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Do Public Health Departments Improve Population Health? The Impact of City-level Health Departments over 1916-1933

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Over the early twentieth century, urban centers across the United States adopted full-time public health departments. Using an event-study design, we show that opening full-time administration had no impact on mortality (all-cause, infant, by-cause). Then, we use city financial records to explain why health departments were ineffective. First, cities with and without health departments had comparable spending on public health. Second, per capita expenditures (and per capita expenditures interacted with a health department) correlate with infant mortality reductions. While urban public health administration as a bureaucratic apparatus appears unnecessary, public health system funding may be more meaningful for local health.

JEL codes: I15, I18, H51, N32.
Keywords: mortality, health departments, local spending, health expenditures, public health, demographic transition.

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 and led ambitious campaigns for sanitation, vaccination, public education, and public hospital construction, among many others. This change was centered in cities, in which new health departments were established and had their budgets rapidly increased. These departments set the stage for the modern context of public health provision: Today in the United States, 2,800 local health departments operate throughout the country (Leep and Shah, 2012). Of these health departments, the median department spends 1.7 million, and 41 dollars per capita (Leep and Shah, 2012).

Yet how effective were these departments when they first began? In this study, we consider the effectiveness of establishing health administration in the form of city-level public health departments from 1916 to 1933. During this period, U.S. cities opened more than 400 full-time departments of health throughout the United States. The health effects of these administrative units are currently unexplored. Understanding whether health administration improves population health is crucial. Local health departments set up at the beginning of the twentieth century continue to operate as the local municipal health departments permeating the United States. Despite their persistence and broad reach, little is know about whether the formation of these public services impacted population health. [1]

To study the health effects of public health departments, we exploit variation in when and where health departments opened in cities around the United States. Using an event-study design, we track changes in mortality and compare health department cities against three groups in various configurations. First, against the pre-entry year in the same city. Second, against cities that had existing health departments by 1916. Third, against mortality in cities that never received a full-time health department (including those with part-time boards). To estimate the event study, we use city-level mortality data over the years 1910 to 1940. We test several measures of mortality, including overall mortality, infant mortality, infectious disease mortality, and several cause-specific mortality measures, including typhoid, tuberculosis, influenza, and diphtheria.

Our findings from the event study suggest that opening a full-time health department did not improve city mortality conditions. These results hold across the balanced panel and unbalanced panel as well as in subsequent robustness checks.[2] The only noticeable decline in mortality is in infant mortality for states with higher-quality state boards of health. These findings suggest that having a city health department alone was not sufficient for improving survival outcomes, but instead, having a robust public health system may have been important in reducing infant mortality.

Why did urban health departments appear to have so little effect? Two alternative hypothe-

[1]Rural county health departments have been studied in Hoehn-Velasco (2018), but cities were not considered in the analysis.

[2]Robustness checks include using city-specific linear time trends, a difference-in-differences approach, testing only small cities under 100,000, the balanced panel of cities, excluding 1918, testing higher quality departments that had boards in 1890 and had high-tenure department heads, and considering alternative control groups. We also test for heterogeneity within the sample, including dropping each region, considering states with the best state health departments, early versus later treated, small versus large cities, and cities with a larger nonwhite population.

ses stand out. One possibility is that health departments were simply ineffective. That hypothesis is broadly consistent with Anderson et al. (2019b), which found that the first major public health campaigns against tuberculosis had limited (though discernible) effects. The second possibility is that health departments may have organized effective projects, but not more so than cities without health departments. Non-adopting cities may have carried out such projects through other public or private channels.

We test the validity of these hypotheses with three alternative strategies. First, we test whether cities without health departments could sufficiently mobilize vaccination campaigns following the diphtheria vaccine's availability, and the provision of federal funding for child health initiatives via the Sheppard-Townsend Act, in 1921. The evidence suggests that both cities with and without health departments experienced similar declines in diphtheria mortality. Based on the similarity in diphtheria declines between city types, we infer that cities without full-time health departments could mobilize effective vaccination campaigns through alternative public or private means.

Second, we examine city-level budgets to see whether cities with health departments allocated their budget differently than other cities. We find that cities that adopted a full-time health department between 1916 and 1933 spent a similar amount on sanitation and child health as never-adopters. Early-adopters had consistently higher per capita spending earmarked towards a health department. Then, when we control for city characteristics, per capita spending on health fails to predict a health department's adoption. The fact that per capita expenditure cannot predict adoption suggests that cities with and without a health department were similarly allocating their budgets on health.

Finally, we test whether infant mortality declined in cities that spent more per capita on a health department. We find that higher per capita spending on a health department is associated with reductions in infant mortality. Particularly important, rather than spending alone, is the interaction of having a health department and higher spending per capita.

Overall, our results suggest that having a health department alone is ineffective. Instead, we show suggestive evidence that both having a health department and providing adequate funds to that health department may be necessary. While our results for expenditures are far from causal, our most compelling results show that organizing full-time health administration does nothing, in and of itself, to improve mortality conditions. Instead, cities had to both set up a health department and fund the health department appropriately.

Put together, we see three main conclusions. First, the network of public health systems may matter, particularly local departments' interaction with state health departments. Second, cities without health departments were able to organize at least some effective health services without having a full-time health department. Thus, having an administrative unit branded as a health department is not the key factor in health improvements. Instead, a full network of public and private health institutions may be more important. Third, health departments are ineffective without proper funding. While we cannot say that expenditure causes mortality to decline, we can say that poorly funded health departments produced no apparent effect.

These findings add to the literature by showing that public health administration is not nearly as effective 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., 2019b; 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).[3] Another portion demonstrates that health campaigns can be effective at improving mortality for some specific causes and infant mortality (Olmstead and Rhode, 2004; Bleakley, 2010; Moehling and Thomasson, 2014; Komisarow, 2017; Hoehn-Velasco, 2018). Expenditure has also been linked to mortality declines. Costa and Kahn (2006) shows that city public health expenditures correlate with lower infant and child mortality.

This study also contributes to a body of work that has found less benefit to public health that the previous literature would suggest (Anderson et al., 2019a,b; Clay et al., 2018). Anderson et al. (2019a) shows that even significant infrastructure investments cannot explain meaningful declines in overall city-level mortality. This study adds to this literature by showing that public health administration as a bureaucratic apparatus is ineffective at improving overall mortality. The findings from this study align with Hoehn-Velasco (2018), which finds little benefit of health departments on overall mortality in rural counties. However, infant mortality does decline to the health department's arrival in Hoehn-Velasco (2018), but not in the present study. Instead, this study finds that a combination of administration and funding may be important for infant health in cities.

The remainder of this study proceeds as follows. In Section 2 we discuss the history of city health departments, as well as their activities, spending, and staff. Section 3 describes the mortality and health department data. Section 4 describes the event-study specification. Section 5 presents the main findings and Section 6 shows series of robustness tests. Then, in Section 7 we discuss potential reasons for the null effect, which includes the per capita expenditure analysis. Section 8 concludes.

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 health departments. A few of these cities include Baltimore in 1793 (Beilenson, 1993), Boston in 1799, (AJPH, 1940), and Philadelphia in 1794.[4] These initial boards were established to directly combat epidemics, such as yellow fever in Philadelphia, Baltimore, and New York City.[5] Over the 1800s, the idea of having a health department gained traction in cities, and

[3]Note that Anderson et al. (2019a) found an error in Cutler and Miller (2005), casting doubt on the magnitude of the effect in the original study. However, in a reply, Culter and Miller state the magnitude of the effect is still 38% Cutler and Miller (2019).

[4]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.

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

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 and acted as the primary initial public health systems in the United States (Chapin, 1900, 1916).[6]

While cities were the first to adopt public health, their initial health boards were still imperfect in their operations.[7] 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" (page 6). To test this claim, we collect and present data covering historic physician presence on health boards using the *Social Statistics of Cities* from 1890 (Bureau, 1890). Table A.1 shows the health board's average size in 1890, the physician composition, and the total expenditure by the board. The median health board in 1890 had five members, one of whom was a physician. 28% of cities with health boards had no physician on their boards (77 out of 273 cities). 36% of all reporting cities reported no health board (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 health departments, three of the seven, Boston, Philadelphia, and Brooklyn, still had no physician on the board in 1890. 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.[8]

As these health departments began to gain traction, they were set up as separate units within the established local government structure.[9] The growing importance of the city health departments as an administrative unit is evident in cities' financial records. In the Statistics of Cities (Bureau, 1912-1931), as late as 1903, health and sanitation were a component of public safety, including police and fire. By 1905, the city financial records listed health and sanitation as a separate undertaking from public safety. By 1911, health conservation (including health department administration) was separated from sanitation activities, emphasizing the health department's importance.

2.2 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]...

[6]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).

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

[8](*City Health Officers: Directory of Those in Cities of 10,000 or More Population*, 1916-1933; Chapin, 1900, 1916; Kramer, 1942; Lancaster, 1937)

[9]Chapin (1900, 1916); Schneider Jr (1916a); Association (1926); Armstrong et al. (1923)

two or three percent of our population are, at any one time, disabled through sickness" (Schneider Jr (1916a), pg. 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).

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).

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.[10] 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 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 small-

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

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)

pox, diphtheria, and typhoid (Ravenel, 1921).[11]

Health department activities 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 educating mothers about the proper storage and heating of milk for infants. Cities targeted infant health directly through public health nursing, with many cities setting up home visits for infants, providing prenatal care, and organizing infant welfare stations (Ravenel, 1921; Armstrong et al., 1923).

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 department 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.[12] 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.

[11] 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)

[12] 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).

2.3 Employment

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) pg. 1222). These health officers in charge of running municipal health departments were paid a modest salary that ranged between $1,300 and $10,000 (Association, 1926) with an average salary of $5,000.[13] 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 aggregate targets of health departments, these staffing numbers are not broken down by city.[14]

2.4 Spending

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. (1923), 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. This 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 the focus of public health was towards children, where there was likely a greater benefit to preventative efforts.[15]

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.[16] As local health gained influence over the period 1900-1940, the state boards similarly grew in scope. State boards formerly only served an advisory role to local boards (Chapin, 1900), but gained influence over the twentieth century, with certain state boards becoming more influential than others.[17] State boards of health acted as central ad-

[13]$5,000 is $76,000 in 2019. The upper bound of $10,000 is $152,000.

[14]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.

[15]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).

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

[17](Chapin, 1916) notes that "The cities have often set the example which the state has followed and recently our largest state has selected an executive of its largest city to carry out a comprehensive state plan of sanitary reform. 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."

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

ministrators who worked together with local boards to provide preventative health services and infectious disease control. In some cases, this meant working alongside local health departments, and in other cases, this meant giving support to health departments through funding or staff. As of 1914, all states (excluding New Mexico) had state boards of health (Chapin, 1916).[18] Merely having a state health department did not necessarily mean that public health systems flourished in the state. There was significant variation in the quality and the spending of the state health departments, with Massachusetts, Pennsylvania, and New York being top performers (Chapin, 1916). High-quality state health departments may have increased the efficacy of urban health departments when the two collaborated and if the former increased public trust in–and compliance with–public health directives (Burg, 2000).

We show Chapin (1916)'s rating of state quality, per capita spending, and the number of part- 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, spending per capita and quality do not appear to be strongly correlated. For example, the three states with the highest per capita spending were Maryland, high quality; Florida, mid-quality; and Nevada, low quality. Third, the highest quality state health departments generally have the largest number of local health departments in this period. For example, 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.[19]

3 Data

3.1 Municipal Health Department Data

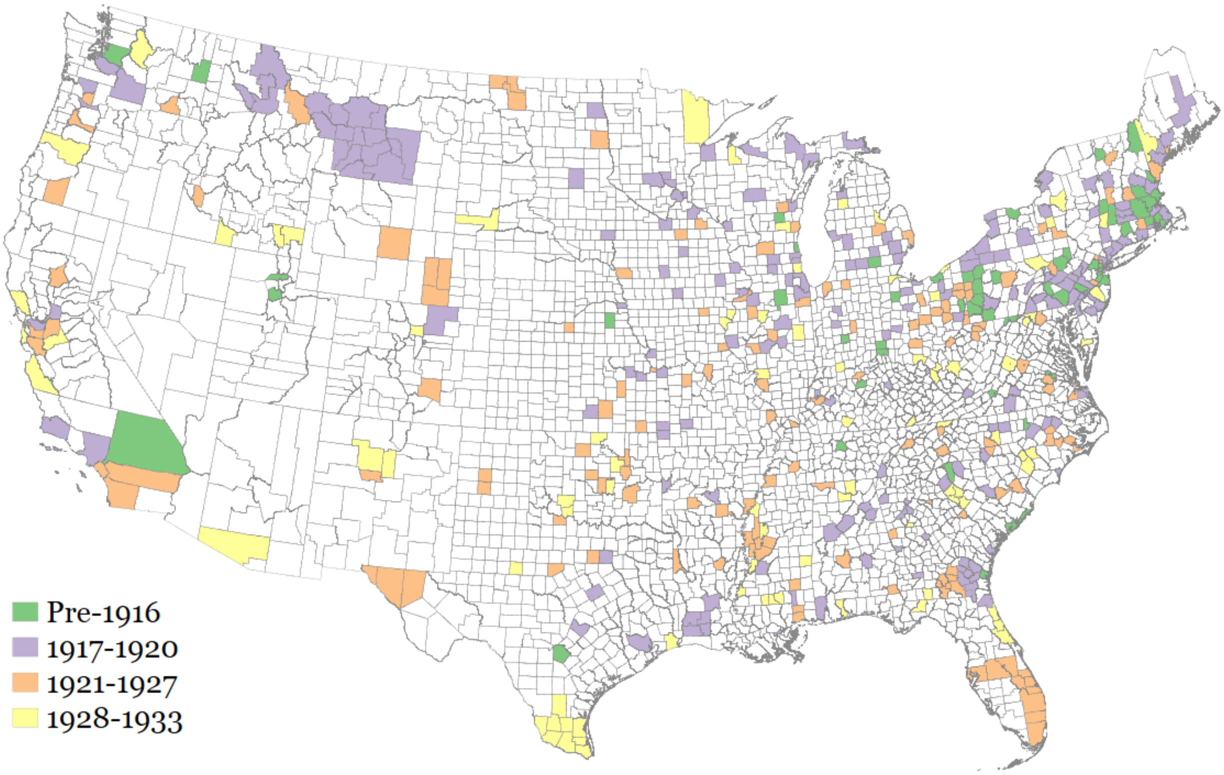
Municipal health departments include health departments that operated in towns and cities with more than 10,000 persons. To track the spread of these health departments, we use data

[18] New Mexico had a state board by 1921 (Ravenel, 1921)

[19] The correlation coefficient between spending and rating 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.

