6-9	5.47*	-1.89	-0.62	-0.49	-0.07	-0.18	-0.52	-0.20	0.32	0.13	-0.03	0.18
	(2.98)	(1.48)	(1.05)	(0.56)	(0.14)	(0.17)	(1.65)	(0.96)	(0.75)	(0.41)	(0.07)	(0.11)
N	7,871	12,665	11,338	12,666	12,666	12,666	4,847	7,876	7,356	7,876	7,876	7,876
Health Departments	375	392	391	392	392	392	212	212	212	212	212	212
Number of Cities	700	834	737	834	834	834	268	269	269	269	269	269
Mean Dependent	73.8	35.7	16.2	8.3	0.9	0.9	72.6	37.6	16.1	9.6	0.8	1.0
Adjusted R-squared	0.73	0.89	0.81	0.88	0.57	0.47	0.91	0.96	0.94	0.95	0.75	0.78
Year FE and City FE	X	X	X	X	X	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X	X	X	X	X	X
Linear Time Trends	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Coefficients are grouped event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. The first row represents the coefficient four periods before treatment, the second row represents the coefficient two and three periods before treatment. The third row is one and two periods after treatment, and so on. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table D.7: Grouped Event Study–Heterogeneity by Physician Access

	Low Physician Access						High Physician Access					
	(1) Infant	(2) Infect	(3) Flu	(4) TB	(5) Typh	(6) Diph	(7) Infant	(8) Infect	(9) Flu	(10) TB	(11) Typh	(12) Diph
Years up to -4	1.79	0.89	0.38	0.18	-0.10	0.07	2.34	2.39	1.26	0.46	0.04	-0.12
	(1.54)	(1.24)	(0.92)	(0.33)	(0.07)	(0.10)	(4.31)	(1.91)	(1.12)	(1.07)	(0.19)	(0.19)
Year -2 and -3	0.76	0.34	0.35	0.13	-0.05	0.01	3.78	2.64*	1.02	0.45	0.14	0.13
	(1.51)	(0.95)	(0.75)	(0.20)	(0.06)	(0.08)	(2.99)	(1.46)	(1.07)	(0.56)	(0.16)	(0.17)
Years 0 and 1	0.12	0.38	0.24	-0.00	-0.05	0.11	2.42	-1.19	-0.59	-0.69*	0.03	-0.05
	(0.98)	(0.94)	(0.79)	(0.20)	(0.05)	(0.09)	(2.72)	(1.11)	(0.84)	(0.41)	(0.14)	(0.11)
Years 2 and 3	0.03	-0.32	-0.35	-0.14	-0.06	0.21	4.96	-1.14	-0.73	-0.44	-0.03	0.11
	(1.17)	(0.85)	(0.72)	(0.26)	(0.05)	(0.23)	(3.31)	(1.08)	(0.85)	(0.44)	(0.13)	(0.14)
Years 4 and 5	0.18	-0.31	-0.26	0.15	-0.02	0.09	4.34	-0.79	-0.64	-0.46	-0.09	0.14
	(1.45)	(0.78)	(0.62)	(0.32)	(0.06)	(0.11)	(3.69)	(1.22)	(0.84)	(0.51)	(0.14)	(0.13)
Years 6-9	0.19	-0.54	0.02	0.05	-0.04	0.16	3.33	-0.53	-0.12	-0.53	-0.12	0.03
	(1.51)	(0.90)	(0.71)	(0.38)	(0.07)	(0.11)	(4.19)	(1.49)	(0.96)	(0.64)	(0.16)	(0.14)
N	7,480	11,839	11,059	11,839	11,839	11,839	5,196	8,655	7,592	8,656	8,656	8,656
Health Departments	289	291	291	291	291	291	298	313	312	313	313	313
Number of Cities	395	402	402	402	402	402	573	701	604	701	701	701
Mean Dependent	72.9	37.3	16.4	9.1	0.9	1.0	73.9	35.4	15.7	8.6	0.8	0.9
Adjusted R-squared	0.89	0.96	0.92	0.94	0.71	0.74	0.77	0.92	0.86	0.90	0.64	0.59
Year FE and City FE	X	X	X	X	X	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X	X	X	X	X	X
Linear Time Trends	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Coefficients are grouped event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. The first row represents the coefficient four periods before treatment, the second row represents the coefficient two and three periods before treatment. The third row is one and two periods after treatment, and so on. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table D.8: Grouped Event Study–Heterogeneity by Foreign Born