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, based on the city population as of 1910. The source document reports the health officer's name and whether the health department operated in a full-time capacity (beginning in 1917). Appendix Figure A.1 shows the original directory record.

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 1916-1932.

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 health departments and rely on the definition of a full-time department provided in *City Health Officers: Directory of Those in Cities of 10,000 or More Population* (1916-1933). This data source also reports municipalities with part-time boards, but 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 under-reported based on the 1890 survey of health boards described in the Background Section.[20]

To illustrate the location of municipal health departments throughout the United States, Figure I maps the timing of full-time health departments. 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 purple, yellow, and orange. Purple indicates adoption throughout the early 1920s. Orange counties indicate adoption in the later 1920s. Yellow indicates later adoption in the

[20]Further, in cross-checking the data source with state health reports, part-time boards appear to be underreported in the primary data source. Part-time boards likely only responded to the health department survey when they convened during epidemics.

early 1930s. Over the map, there is no apparent regional placement of the 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.2 and the number of health departments opened over time in Figure A.3.

The timing of the health departments, shown in Figure A.3, is key to identification. The majority of full-time health departments opened over the 1910s and early 1920s. As controls, we include the cities that never adopted a 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 most fullest specification, is against cities that (i) already had a health department in 1916 and (ii) cities that operated a part-time health department. We also run the same models omitting the cities that already had a health department in 1916. We test additional control groups in the robustness tests in Table 4.

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 began operation during the period 1916-1933. Along similar lines, the full-time data is only available beginning in 1917 and is not reported in 1918, and 1916.[21] We fill in the missing full-time information based on 1917. If the health officers have the same name and title over the following years, 1917 and 1919, we assume they were full-time in 1916 and 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 produce over-estimates of the effectiveness of public health measures.

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) and the importance of city-level spending in Costa and Kahn (2006) for infant and child mortality. We also explore other measures of cause-specific mortality, as cities spent significant amounts towards child mortality (diphtheria), tuberculosis prevention, as well as on sanitation (typhoid) (Bureau, 1912-1931). 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 and consider these grouped measures.

We show several versions of the summary statistics for our main measures of mortality in

[21] 1932 is another gap year, but less critical.

Table 3: Summary Statistics for Mortality Data by Health Department Year

	Pre-1917	1917-1920	1921-1924	1925-1933	Never
	1916 Mean	1916 Mean	1916 Mean	1916 Mean	1916 Mean
Composition					
Populations (1,000)	120.390	115.997	36.170	42.084	29.727
Share Under 5	0.115	0.110	0.110	0.104	0.111
Share Over 65	0.034	0.035	0.036	0.040	0.037
Physicians per 10,000	16.992	16.870	17.436	18.252	15.776
Share White	0.936	0.925	0.931	0.917	0.969
Mortality					
Overall Rate	157.515	158.811	165.243	163.004	155.192
Infectious Rate	54.358	52.691	57.006	52.141	50.461
Non-Infectious Rate	103.156	106.120	108.237	110.863	104.731
Infant Mortality	112.188	104.234	113.435	105.737	107.075
Birth Rate	26.439	26.004	27.107	25.812	24.976
Rate Tuberculosis	14.140	14.253	15.616	16.057	14.529
Rate Typhoid	1.386	1.837	2.043	1.737	1.725
Rate Diphtheria	1.537	1.497	1.110	1.367	1.171
Rate Influenza/Pneumonia	19.077	18.248	18.874	17.265	16.987
Observations	66	177	46	46	136

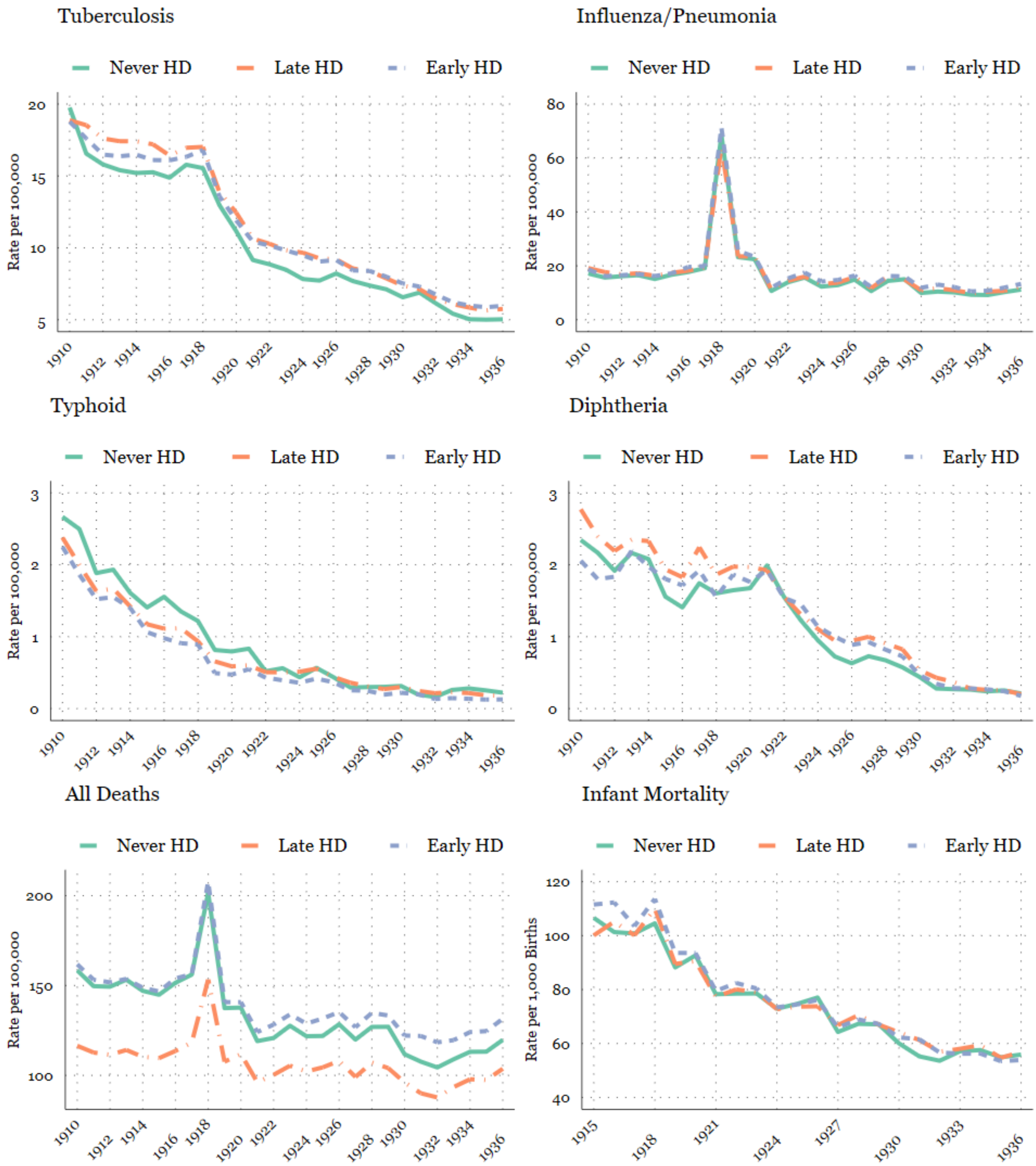
NOTES: Table shows the summary statistics across cities in 1916. Alternative version with 1936 is shown in Appendix Table A.4.
SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table 3, Table A.5, and Table A.6. 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. Other features of city demographic characteristics appear similar across adoption years.

Next, Table A.5 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. The most apparent differences are between part-time versus full-time cities. Cities with full-time health departments are much larger, have a higher non-white population, and have higher mortality. Across the mortality rates, the means are higher for overall, infectious, non-infectious, and pneumonia and influenza. For the remainder of by-cause illnesses and infant mortality, the mortality rates are similar across full and part-time cities. Early- versus later-adopting cities are more comparable across characteristics than part- versus full-time cities. Early-treated cities have slightly lower typhoid mortality, slightly lower infectious disease mortality, and are larger than later-treated. 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, blue), late full-time health departments (1917-1933, orange), and

Figure II: Mortality by City Health Department Status



NOTES: Never having a health department refers to no adoption by 1933. Late adoption is defined as adoption between 1916 and 1933. Early adoption is defined as having a health department before 1917. Measures of mortality are per 100,000 individuals, except infant mortality, which is per 1,000 births.
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 1916-1932. Vital statistics are from the U.S. Vital Statistics.

cities that never adopted full-time health departments (green). Influenza, infant mortality, and diphtheria mortality are similar across city-type.[22] For the remaining causes of death, never-

[22] A portion of the visual similarity is due to the scale of the 1918 spike. Figure A.4 shows the influenza and pneumonia graph without 1918, and the influenza mortality rates are still reasonably parallel across health department access. However, influenza and pneumonia mortality is somewhat lower among never-adopters, perhaps reflecting their

adopters had higher typhoid, but lower tuberculosis and (potentially) diphtheria mortality. All-cause mortality is similar between never-adopter and early-adopters but substantially lower in late-adopters. Despite the small difference in levels of mortality, all city types appear to be on similar trajectories.

3.3 Census Controls and Budget Estimates

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)). We fill the time between Census years with linear averages.[23]

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. These cities do 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 to capture the health benefits of establishing administration. 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 timing of establishment, and less so about time-invariant characteristics that influence city-level adoption due to the inclusion of city-level fixed effects. 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 similarly 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 exploit variation in the year that cities reported operating full-time health departments. We track the mortality changes following the availability 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 a difference-in-differences approach. 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.[24]

smaller population size.

[23]Note that we only use cities that were available in the full count census. Some cities included in the source document were not large enough to be reported as cities in the census.

[24]For difference-in-differences specification see Table C.1.

More formally, we test the following specification:

$$M_{jst} = a_j + \eta_{st} + \pi_{hjt} + \sum_{m=-4}^{9} \beta_m HD_{jm} + \mathbf{X}'_{jt}\gamma + \epsilon_{jst} \quad (1)$$

where M_{jst} is the mortality rate in city j, state s, and time t.[25] 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 in 1910.[26] 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. Controls include the share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. 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. For the results, m ranges from four years prior to HD entry to nine years after HD entry. We choose only four years before operation, as some of the mortality series have less information earlier on in the series (e.g., infant mortality begins in 1915). The treatment effect of the health departments is captured by the dummy variables, $m = 0, 1, 2, ..., 9$. We focus our study on the years surrounding adoption, and entirely **remove** all years that were more than four years before and later than nine years after the health department arrived from the analysis. These years are replaced with missing timing, and are not included in the omitted group. We choose to remove these years, rather than group them with -4 and +9, due to the fact that mortality was not well populated early in our series, and our time series concludes in 1940 (all and by-cause) and 1936 (infant).

The health department's main effect is relative to the year before the health department opened, $m = -1$, the omitted period (from the regression). Because we do not observe the pre-treatment period for cities that adopted a health department before 1916, we report two variants of the model. The specification that includes all cities addresses the concern that unobserved selection into establishing a health department (at any time) might bias comparisons that draw heavily on comparing late adopters to never-adopters. (We also address this worry with an alternative control group in Table 4, below.) In this specification, the excluded period includes (1) treated cities in the year before the health department opened, (2) cities with existing health departments in 1916, and (3) cities that never instituted full-time departments. The alternative specification that excludes early-adopters allows us to be sure that the inclusion of these cities in the baseline group does not drive the null results. We also test alternative control groups in the

[25] For infant mortality $t = 1915, ..., 1936$ and for the remainder of mortality measures $t = 1913, ..., 1940$.

[26] Each group dummy variable represents the percentile ranking of the size of the urban population relative to other cities. The groups include percentiles from 0-20, 20-40, 40-60, 60-80, 80-100. These dummy variables are then interacted with year dummy variables

robustness checks on the main analysis in Section 6 and Table 4.[27]

We add controls for a number of other factors that may affect changes in mortality. First, we directly control for the city-level share female, the share white, and the share under five and over 65. These factors address the differing population distributions between cities. We then include the average occupational scores and the share of household heads that own their homes to address city-level wealth. 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 number of physicians per 10,000.[28]

5 Main Results

5.1 Full-time Health Departments

Figure III shows the results for overall mortality, non-infectious mortality, infectious mortality, and infant mortality. The vertical line depicts the excluded pre-treatment group, which includes control cities, and the plotted points represent the coefficients on event-study dummy variables (see Equation 1). The first graph shows the overall mortality rate. The second shows the non-infectious death rate. The third graph shows the infectious mortality rate, and the bottom right chart shows infant mortality. The dark green points show the main specification. The lighter points show the specification excluding controls (light green) and excluding early-treated cities (pre-1916, in light gray squares).

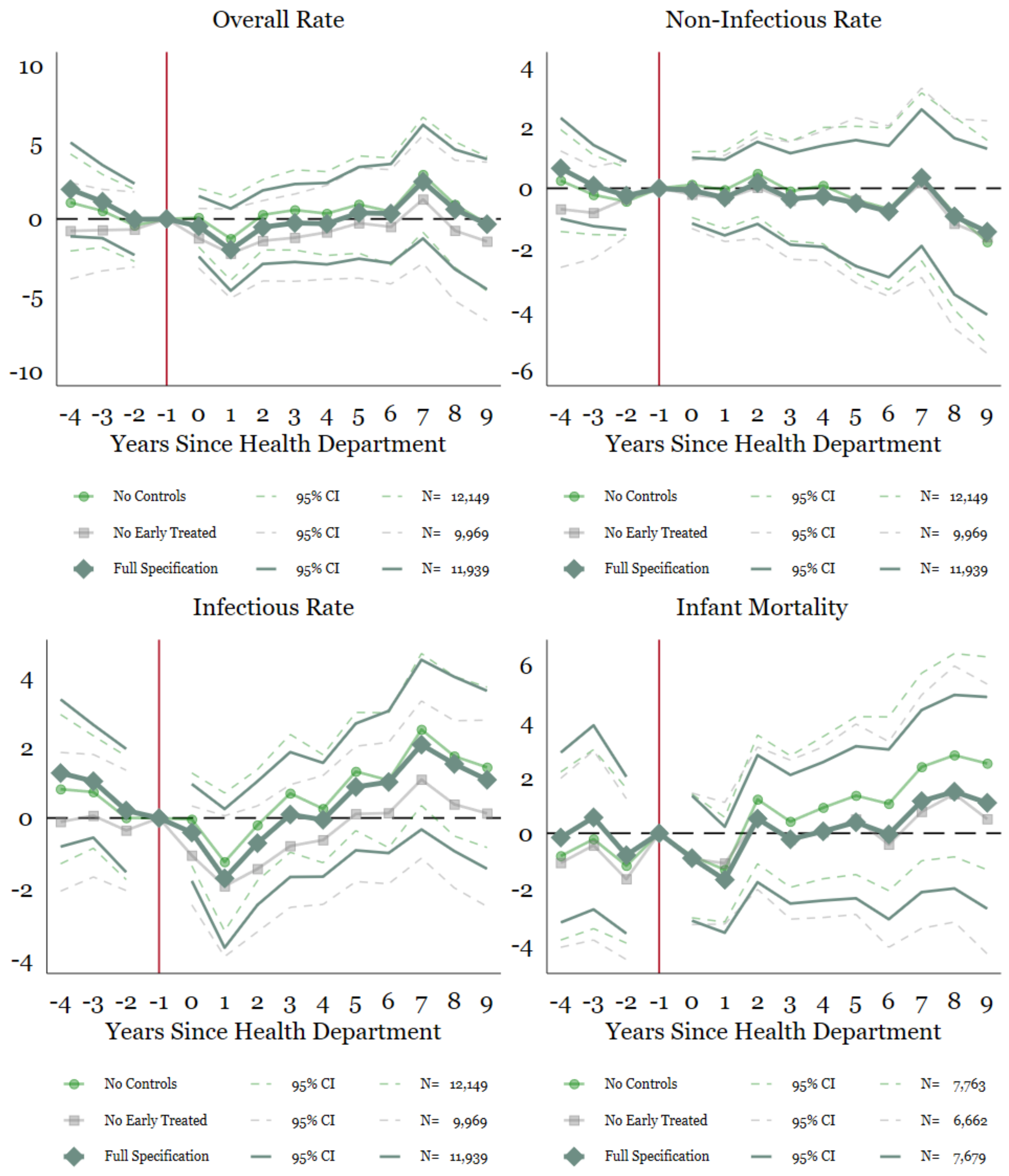
In the first plot, the city-level mortality rate remains stagnant following health department entry. The plotted points suggest that total mortality is unaffected by health department arrival. The next graph shows a similar picture of mortality to non-infectious causes, which is not surprising. We anticipate that health departments will primarily affect infectious disease mortality. The bottom two graphs, infant and infectious disease mortality, are where we expect to see an effect. Despite this expectation, health departments still have little impact on infectious or infant mortality. Both measures of mortality dip slightly after the arrival of the health department and then increase over time.

The infant mortality findings are the most surprising. Infant mortality should be relatively sensitive to public health investment. Infant deaths also composed the majority of preventative deaths in the early twentieth century; about one-third of preventable deaths occurred among infants (Schneider Jr, 1916a). Further, the measures instituted to prevent infant deaths should deliver a noticeable response relatively quickly: public health efforts to increase breastfeeding rates or changes in sanitation practices should create a prompt decline in infant mortality. The fact that the infant mortality results are inconclusive provides strong evidence against the effectiveness of health administration.

[27] Table 4 shows the results over (1) full-time versus cities with only part-time boards, (2) newly opened health departments versus the control group of established health departments as of 1916 (3) no control group beyond the omitted period.

[28] The number of physicians originates from the reported occupation in the Full Count Census. (Minnesota Population Center and Ancestry.com (2013); Ruggles et al. (2020))

Figure III: Full-time Health Department Entry and Mortality

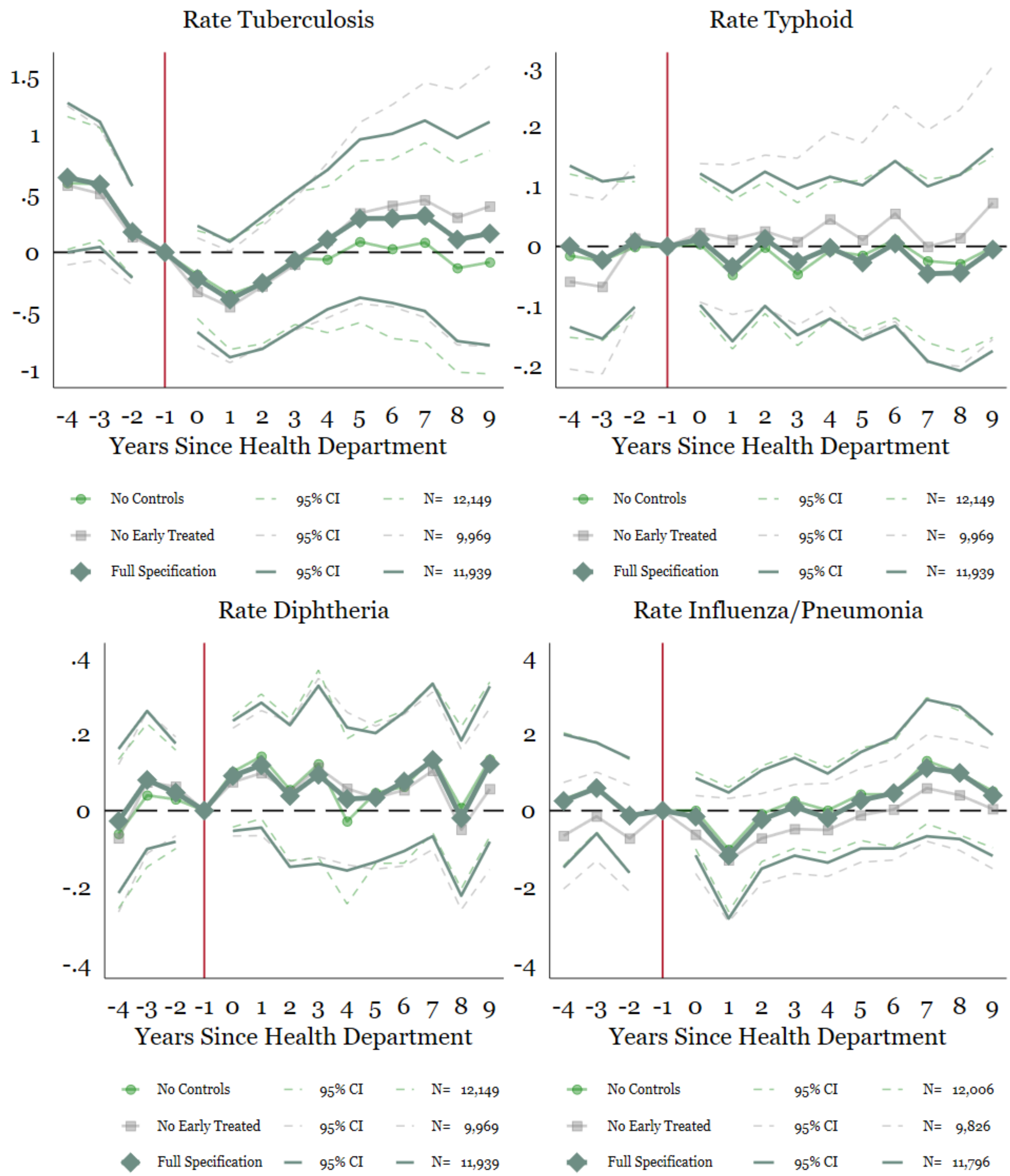


NOTES: Plotted coefficient are event-study dummy variables, β_m, from a weighted least squares estimation of Equation 1. Each plotted point represents the time before and after the health department implementation. $m = -1$ is the excluded period. The dark green points show the main specification. The lighter points show the main specification excluding controls (light green) and population weights (purple). Dashed and dotted lines display the 95 percent confidence intervals. Observations more than four years before and more than nine years after the health department arrived are removed from the analysis. Measures of mortality are per 100,000 individuals, except infant mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons.

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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Next, we consider alternative measures of by-cause mortality to test whether aggregate measures lack the sensitivity needed to detect real mortality declines. Figure IV shows the impact on mortality to tuberculosis, typhoid, diphtheria, and influenza, and pneumonia. There are slight

Figure IV: 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. The dark green points show the main specification. The lighter points show the main specification excluding controls (light green) and population weights (purple). Dashed and dotted lines display the 95 percent confidence intervals. Observations more than four years before and more than nine years after the health department arrived are removed from the analysis. Measures of mortality are per 100,000 individuals, except infant mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons.

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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

declines in both influenza and pneumonia and typhoid, but they are not statistically significant, and tuberculosis appears to be on a pre-trend. Health departments were generally established in the context of a preexisting decline in tuberculosis, which is consistent with Anderson et al.

(2019b)'s finding that tuberculosis declines predated the establishment of major campaigns designed to eradicate it.

The cause-specific outcomes again suggest that health departments were ineffective at reducing mortality for any of the major categories, including infant, typhoid, and tuberculosis. Diphtheria should also be similarly responsive, as a vaccine became widely available in the 1920s. Despite this fact, mortality from diphtheria appears flat upon arrival. (Diphtheria mortality is examined in detail in Section 7, below.) Overall, the full-time city health department fails to yield a detectable mortality effect in any of the eight plots.

5.2 Part-time Boards of Health

Next, we consider whether the part-time departments can be associated with distinctive health effects from the full-time boards. Anecdotal evidence (discussed in Section 2) suggests that part-time health boards gathered in reaction to epidemic illness rather than administer preventative programs. This claim is partially illustrated by the number of boards that were organized in 1918 (see Figure A.3), the year of the 1918 influenza pandemic. Figure C.1 repeats the estimation displayed in Figure III. While the estimates appear noisier than full-time departments, there is similarly no clear change in any mortality level over the first few years of operation.

6 Robustness

To ensure the results are robust across modifications to our main specification, we perform several checks. First, we test a difference-in-differences specification to check whether the null result is purely due to the choice of an event-study approach. Second, we test whether the findings are distinct in smaller cities (under 100,000). Third, we confirm that the findings are not driven by underlying data limitations in the unbalanced panel, due to the 1918 pandemic, or by the ineffectiveness of low-quality boards. Fourth, we test whether the results are robust to alternative specifications, including annual time trends and alternative control groups. Fifth, we conclude by testing for heterogeneity within the sample, including dropping each region, considering states with the best state health departments, and considering the highest-quality health departments. We also show results for early versus later treated, small versus large cities, cities with a larger nonwhite population, and cities with higher physician access. The null results largely hold over the battery of tests, except that we note a small decline in infant mortality in the best health department states.

6.1 The null results hold in the difference-in-differences specification and small cities

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 for two reasons. First, the event-study captures the fact that the treatment effect may vary in the post-period. Difference-in-differences does not capture this time-varying effect (Wolfers, 2006; Goodman-Bacon, 2018). Instead, the difference-in-difference strategy yields the average effect over the post-period, but it ignores

Table 4: Robustness Checks on the Event-Study Specification

Panel A: Alternative Control Groups

	County Trends			Relative to Part-Time			Only Full-Time			No Control Group		
	(1) All	(2) Infect.	(3) Infant	(4) All	(5) Infect.	(6) Infant	(7) All	(8) Infect.	(9) Infant	(10) All	(11) Infect.	(12) Infant
Years up to -4	0.83	0.35	-0.25	0.34	-0.24	-0.08	1.60	0.44	-0.10	-1.93	-0.88	-0.95
	(1.53)	(1.16)	(1.72)	(1.53)	(1.07)	(1.70)	(1.67)	(1.17)	(1.80)	(1.71)	(0.99)	(1.89)
Year -2 and -3	0.12	0.38	-0.10	-0.01	0.17	-0.08	0.71	0.51	0.07	-0.61	-0.16	-0.61
	(1.02)	(0.76)	(1.39)	(1.04)	(0.76)	(1.36)	(1.11)	(0.80)	(1.37)	(1.26)	(0.81)	(1.45)
Years 0 and 1	-0.91	-0.97	-1.09	-0.72	-0.66	-1.12	-0.62	-0.65	-1.25	-0.33	-0.85	-0.56
	(1.12)	(0.84)	(0.94)	(1.11)	(0.78)	(0.94)	(1.21)	(0.86)	(0.94)	(1.28)	(0.85)	(0.97)
Years 2 and 3	0.06	-0.55	-0.22	0.58	0.33	-0.16	-0.14	-0.19	-0.08	0.41	-0.69	0.46
	(1.34)	(1.16)	(1.23)	(1.27)	(0.84)	(1.24)	(1.39)	(0.92)	(1.29)	(1.61)	(0.91)	(1.39)
Years 4 and 5	-0.82	-0.61	0.22	-0.17	0.47	0.17	-0.68	-0.05	0.20	1.62	0.01	0.75
	(1.58)	(1.32)	(1.62)	(1.50)	(0.92)	(1.61)	(1.67)	(1.00)	(1.67)	(2.14)	(1.08)	(1.87)
Years 6-9	-1.68	-0.68	0.66	-0.62	0.94	0.61	-1.52	0.15	0.76	2.00	0.26	0.16
	(2.16)	(1.90)	(2.12)	(2.03)	(1.33)	(2.11)	(2.28)	(1.45)	(2.19)	(2.90)	(1.44)	(2.37)
N	15,653	15,653	8,174	15,558	15,558	8,158	10,960	10,960	5,582	8,887	8,887	4,567
Adjusted R-sq.	0.92	0.92	0.84	0.92	0.93	0.84	0.92	0.93	0.85	0.92	0.93	0.82
Mean Dep	151.2	46.6	79.3	151.2	46.6	79.3	151.2	46.6	79.3	150.9	45.9	78.9
Baseline FE	X	X	X	X	X	X	X	X	X	X	X	X
Time Trend	X	X	X	X	X	X	X	X	X	X	X	X