	Low Foreign Born						High Foreign Born					
	(1) Infant	(2) Infect	(3) Flu	(4) TB	(5) Typh	(6) Diph	(7) Infant	(8) Infect	(9) Flu	(10) TB	(11) Typh	(12) Diph
Years up to -4	0.66	1.04	-0.26	0.13	-0.10	0.12	2.08	1.75	1.52	0.32	-0.08	-0.01
	(2.13)	(1.21)	(0.90)	(0.47)	(0.13)	(0.11)	(2.00)	(1.79)	(1.32)	(0.43)	(0.07)	(0.13)
Year -2 and -3	3.70*	1.69	0.20	0.62*	0.06	0.00	0.93	0.56	0.86	0.01	0.00	0.04
	(1.95)	(1.08)	(0.88)	(0.34)	(0.11)	(0.09)	(1.96)	(1.20)	(0.95)	(0.24)	(0.05)	(0.12)
Years 0 and 1	2.89*	-0.96	-0.90	-0.21	-0.03	-0.07	0.15	1.59	1.34	0.08	0.01	0.14
	(1.58)	(1.19)	(0.92)	(0.28)	(0.10)	(0.08)	(1.09)	(1.06)	(0.97)	(0.23)	(0.05)	(0.11)
Years 2 and 3	4.42**	-0.75	-1.01	0.00	0.01	0.13	-0.19	0.64	0.71	-0.05	-0.03	0.25
	(1.81)	(0.99)	(0.78)	(0.28)	(0.10)	(0.11)	(1.25)	(1.04)	(1.00)	(0.27)	(0.05)	(0.29)
Years 4 and 5	3.45	-0.39	-0.92	0.18	0.05	0.12	1.07	0.29	0.55	0.18	-0.04	0.02
	(2.16)	(1.04)	(0.77)	(0.32)	(0.10)	(0.11)	(1.54)	(0.83)	(0.78)	(0.36)	(0.06)	(0.13)
Years 6-9	3.81	-0.55	-0.54	0.19	0.00	0.05	0.43	0.57	1.05	0.12	0.00	0.13
	(2.53)	(1.17)	(0.82)	(0.41)	(0.12)	(0.10)	(1.59)	(1.10)	(1.02)	(0.43)	(0.06)	(0.12)
N	7,583	12,579	11,250	12,580	12,580	12,580	5,101	7,926	7,408	7,926	7,926	7,926
Health Departments	402	417	416	417	417	417	185	187	187	187	187	187
Number of Cities	706	834	737	834	834	834	262	269	269	269	269	269
Mean Dependent	74.9	37.1	16.1	9.4	1.0	0.8	71.0	35.8	16.2	8.1	0.6	1.1
Adjusted R-squared	0.77	0.93	0.87	0.93	0.68	0.55	0.91	0.96	0.94	0.94	0.68	0.77
Year FE and City FE	X	X	X	X	X	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X	X	X	X	X	X
Linear Time Trends	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Coefficients are grouped event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. The first row represents the coefficient four periods before treatment, the second row represents the coefficient two and three periods before treatment. The third row is one and two periods after treatment, and so on. Measures of mortality are per 100,000 individuals, except infant and maternal mortality, which are both per 1,000 births. Infant mortality and maternal mortality results are weighted by the number of births. The remainder of mortality results are weighted by the population. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