Panel B: Alternative Subsamples

	No Northeast		No Midwest		No South		No West		Treated Pre-1922		Treated After-1921	
	(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	-1.83	0.39	0.96	0.68	-0.68	0.26	-0.29	0.49	-4.43	0.29	0.25	0.74
	(2.02)	(1.11)	(2.03)	(1.52)	(1.79)	(1.22)	(1.85)	(1.28)	(6.53)	(1.87)	(2.38)	(1.80)
Year -2 and -3	0.48	0.17	-0.69	0.68	-0.37	0.20	0.01	0.64	-2.86	0.51	1.05	0.36
	(1.88)	(0.86)	(1.69)	(0.98)	(1.43)	(0.81)	(1.47)	(0.82)	(2.96)	(1.44)	(1.81)	(0.99)
Years 0 and 1	1.57	0.60	-2.02*	-1.96*	-1.07	-1.21	-1.46	-1.04	0.29	-1.63	0.34	-0.17
	(1.43)	(0.99)	(1.08)	(1.13)	(0.96)	(0.84)	(0.98)	(0.89)	(2.12)	(1.56)	(1.65)	(0.93)
Years 2 and 3	1.32	-0.84	-0.40	-0.58	-0.20	-0.48	-0.39	-0.32	4.95	-1.38	0.15	-1.60
	(2.00)	(0.88)	(1.41)	(1.63)	(1.26)	(1.26)	(1.30)	(1.24)	(3.69)	(1.90)	(2.29)	(1.65)
Years 4 and 5	1.33	-0.50	0.20	-0.53	0.60	-0.61	-0.14	-0.49	6.97	-1.07	-1.91	-1.85
	(2.58)	(1.11)	(1.88)	(1.81)	(1.68)	(1.41)	(1.70)	(1.42)	(4.67)	(2.02)	(2.79)	(2.45)
Years 6-9	2.16	-0.29	0.15	-0.81	1.00	-0.72	0.46	-0.61	6.16	-0.53	-1.34	-2.17
	(3.35)	(1.46)	(2.43)	(2.53)	(2.19)	(2.06)	(2.25)	(2.04)	(5.24)	(2.16)	(3.86)	(3.55)
N	4,573	8,841	5,324	10,347	7,190	13,479	7,435	14,279	2,442	5,148	1,968	3,371
Adjusted R-sq.	0.81	0.92	0.86	0.92	0.84	0.92	0.83	0.92	0.82	0.93	0.75	0.90
Mean Dep	76.7	45.6	81.4	49.6	76.7	43.9	81.7	47.3	82.9	48.6	74.1	41.8
Baseline FE	X	X	X	X	X	X	X	X	X	X	X	X
Time Trend	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 mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. 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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

changing treatment effects over time. This average effect potentially yields inconsistent results in the literature as it ignores the changing treatment effect over time and heavily depends on the endpoints (Wolfers, 2006). Second, we see a benefit in considering the periods leading up to the health department's arrival to analyze pre-trends. Without these points, we will not know whether mortality was on a downward trend before the health department arrived.

Despite these limitations with a difference-in-differences approach, it still may determine whether our event study over-corrects and potentially removes too much variation from the mortality estimates. We show the difference-in-difference specification in Table C.1, where the results are shown with and without city fixed effects, with and without controls, and with and without weights. The null results hold across all specifications. None of the measures of the mortality meaningfully decline. Overall, the difference-in-differences results largely tell the same story as the event study; health departments are ineffective at preventing mortality.

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.2. The results here show cities with populations of less than 100,000 in 1910. From the figures, full-time health departments still produce no change in mortality after the health department opens.

6.2 There is no effect in the balanced panel, when excluding 1918, or in higher quality health departments

Second, a significant limitation of this study is the unbalanced panel of mortality figures. Not all states appeared in the death registration area in 1910, and the U.S. did not mandate reporting until 1933 (Haines, 2001). We show this issue clearly in Table A.6. Here the sample size of mortality in 1916 is half of the number of cities reported in 1936. This staggered entry during the analysis time frame may bias the coefficients. At the same time, the direction of the bias is 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 the ability to detect an effect, we show the findings over a balanced panel of cities in Figure C.3 (in blue). Despite initial concerns over the unbalanced panel, the balanced panel shows a similar lack of health departments' effect on mortality.

In the same graph, we show the results excluding 1918. We make this exclusion to rule out factors that are related to higher mortality in the year of the 1918 global pandemic. Across the purple estimates of Figure C.3, the findings appear similar to the baseline. The main difference is that the results without 1918 show no dip in mortality after the health department arrives. Health departments convening in the aftermath of the 1918 pandemic may be producing the mortality dips in year one.

Then we test whether the highest quality health departments experienced declines in mortality after opening a health department. We measure quality with both an early board, as of 1890, and having a long tenure of the health officer in charge of the health department. Figure C.4 presents the results, which suggest little differential effect for the highest quality boards.

6.3 The null effect holds in alternative control groups and subsamples

In Table 4, we test several alternative specifications using grouped event-study indicators. 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 through 9. 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 is different with alternative control groups. In Columns (4)-(6), we examine the impact 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 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 Panel B of Table 4. In Panel B, 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 1921; and those that adopted after 1921. Across these columns, if anything, mortality appears lower before the health department opened.

6.4 There is a decline in infant mortality only in the best state health department states

We also show the heterogeneous effects in Appendix Tables C.4, C.5, and C.6. In Table C.4, we limit the sample to states with the best state health departments. These states were categorized as states with a state department of health rating of higher than five, as measured by (Chapin, 1916) (seven states in total). These results show the only clear effect of the city health administration. Cities with the best state health departments show reductions in infant mortality in the first few periods after the health department arrived. This decline is similar in magnitude to Hoehn-Velasco (2018), and suggests that the most effective health departments may have been successful at targeting infant mortality. However, these same cities appear to be less effective at preventing other causes of death over Columns (2)-(6).

In Columns (7)-(12), we also show the findings for cities with a sizeable nonwhite population. There is no apparent effect in these cities. Then, we show the results in Table C.5 in large versus small cities. There is a slight decline in infant mortality for large cities, but it is not persistent. Similarly, the results in Table C.6 suggest no difference in effect across areas with high or low-physician access.

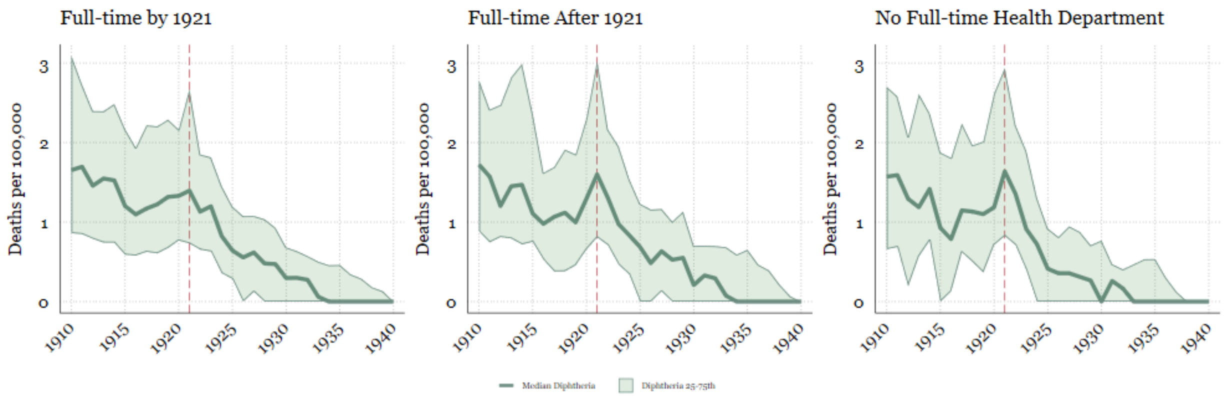
These physician access results help to reconcile these results with prior work. Based on Hoehn-Velasco (2018), rural health departments were most effective at reduce infant mortality in rural-only counties. This finding suggests that the greatest benefit to public health may have occurred in areas with limited prior access to physicians and, perhaps, to basic sanitation knowledge. The lack of response in towns and cities might be due to existing health services and infrastructure, including both private and public. Considering the number of physicians per 10,000 persons by area shows this access issue even more clearly. Counties with a municipal health department had 10.5 physicians per 10,000 persons, while areas with a rural county health department had 7.8. In counties that were completely rural, and showed the largest benefit from a rural health department, there were only 6.3 physicians per 10,000 persons. This preexisting availability of physicians and general sanitation knowledge may help to explain the differences between this study and Hoehn-Velasco (2018), since health departments in rural areas may have filled a health access gap.[29] In cities, it appears the there were more available private means of health education and health care than in rural areas.[30]

7 Explanations for the Null Effect

Why did urban health departments appear to have so little effect? Two alternative hypotheses stand out. One possibility is that health departments were entirely ineffective at improving health. In other words, their initiatives did not work. The 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 by other means. These alternative health programs could have occurred through other public projects (state or local) or the available private physicians and private donors.

To test the validity of these alternative hypotheses, we take several approaches. First, we consider whether cities without health departments could sufficiently mobilize vaccination campaigns without having a health department. We focus on the decline in diphtheria following the diphtheria vaccine's widespread availability after around 1921 to test this hypothesis. Second, we examine city-level budgets to see whether cities with health departments allocated their budget differently than early and never-adopters. We test both the raw per capita expenditures and control for city characteristics. Finally, we consider whether per capita spending on a health department can be associated with declines in mortality.

Figure V: Diphtheria Mortality by 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 1916-1932. Vital statistics are from the U.S. Vital Statistics.

7.1 Vaccine-related mortality improved in never-adopting cities

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). An 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 and expanding through the 1930s, and improved in 1926. Its usage became widespread in the context of expanded public health focus on young children (older than infants) in the wake of World War I, which brought public attention 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 health departments both experienced declines in diphtheria mortality after 1921 when the vaccine first began to be 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 diphtheria mortality in cities that had a health department before 1921, in cities with a health department by 1933 but without one in 1921, and in cities that never adopted a full-time health department. All three city types experienced declines in diphtheria, 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 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

[29] Note these are county-wide numbers to compare between the health department types. If we calculate based on the city estimates, the inequalities appear even worse. Cities had 13.6 physicians per 10,000 in "low-access" cities and more than 15 per 10,000 persons in "high-access" cities.

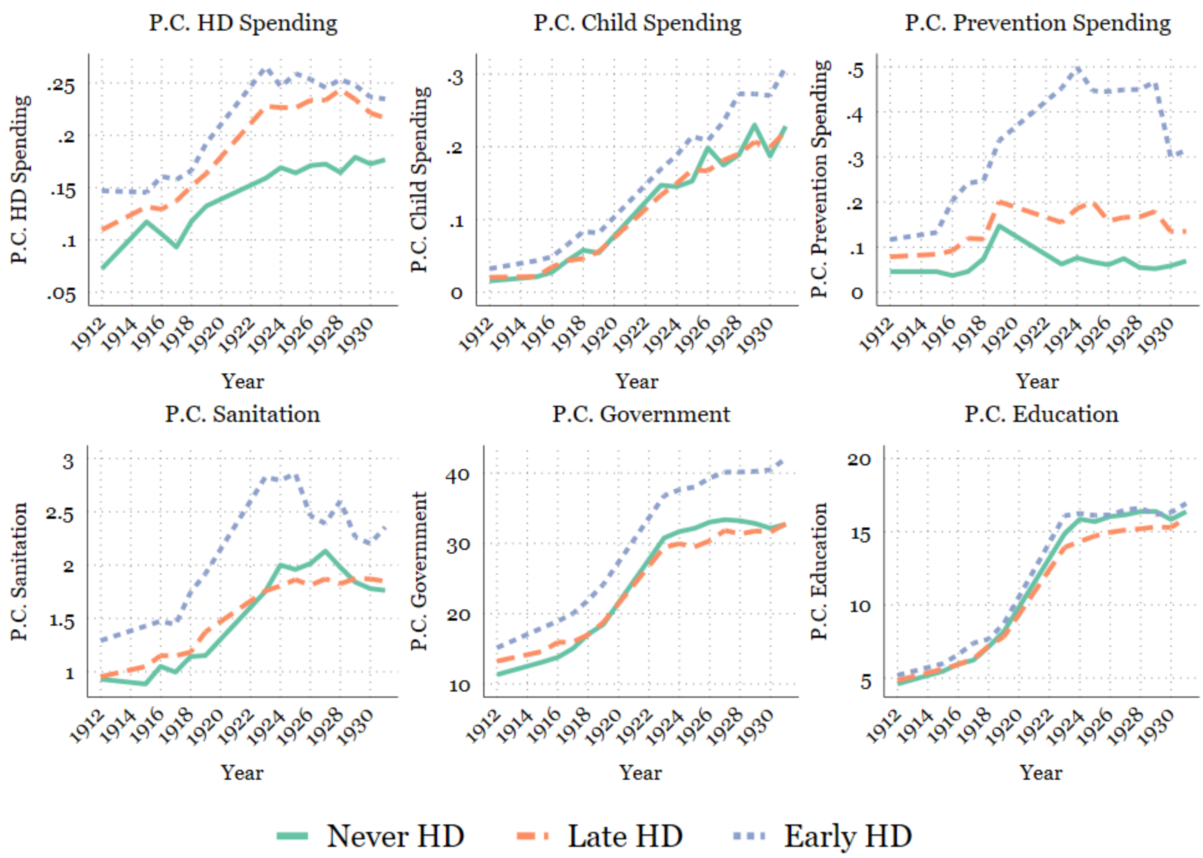
[30] An alternative mechanism by which the presence of more doctors may have reduced the effectiveness of health departments is that doctors and public health experts often had conflicting interests in this era; doctors and their professional associations often opposed reforms that public health organizations supported. (Hammonds (1999) p. 14, Meckel (1990) p. 209.

could have been organized. First, never-adopting and late-adopting cities may have been allocating resources toward public health without an administrative unit. 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 being able to mobilize private funding, and the boundaries between public and private campaigns was often blurry (Hammonds (1999) p. 89). Third, apparently never-adopting cities may have effectively set up a health department without reporting one. 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 see 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.

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



NOTES: Never having a health department refers to no adoption by 1933. Late adoption is defined as adoption between 1916 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 1916-1932.

To start, Figure VI shows the evolution of spending from 1912 to 1931. Cities that adopted a health department early (before 1916, plotted in blue dashes) had consistently higher health and sanitation expenditure. Cities that adopted a health department after 1916 (later-adopting health departments, plotted in orange dashes) spent more on health departments but spent a similar amount on other activities to never-adopters. Never-adopters (plotted in solid green) spent an equivalent amount on sanitation and child health. These never-adopters spent slightly more than late-adopters on education.

Despite the deficit in spending towards the administrative health department, it appears that never-adopting cities put similar per capita funds towards other types of health initiatives. These findings suggest that while never-adopters did not invest in health departments, they put the funds towards specific health programs. The similar trends in spending growth indicate that cities with and without health departments were experiencing similar local government growth, irrespective of the bureaucratic apparatus. To illustrate this further, Figure D.2 displays the median percentage breakdown by health department status. The breakdown of funds for local government is similar between the late-adopting and never adopting cities.

In Appendix Table D.1, we next test whether spending predicts whether a city has a full-time health department in a given year. The results suggest that per capita spending on health *fails* to predict whether a city operates a health department over the available years. By contrast, per capita, spending on prevention and child health is inversely related to having a health department. Table D.1 demonstrates that even in years where the health department was active, cities without health departments were allocating their budgets similarly.

These results affirm the hypothesis that health departments made little difference because health activities occurred irrespective of the 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 health department still engaged in health activities. These never-adopters may have provided even more child-based health services than health department cities. It seems highly likely that cities that never adopted a health department were already fulfilling similar health functions by alternative means.

We conclude this section by showing the private alternative to public health, physician access per 10,000. Figure D.3 plots physician access over time and suggests that cities with late health departments had the highest physician access. Early and never-adopters were similar in physician presence before 1910, but the never-treated group had lower access by 1930. 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 facing a trade-off between investing in public and private services.

Overall, the evidence suggests that cities opening health departments between 1916 and 1933 were spending a similar amount on health (per capita) after controlling for population characteristics. The results also suggest that spending changes could be associated with mortality declines, even though health administration fails to explain population health improvements.

7.3 Health department spending is correlated with lower infant mortality

To test whether mortality improvements are associated with increases in per capita spending on health over 1912-1931, we turn to an analysis of public expenditure at the city level. We focus this analysis on infant mortality for two reasons. First, the main effect in Hoehn-Velasco (2018) was discovered with infant mortality. Second, infant mortality exhibited the only noticeable decline in our results. In particular, we test 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.[31]

Our main specification appears as:

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

where M_{jst} is the mortality rate in city j and time t. $E_{j,t-1}$ is the per capita expenditures at the city level from the prior year.[32] 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 urban-group-by-year fixed effects, which control for the relative size of the city in 1910.[33] 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. Controls include the share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. ϵ_{jst} is the regression error, which we cluster at the city level.

Table 5 shows the baseline relationship between per capita expenditure in 1912-1931 (with gap years) and the infant mortality in the subsequent year.[34] The findings show that cities that spend more per capita on health departments experience reductions in infant mortality. The results hold for the specification without controls, with controls (Column (2)), and the specification with linear trends (Column (3)). In Columns (4)-(6), we show the relationship between having a health department and mortality declines. Having a health department (alone) again fails to be correlated with infant mortality declines.

We then present the results for sanitation spending, child health spending, prevention spending, general spending (courts and administration), and education spending in Appendix Table D.2. None of the other spending groups are consistently correlated with reductions in infant mortality. The lack of correlation with the remainder of public expenditure categories suggests that the relationship is not through having wealthier cities or a higher spending local government.

Since per capita spending on a health department appears to be predict mortality decline, we next consider the interaction between having a health department and per capita spending. This specification reveals whether having a health department and spending more produces higher

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

[32] Note that expenditure is only available for 1912, 1915-1919, 1923-1931. We do, however, have total expenditure for 1921.

[33] Each group dummy variable represents the percentile ranking of the size of the urban population relative to other cities. The groups include percentiles from 0-20, 20-40, 40-60, 60-80, 80-100. These dummy variables are then interacted with year dummy variables

[34] 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 5: Infant Mortality, Per Capita Spending, and Health Department Presence

	Infant Mortality					
	(1)	(2)	(3)	(4)	(5)	(6)
P.C. HD Spending	-23.928**	-17.992*	-13.418*			
	(10.837)	(9.115)	(7.273)			
HD				1.411	0.070	-0.194
				(1.801)	(1.736)	(1.552)
Observations	1,562	1,562	1,562	1,868	1,868	1,868
Adjusted R-sq.	0.86	0.87	0.90	0.86	0.87	0.90
F-statistic	4.88	5.85	2.80	0.61	5.24	2.68
Baseline FE	X	X	X	X	X	X
Controls		X	X		X	X
Time Trends			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 size of the population, the share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. 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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

declines in infant mortality.

Table 6 shows the results. Having a health department and spending more on that health department is highly correlated with lower infant mortality. Here neither spending nor having a health department alone appears to be associated with lower infant mortality. Instead, the interaction of having a health department and spending more per capita is key. These results suggest that the best-funded health departments may have been effective at improving infant health. The results are robust to the inclusion or exclusion of weights, excluding early-treated cities, and only including later-treated cities (excluding early and never treated). The results do fail to be robust when including linear trends. We then show the region-specific effect and the results over the best state health department states in Appendix Table D.3. The clearest declines in mortality are in the best health department states and the Northeast. The results also hold with New York, but not within Massachusetts.

Overall, our results suggest that having a health department alone is ineffective. Instead, we show suggestive evidence that both having a health department and providing adequate funds to that health department may be necessary. While our results for expenditures are far from causal, our overall results show that organizing health administration is insufficient to improve mortality conditions. Instead, it appears that cities had both set up a health department and spend more per capita on that department to improve health.

There are many caveats to interpreting a direct link between spending and infant mortality declines. Instead of being causally associated with infant mortality declines, cities that adopted a health department may have provided health services by non-public means, particularly with

Table 6: Interaction of Per Capita Spending and Presence of a Health Department

	Infant Mortality				
	(1)	(2)	(3)	(4)	(5)
P.C. HD Spending	-1.770	4.567	-1.066	16.313	21.390
	(13.144)	(11.684)	(12.054)	(11.802)	(13.684)
HD=1	6.209**	4.586*	6.321*	5.294	4.515
	(3.099)	(2.728)	(3.304)	(3.292)	(3.830)
HD=1 × P.C. HD Spending	-27.360**	-26.993**	-28.885**	-33.907**	-34.810**
	(13.268)	(12.333)	(14.172)	(13.320)	(16.809)
N	1,562	1,562	1,562	1,142	836
Adjusted R-sq.	0.86	0.87	0.78	0.86	0.88
Baseline FE	X	X	X	X	X
Weights	X	X		X	X
Controls		X	X	X	X
No Early-Treated				X	
Only Later-Treated					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 size of the population, the share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. 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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

higher physician access. These cities may have also spent more on infrastructure outlays, which are unobservable in municipal services' annual spending. What is clear is the importance of the health department's expenditure rather than other government functions (including sanitation and child health). Despite this pattern, however, the main effect may be through another channel rather than directly through spending.

8 Conclusion

This study tracks the expansion of urban health departments throughout the United States over 1916-1933. Our results show no mortality benefit from public health administration. These findings hold across multiple robustness checks and subsamples. The only observed effect is in states with the best state health departments, where there is a small decline in infant mortality. Otherwise, our findings point to the organization of health administration as ineffective. We further show that bureaucratic arrangement for providing health services, such as vaccination campaigns, was not the key determinant of whether such campaigns occurred (in the case of diphtheria). Instead, we show suggestive evidence that both having a health department and providing adequate funds to that health department may be necessary. Cities that both set up a health department and spent more per capita on that department experienced declines in infant mortality.

We draw three general conclusions. First, we see improvements in infant mortality after cities open health departments under the best state health departments. The state health department's importance suggests that networks of public and private health systems may matter more than the existence of a city health department alone. Second, while our findings do not allow us to say definitively whether higher spending caused mortality to decline, we do show that higher health department funding may be important for reductions in infant mortality. Cities that experienced declines in infant mortality put more funds to their health department; however, we cannot establish the direction of causality. Third, cities without health departments organized health services without having a full-time health department. Thus, having an administrative unit branded as a health department is not necessary for effective public health campaigns in the right context (such as the availability of medical technologies and federal funding).

Why weren't health departments more effective? While some of their activities seem likely to have been important in reducing mortality (and may have been carried out by other means), others were more dubious in value. In some cases, these two types of activities were heavily intertwined: 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), but not 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. In New York, 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," and few health department inspectors carried out their work in any rigorous fashion (Hammonds, 1999, p. 172-173). Many campaigns were also 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).

Perhaps the two sides of health departments' ambitious undertakings are captured well by a capsule history of a public hospital in Milwaukee. The first attempt at a city hospital, opened 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). It had been opened under health department administration over the strong objections of the health commissioner. Yet the revamped hospital completed in 1916, 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 short, health departments may have been intermittently effective or successful in particular campaigns without being consistently successful in reducing mortality.

The findings from this study fit broadly into a literature that has linked mortality declines to specific public health and infrastructure improvements in cities. (Troesken, 1999, 2001; Haines, 2001; Olmstead and Rhode, 2004; Cutler and Miller, 2005; Bleakley, 2010; Moehling and Thomasson, 2014; Beach et al., 2016; Komisarow, 2017; Alsan and Goldin, 2019). Costa and Kahn (2006) also show the importance of per capita expenditure by the city, which is linked to lower infant and child mortality. Our findings on the ineffectiveness of health administration align with Anderson et al. (2019a,b); Clay et al. (2018), which, as a group, places skepticism on the universal benefits of instituting public health measures. Taken as a whole, our results suggest that the particular bureaucratic arrangement through which health initiatives are carried out—a municipal health department—may be less important than the specific initiatives. In the case of vaccination campaigns and initiatives designed to limit infant mortality, these activities may have been achievable through a variety of administrative means.

This study is innovative in its focus on public health administration, but its findings have limitations that open the field to future research. While the broad activities of health departments may have provided little benefit when mortality was dominated by infectious diseases, 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 which health departments might have been uniquely suited to carry out, such as large-scale epidemiological surveys, 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 medical knowledge grew (Colgrove, 2011), and whether health departments became more effective over time.

More broadly, the results here are limited to medium-term effects: mortality reductions in the nine years following the establishment of a health department. Nevertheless, some of the health departments' activities may have needed many years to come to fruition. For example, some accounts (Leavitt, 1982, p. 214-227) argue 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). Future work could explore the contextual factors that may have allowed health departments to be notably effective in particular moments, even when, in general, they were not.

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Online Appendices

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

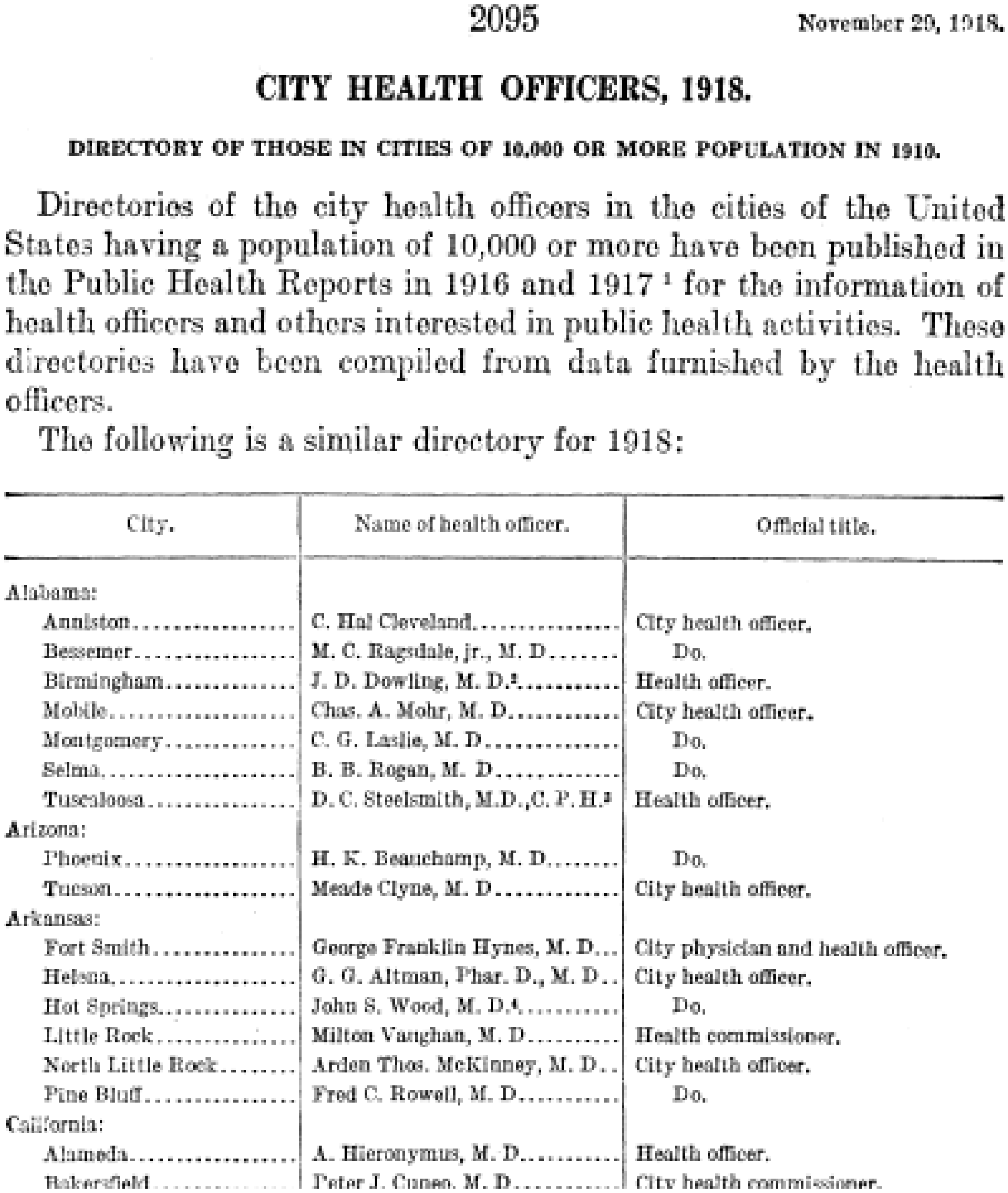
City	(1) Board Members	(2) Physicians on Board	(3) Expenditures (1,000s)
New York	8	2	375
St Louis	6	2	335
Chicago	3	1	207
Boston	3	0	105
Philadelphia	6	0	97
Baltimore	3	2	80
Brooklyn	1	0	77

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	40	36	745	4.95	1916	1916
NY	69	22	730	2.87	1916	1916
PA	92	80	716	12.7	1916	1916
MN	14	8	574	3.25	1916	1918
NJ	54	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	1917
VT	3	3	486	9.27	1916	1916
OH	59	39	462	1.8	1916	1916
RI	7	3	432	3.14	1916	1916
NC	21	17	411	2.6	1916	1916
VA	14	12	397	2.09	1916	1916
KY	13	8	393	1.27	1916	1916
CT	21	10	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	9	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	8	262	1.08	1916	1916
FL	14	8	253	15.21	1916	1917
MT	6	4	246	5.45	1916	1919
OR	6	4	227	1.78	1916	1917
IA	21	10	225	1.46	1916	1917
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	1917
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	1917
AL	14	12	105	1.11	1916	1917
SD	6	3	101	1.43	1916	1917
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: Original City-Level Full-Time Health Department Records



2095 November 29, 1918.

CITY HEALTH OFFICERS, 1918.