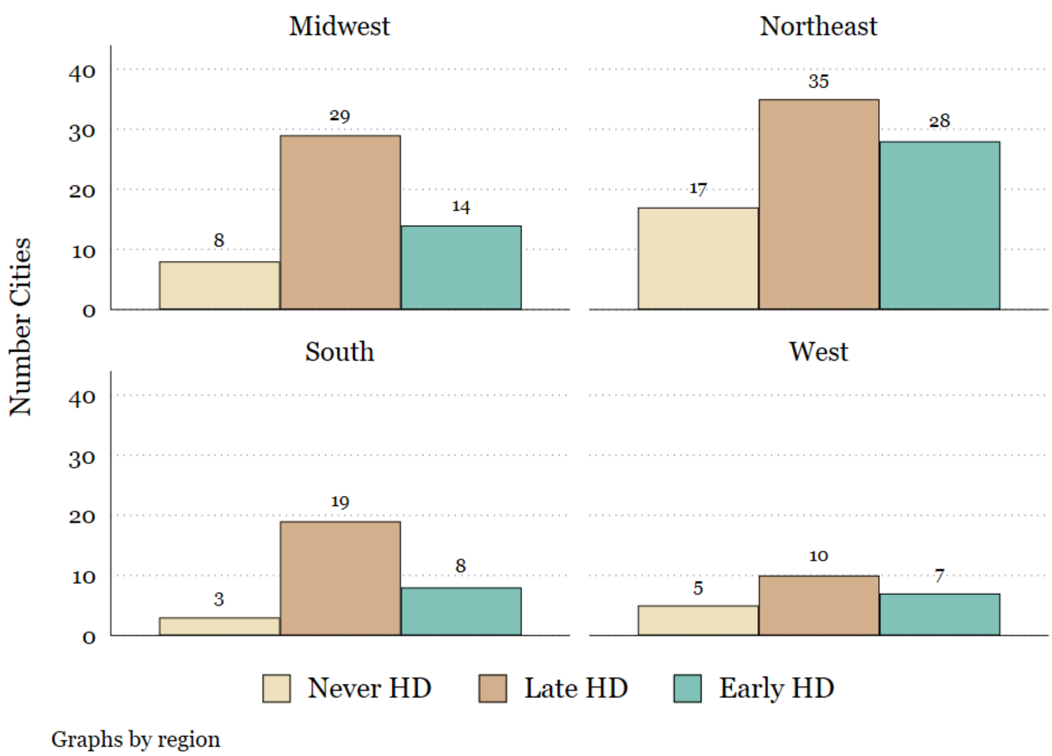
E Expenditure Analysis

Table E.1: Summary Statistics: Expenditure by Entry of Health Department

	Never HD	Late HD	Early HD
	Mean	Mean	Mean
P.C. - HD Spending - 1915	0.103	0.117	0.133
P.C. - HD Spending - 1930	0.173	0.222	0.233
P.C. Prevention Spending - 1915	0.040	0.080	0.098
P.C. Prevention Spending - 1930	0.058	0.136	0.227
P.C. Child Spending - 1915	0.019	0.021	0.035
P.C. Child Spending - 1930	0.193	0.200	0.268
P.C. Sanitation Spending - 1915	0.814	0.945	1.276
P.C. Sanitation Spending - 1930	1.782	1.863	2.286
P.C. Education Spending - 1915	4.955	5.037	5.231
P.C. Education Spending - 1930	15.842	15.395	16.320
Observations	62	176	68

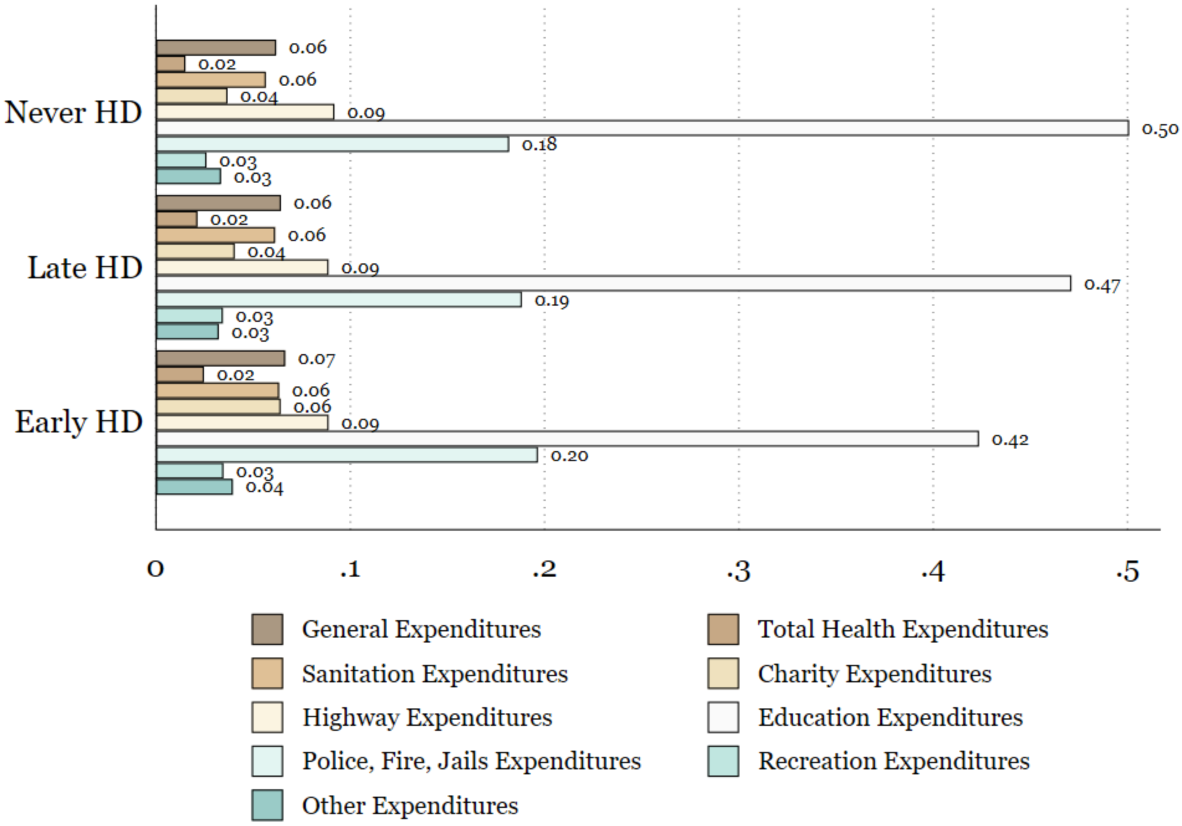
NOTES: Per capita expenditure are the dollars spent over the population of the city.
SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31.