DIRECTORY OF THOSE IN CITIES OF 10,000 OR MORE POPULATION IN 1910.

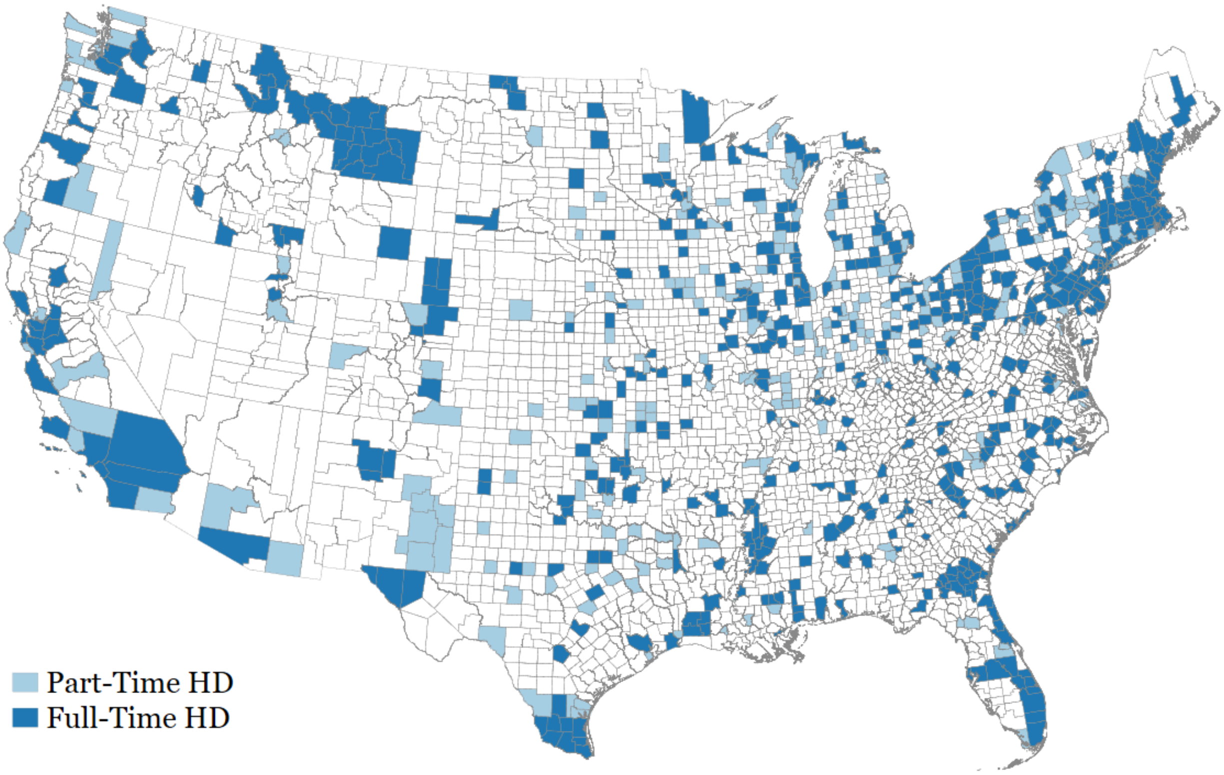
Directories of the city health officers in the cities of the United States having a population of 10,000 or more have been published in the Public Health Reports in 1916 and 1917 [1] for the information of health officers and others interested in public health activities. These directories have been compiled from data furnished by the health officers.

The following is a similar directory for 1918:

City.	Name of health officer.	Official title.
Alabama:		
Anniston	C. Hal Cleveland	City health officer.
Bessemer	M. C. Ragsdale, jr., M. D	Do.
Birmingham	J. D. Dowling, M. D.[2]	Health officer.
Mobile	Chas. A. Mohr, M. D	City health officer.
Montgomery	C. G. Laslie, M. D	Do.
Selma	B. B. Rogan, M. D	Do.
Tuscaloosa	D. C. Steelsmith, M.D., C. P. H.[3]	Health officer.
Arizona:		
Phoenix	H. K. Beauchamp, M. D	Do.
Tucson	Meade Clyne, M. D	City health officer.
Arkansas:		
Fort Smith	George Franklin Hynes, M. D	City physician and health officer.
Helena	G. G. Altman, Phar. D., M. D	City health officer.
Hot Springs	John S. Wood, M. D.[4]	Do.
Little Rock	Milton Vaughan, M. D	Health commissioner.
North Little Rock	Arden Thos. McKinney, M. D	City health officer.
Pine Bluff	Fred C. Rowell, M. D	Do.
California:		
Alameda	A. Hieronymus, M. D	Health officer.
Bakersfield	Peter J. Cuneo, M. D	City health commissioner.

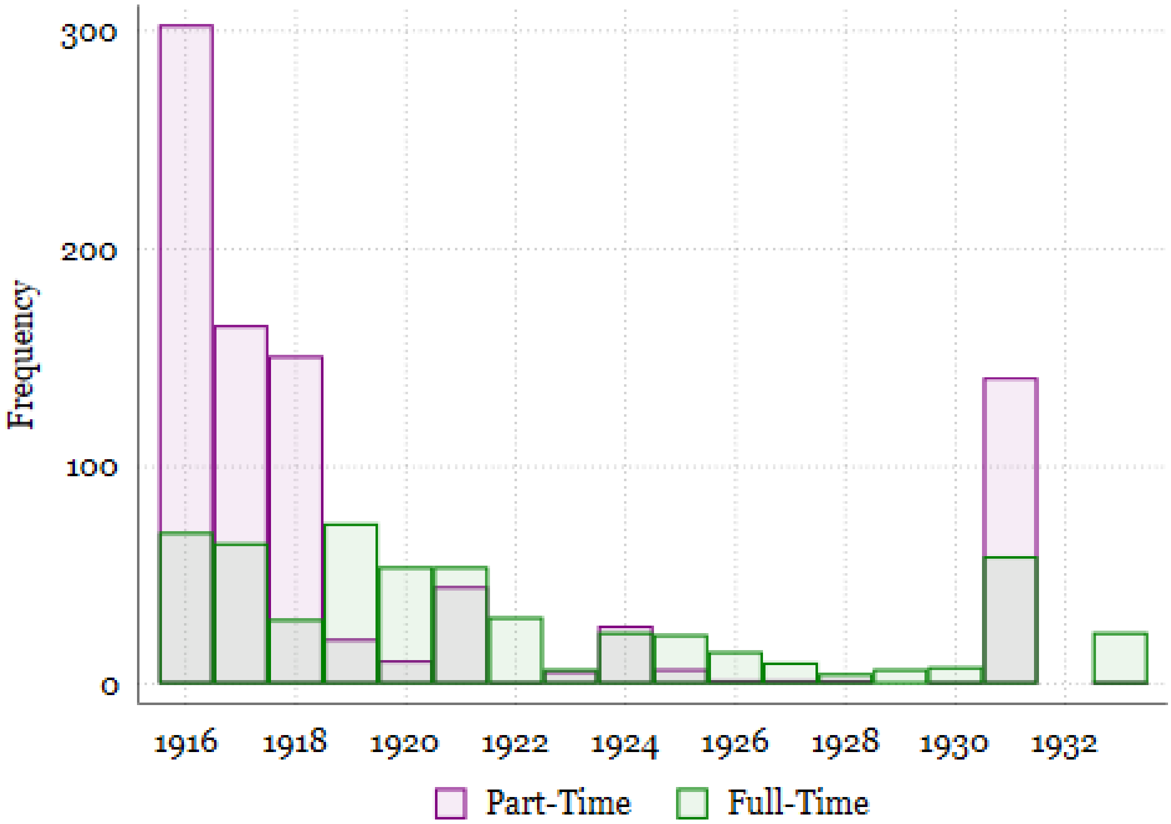
SOURCE: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1932.

Figure A.2: Location 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 1916-1932.

Figure A.3: Timing of Part-time versus 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 1916-1932.
NOTES: Green bars represent the number of full-time health departments that opened in each year. Purple bars show the number of part-time health departments that opened in each year.

Table A.4: Summary Statistics for Mortality Data and Health Departments, 1936

	Pre-1917	1917-1920	1921-1924	1925-1933	Never
	1936 Mean	1936 Mean	1936 Mean	1936 Mean	1936 Mean
Composition					
Populations (1,000)	145.218	138.290	35.507	35.916	27.083
Share Under 5	0.080	0.079	0.082	0.079	0.081
Share Over 65	0.049	0.050	0.048	0.052	0.052
Physicians per 10,000	15.682	15.151	15.233	18.257	15.548
Share White	0.923	0.913	0.888	0.907	0.941
Mortality					
Overall Rate	134.321	139.586	143.243	140.269	135.510
Infectious Rate	24.013	25.989	29.093	29.374	25.023
Non-Infectious Rate	110.307	113.597	114.150	110.853	110.491
Infant Mortality	53.539	56.855	65.732	63.096	58.212
Birth Rate	17.599	19.213	19.438	17.694	17.550
Rate Tuberculosis	4.540	4.440	5.103	5.406	4.514
Rate Typhoid	0.196	0.267	0.382	0.387	0.312
Rate Diphtheria	0.228	0.227	0.367	0.294	0.271
Rate Influenza/Pneumonia	12.755	13.845	14.718	14.930	12.707
Observations	70	225	117	155	351

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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table A.5: Full Summary Statistics

Panel A: Full v. Part-Time

	FULL-TIME		PART-TIME		DIFF.
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Est.*
Mortality					
Overall Rate	135.238	48.640	125.217	52.380	10.021**
Infectious Rate	29.904	15.692	26.818	17.235	3.086**
Non-Infectious Rate	105.334	37.583	98.399	40.252	6.935*
Infant Mortality	67.016	30.732	63.991	28.051	3.025
Birth Rate	21.009	6.717	19.631	7.763	1.379**
Rate Tuberculosis	6.867	6.951	6.240	6.474	0.626
Rate Typhoid	0.539	0.878	0.455	0.966	0.083
Rate Diphtheria	0.549	1.101	0.518	0.896	0.031
Rate Influenza/Pneumonia	11.895	5.700	10.467	6.128	1.427***
Characteristics					
Population (10,000's)	8.780	35.765	2.295	2.208	6.485***
Share White	0.909	0.132	0.947	0.089	-0.038***
Share Under 1	0.016	0.003	0.016	0.003	-0.000
Share Under 5	0.085	0.012	0.085	0.014	-0.001
Share Over 65	0.047	0.018	0.051	0.020	-0.003*
Share Females	0.510	0.019	0.503	0.022	0.007***
Share HH Own	0.471	0.108	0.531	0.102	-0.059***
Physicians per 10,000	13.716	8.843	12.505	7.172	1.212*
Average Occscore	8.476	0.679	8.419	0.867	0.057
N	560		326		886

Panel B: Early Versus Later-Treated

	BEFORE 1916		AFTER 1916		DIFF.
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Est.*
Mortality					
Overall Rate	128.786	36.898	136.160	50.056	-7.373
Infectious Rate	26.525	11.284	30.387	16.175	-3.861*
Non-Infectious Rate	102.261	28.489	105.773	38.711	-3.512
Infant Mortality	64.423	18.244	67.394	32.148	-2.971
Birth Rate	20.789	5.644	21.041	6.864	-0.252
Rate Tuberculosis	5.988	3.793	6.992	7.285	-1.004
Rate Typhoid	0.326	0.419	0.569	0.921	-0.243***
Rate Diphtheria	0.564	0.599	0.547	1.155	0.017
Rate Influenza/Pneumonia	11.186	4.480	11.996	5.850	-0.810
Characteristics					
Population (10,000's)	14.311	19.940	7.990	37.432	6.320*
Share White	0.928	0.107	0.906	0.135	0.021
Share Under 1	0.016	0.002	0.016	0.003	-0.000
Share Under 5	0.084	0.012	0.085	0.012	-0.001
Share Over 65	0.048	0.016	0.047	0.018	0.001
Share Females	0.511	0.017	0.509	0.019	0.002
Share HH Own	0.432	0.112	0.477	0.106	-0.045**
Physicians per 10,000	13.041	4.878	13.813	9.275	-0.773
Average Occscore	8.623	0.679	8.455	0.677	0.168
N	70		490		560

NOTES: Table shows the summary statistics across cities in 1930.