Figure E.1: Number Cities in the Per Capita Expenditure Analysis by Region



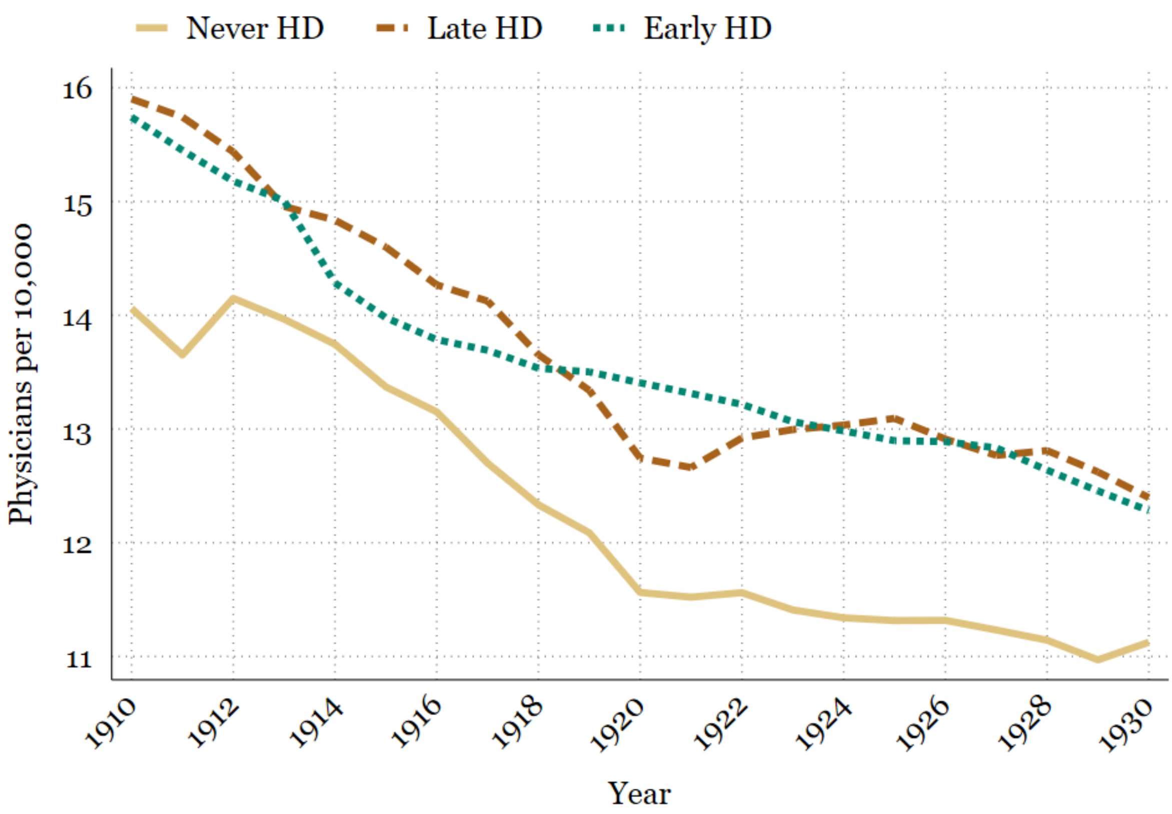
SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31.