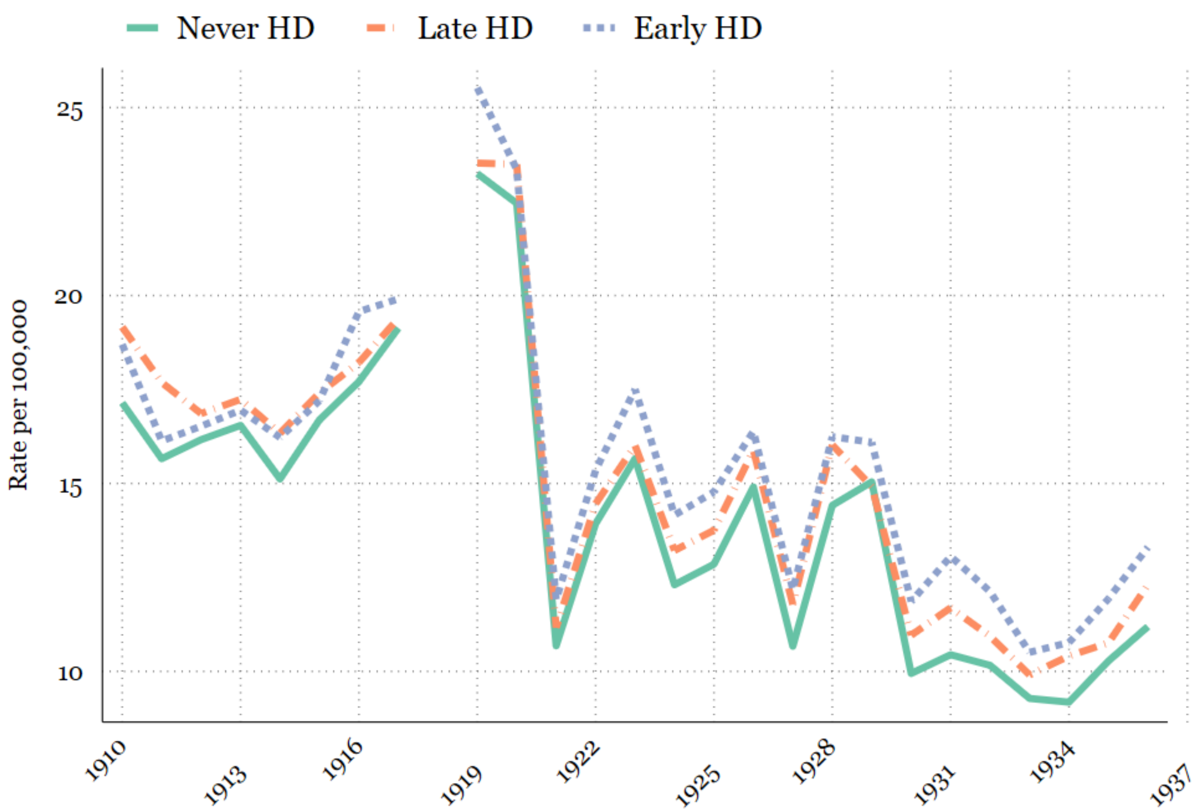
SOURCES: City health department records from public health reports from volumes entitled: *City Health Officers: Directory of Those in Cities of 10,000 or More Population* for years 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table A.6: Summary Statistics for Mortality Data and Health Departments

	Mean	Std. Dev.	50th Pct	Min	Max	Count
Share Adopted Over Time						
Full-Time HD (Pre 1916)	0.08	0.3	0.0	0.0	1.0	924.0
Full-Time HD (Post 1916)	0.54	0.5	1.0	0.0	1.0	924.0
Part-Time HD (Pre 1916)	0.33	0.5	0.0	0.0	1.0	924.0
Part-Time HD (Post 1916)	0.66	0.5	1.0	0.0	1.0	924.0
Aggregate Mortality						
Death Rate - 1916	158.63	42.8	154.4	70.3	440.6	470.0
Death Rate - 1936	138.21	66.7	136.5	5.4	1,381.8	917.0
Infectious Rate - 1916	52.65	20.1	50.0	19.2	214.9	470.0
Infectious Rate - 1936	26.44	17.6	23.0	0.5	239.6	917.0
Non-Infectious - 1916	105.98	30.7	101.1	43.7	300.2	470.0
Non-Infectious - 1936	111.77	53.4	110.8	4.9	1,142.3	917.0
Infant Rate - 1916	107.02	33.8	105.1	37.0	325.4	226.0
Infant Rate - 1936	59.29	30.3	54.4	0.0	281.3	891.0
Birth Rate - 1916	25.85	6.2	25.0	8.5	50.9	226.0
Birth Rate - 1936	18.23	8.6	18.3	0.0	97.3	855.0
By Cause Mortality						
Tuberculosis - 1916	14.63	8.7	12.7	2.5	76.0	470.0
Tuberculosis - 1936	4.72	5.4	3.3	0.0	58.5	917.0
Flu/Pneumonia - 1916	17.97	7.4	16.6	2.1	63.6	470.0
Flu/Pneumonia - 1936	13.62	8.7	12.1	0.0	136.9	917.0
Rate Typhoid - 1916	1.75	1.9	1.2	0.0	20.6	470.0
Rate Typhoid - 1936	0.31	0.7	0.0	0.0	8.1	917.0
Diphtheria - 1916	1.36	1.4	1.1	0.0	14.3	470.0
Diphtheria - 1936	0.27	0.5	0.0	0.0	3.2	917.0
Observations	924					

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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Figure A.4: Influenza and Pneumonia Mortality, Excluding 1918



SOURCE: Vital statistics are from the U.S. Vital Statistics.
NOTES: Never having a health department refers to no adoption by 1933. Late adoption is defined as adoption between 1916 and 1933. Early adoption is defined as having a health department before 1917. Measures of mortality are per 100,000 individuals, except infant mortality, which is per 1,000 births.

B What Explains the Variation in Timing of City-level Adoption?

To test the effect of preventative public health, we exploit the timing of the health department to measure the effect on local mortality. In this section, we briefly test whether the timing is influenced by a city's characteristics. To test which factors affected adoption, 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 part-time health departments and Columns (3) and (4) show the full-time health departments. Aside from the size of the city, no other factors predict adoption of a health department, including the infectious disease mortality rate. In the last two columns, we also show the results across the adoption of a full-time health department. The estimates suggest that there were varied factors that affected adoption. Existing physicians, lower infectious mortality, as well as lower economic conditions, appear to 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 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

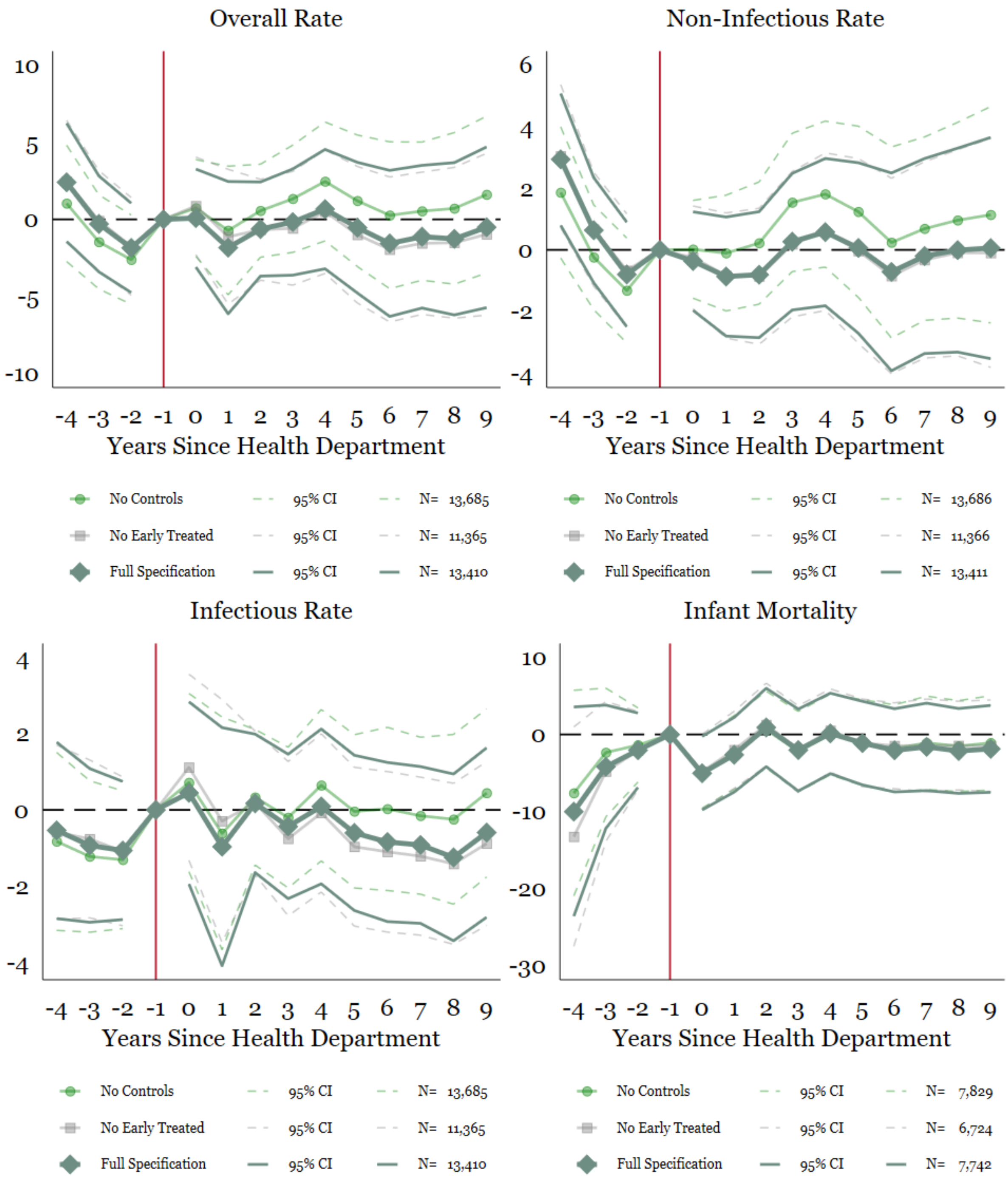
	Part-Time HD		Full-Time HD			
	(1)	(2)	(3)	(4)	(5)	(6)
	Timing	Timing	Timing	Timing	Treat -ment	Treat -ment
Log of Population	-0.147***	-0.158***	-0.759**	-0.802**	0.112***	0.098**
	(0.026)	(0.028)	(0.289)	(0.350)	(0.034)	(0.039)
Infectious Rate	0.002	0.001	0.018	0.015	-0.001	-0.003**
	(0.002)	(0.002)	(0.016)	(0.023)	(0.001)	(0.001)
Share White		-0.255		5.934		-1.279*
		(0.867)		(9.355)		(0.725)
Share Under 5		-1.995		14.690		-1.518
		(4.601)		(35.287)		(3.538)
Share Females		0.821		-5.254		-0.778
		(1.785)		(13.943)		(0.838)
Physicians per 10,000		-0.003		0.020		0.005**
		(0.005)		(0.026)		(0.002)
Average Occscore		-0.004		-0.205		-0.033
		(0.064)		(0.414)		(0.027)
Share HH Own		-0.052		-4.930		-0.436**
		(0.681)		(4.257)		(0.214)
Share Over 65		-4.507		41.920		-0.702
		(4.326)		(38.152)		(2.465)
Observations	434	424	310	301	435	425
Adjusted R-sq.	0.04	0.02	0.05	0.03	0.22	0.25
F-statistic	20.40	12.09	3.65	3.04	5.93	4.51
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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

C Additional Specification based on the Main Results

Figure C.1: Part-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. Measures of mortality are per 100,000 individuals, except infant mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons.

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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table C.1: Difference-in-Differences Specification

Panel A: All Cities

	Death Rate					Infectious Mortality					Infant Mortality				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Post x HD	-1.35	-0.09	1.11	-0.10	-1.02	0.23	0.67	0.88	-0.51	-0.73	2.73*	1.55	0.58	-0.62	-0.06
	(1.65)	(2.14)	(1.55)	(1.13)	(1.19)	(0.75)	(1.12)	(0.87)	(0.57)	(0.52)	(1.46)	(1.11)	(1.01)	(0.98)	(1.05)
N	23,407	23,407	22,978	22,978	22,978	23,407	23,407	22,978	22,978	22,978	12,211	12,211	12,092	12,092	12,092
HD x Year	15,999	15,999	15,999	15,999	15,999	15,999	15,999	15,999	15,999	15,999	8,191	8,191	8,191	8,191	8,191
Mean Dep	145.0	145.0	145.0	145.0	145.0	40.2	40.2	40.2	40.2	40.2	73.8	73.8	73.8	73.8	73.8
Baseline FE	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	
Controls			X	X	X			X	X	X			X	X	X
Time Trends				X	X				X	X				X	X