Figure E.2: Share of City Budget Dedicated to Each Category –1930



SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31.

Figure E.3: Physician Access by Adoption Timing, 1910-1932



SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31.

Table E.2: Per Capita Expenditures and Adoption of a Health Department

	1(Health Department)					
	(1)	(2)	(3)	(4)	(5)	(6)
P.C. Sanitation Expenditures	0.010					
	(0.023)					
P.C. HD Expenditures		0.049				
		(0.137)				
P.C. Child Health Expenditures			-0.033			
			(0.117)			
P.C. Prevention Expenditures				-0.041		
				(0.055)		
P.C. General Expenditures					-0.040**	
					(0.019)	
P.C. Education Expenditures						0.005
						(0.006)
Observations	3,462	3,299	3,299	3,299	3,462	3,462
Health Departments	587	587	587	587	587	587
Number of Cities	968	968	968	968	968	968
Adjusted R-sq.	0.82	0.82	0.82	0.82	0.82	0.82
F-statistic	0.19	0.13	0.08	0.56	4.30	0.70
Baseline FE	X	X	X	X	X	X
Controls	X	X	X	X	X	X
Time Trends	X	X	X	X	X	X

NOTES: Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Because the dependent variable is not a rate, we do not weight these findings. Per capita expenditure are the dollars spent over the population of the city. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31. City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table E.3: Per Capita Expenditures and Infant Mortality, Lags and Leads

	Infant Mortality Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
F.P.C. HD Expenditures	-5.060					
	(5.911)					
P.C. HD Expenditures		-0.634				
		(5.500)				
L.P.C. HD Expenditures			-14.021**			-3.252
			(6.892)			(7.976)
L2.P.C. HD Expenditures				-11.973**		-0.769
				(5.075)		(5.843)
L3.P.C. HD Expenditures					-6.380	-8.459
					(5.869)	(6.975)
Observations	2,431	2,599	2,684	2,772	2,923	1,919
Health Departments	587	587	587	587	587	587
Number of Cities	968	968	968	968	968	968
Adjusted R-sq.	0.89	0.90	0.90	0.90	0.91	0.91
F-statistic	0.73	0.01	4.14	5.57	1.18	0.50
Baseline FE	X	X	X	X	X	X
Controls	X	X	X	X	X	X
Time Trends	X	X	X	X	X	X

NOTES: Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Because the dependent variable is not a rate, we do not weight these findings. Per capita expenditure are the dollars spent over the population of the city. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31. City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table E.4: Per Capita Expenditures and Infant Mortality

	Infant Mortality Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
L.P.C. Sanitation Expenditures	-0.483					
	(0.599)					
L.P.C. HD Expenditures		-14.023**				
		(6.893)				
L.P.C. Child Health Expenditures			1.323			
			(3.654)			
L.P.C. Prevention Expenditures				-5.125***		
				(1.811)		
L.P.C. General Expenditures					-0.467	
					(0.460)	
L.P.C. Education Expenditures						-0.210
						(0.139)
Observations	2,828	2,684	2,684	2,684	2,828	2,828
Health Departments	587	587	587	587	587	587
Number of Cities	968	968	968	968	968	968
Adjusted R-sq.	0.90	0.90	0.90	0.90	0.90	0.90
F-statistic	0.65	4.14	0.13	8.01	1.03	2.30
Baseline FE	X	X	X	X	X	X
Controls	X	X	X	X	X	X
Time Trends	X	X	X	X	X	X

NOTES: Results from Equation 2. Baseline fixed effects include the city, the state x year, and the city-population-group x year. Controls include the interaction of pre-treatment levels of city characteristics with year indicators. We include these controls based on the 1910 level of the share white, the share under five, the share over 65, the share female, the physicians per 10,000, and the average occupational score. Infant mortality results are weighted by the number of births. Per capita expenditure are the dollars spent over the population of the city. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

SOURCES: Financial Statistics of Cities Having a Population of Over 30,000 for 1912,1915-1919,1921-31. City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1933. The number of deaths, infant deaths, and births comes from U.S. Vital Statistics. To calculate rates, we combine this information with census data. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.