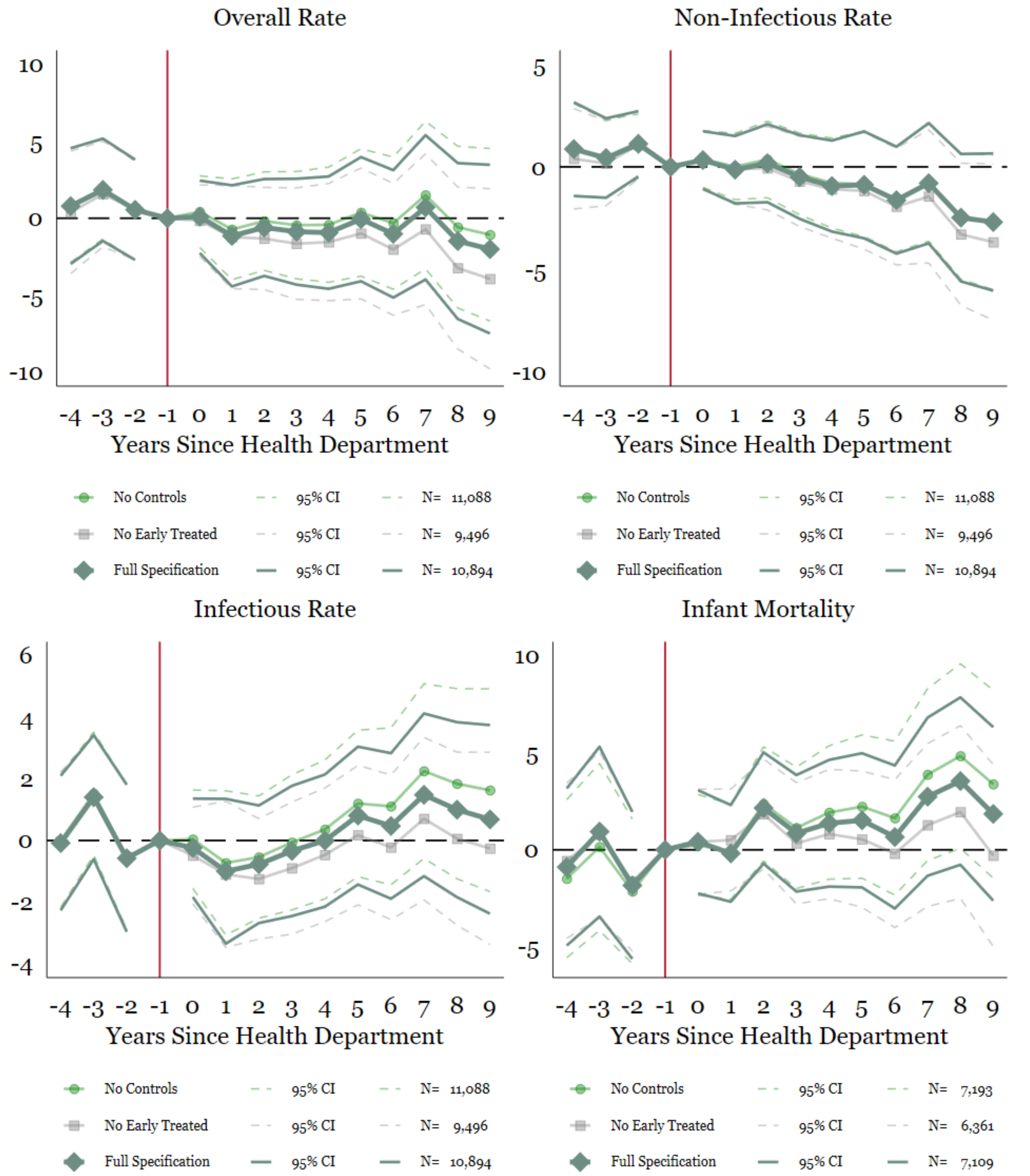
Panel B: Excluding Early Treated Health Departments (Before 1916)

	Death Rate					Infectious Mortality					Infant Mortality				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Post x HD	-2.82	-0.61	0.08	0.30	-1.08	-0.56	0.32	0.39	-0.42	-0.86	2.23	0.45	-0.25	-0.28	-0.35
	(1.77)	(2.78)	(1.87)	(1.16)	(1.22)	(0.78)	(1.47)	(1.02)	(0.64)	(0.55)	(1.52)	(1.13)	(0.99)	(1.05)	(1.09)
N	20,776	20,776	20,369	20,369	20,369	20,776	20,776	20,369	20,369	20,369	10,919	10,919	10,803	10,803	10,803
HD x Year	13,361	13,361	13,361	13,361	13,361	13,361	13,361	13,361	13,361	13,361	6,892	6,892	6,892	6,892	6,892
Mean Dep	144.6	144.6	144.6	144.6	144.6	39.5	39.5	39.5	39.5	39.5	73.4	73.4	73.4	73.4	73.4
Baseline FE	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	
Controls			X	X	X			X	X	X			X	X	X
Time Trends				X	X				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 mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. 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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

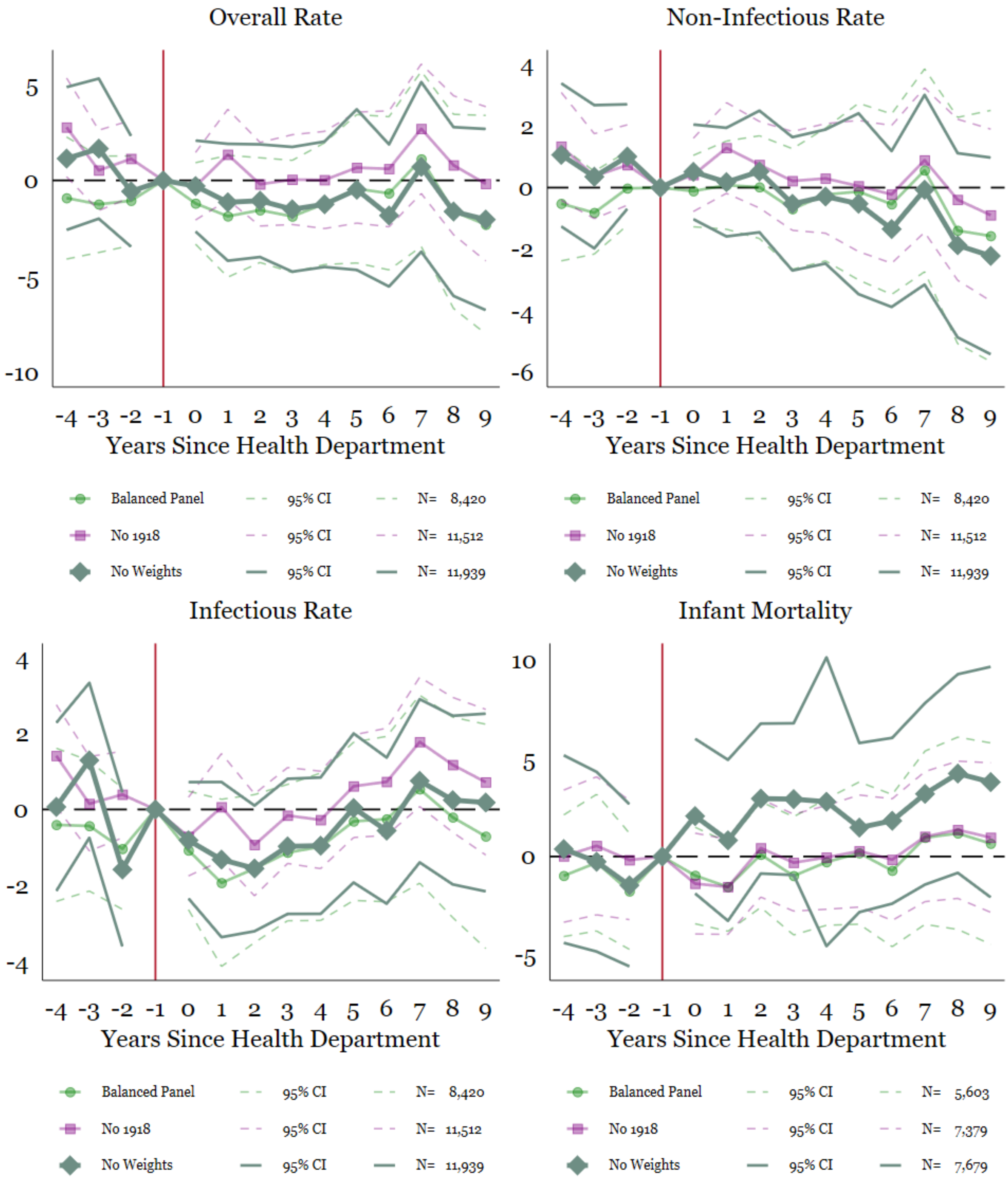
Figure C.2: Full-time Health Department Entry, Only Cities with a Population of Less than 100,000



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. The dark green points show the main specification. The lighter points show the main specification excluding controls (light green) and population weights (purple). Dashed and dotted lines display the 95 percent confidence intervals. Observations more than four years before and more than nine years after the health department arrived are removed from the analysis. Measures of mortality are per 100,000 individuals, except infant mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons.

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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

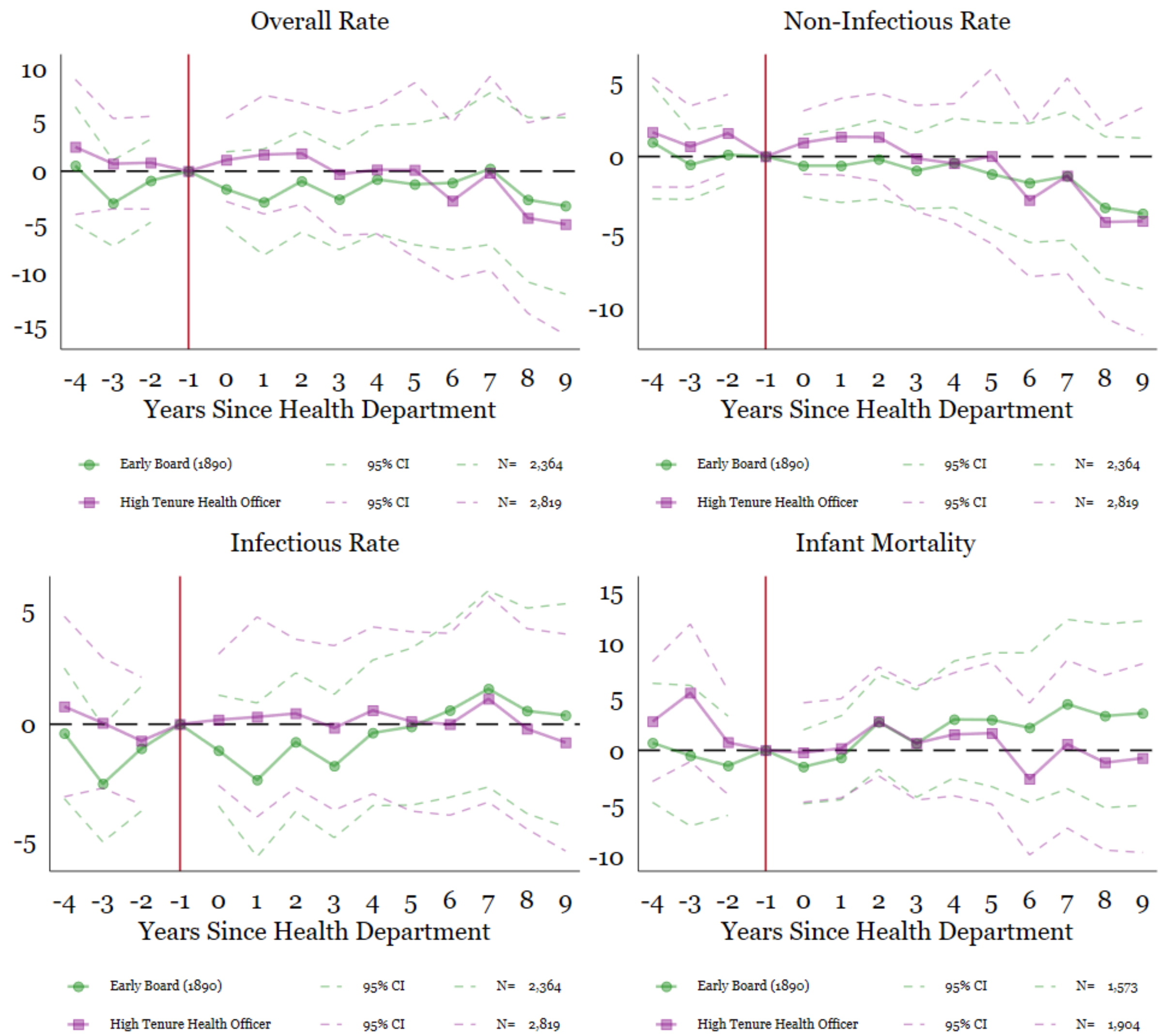
Figure C.3: Full-time Health Department Entry, Balanced Panel and Excluding 1918



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. Measures of mortality are per 100,000 individuals, except infant mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons.

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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Figure C.4: Part-time Health Department Entry and Mortality, By 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. The dark green points show the main specification. The lighter points show the main specification excluding controls (light green) and population weights (purple). Dashed and dotted lines display the 95 percent confidence intervals. Observations more than four years before and more than nine years after the health department arrived are removed from the analysis. Measures of mortality are per 100,000 individuals, except infant mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons.

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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table C.2: Heterogeneity by Early v. Later-Treated

	Treated Before 1922						Treated After 1921					
	(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	-4.43	0.29	0.33	-0.44	-0.12	-0.34	0.25	0.74	0.34	0.55	-0.28*	0.24
	(6.53)	(1.87)	(1.26)	(0.58)	(0.20)	(0.21)	(2.38)	(1.80)	(1.00)	(0.65)	(0.17)	(0.24)
Year -2 and -3	-2.86	0.51	0.37	-0.29	0.01	0.02	1.05	0.36	0.34	0.21	-0.13	0.08
	(2.96)	(1.44)	(1.17)	(0.25)	(0.11)	(0.13)	(1.81)	(0.99)	(0.61)	(0.48)	(0.13)	(0.14)
Years 0 and 1	0.29	-1.63	-1.43	-0.21	0.05	0.21	0.34	-0.17	-0.38	-0.12	0.10	0.00
	(2.12)	(1.56)	(1.25)	(0.27)	(0.09)	(0.16)	(1.65)	(0.93)	(0.48)	(0.40)	(0.13)	(0.14)
Years 2 and 3	4.95	-1.38	-1.52	-0.05	0.10	0.29	0.15	-1.60	-1.45*	-0.06	0.13	0.03
	(3.69)	(1.90)	(1.32)	(0.41)	(0.12)	(0.28)	(2.29)	(1.65)	(0.86)	(0.54)	(0.16)	(0.23)
Years 4 and 5	6.97	-1.07	-1.35	0.09	0.14	0.25	-1.91	-1.85	-2.34*	0.29	0.31	-0.11
	(4.67)	(2.02)	(1.36)	(0.54)	(0.15)	(0.33)	(2.79)	(2.45)	(1.35)	(0.78)	(0.24)	(0.26)
Years 6-9	6.16	-0.53	-0.92	0.30	0.11	0.23	-1.34	-2.17	-2.76	0.36	0.52	-0.23
	(5.24)	(2.16)	(1.44)	(0.66)	(0.18)	(0.37)	(3.86)	(3.55)	(1.97)	(1.22)	(0.39)	(0.37)
N	2,442	5,148	5,148	5,148	5,148	5,148	1,968	3,371	3,228	3,371	3,371	3,371
Adjusted R-sq.	0.82	0.93	0.91	0.95	0.74	0.71	0.75	0.90	0.83	0.89	0.66	0.59
Mean Dep	82.9	48.6	17.6	12.7	1.8	1.8	74.1	41.8	15.8	11.6	1.4	1.2
Baseline FE	X	X	X	X	X	X	X	X	X	X	X	X
Time Trend	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 mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

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Table C.3: Heterogeneity by Early v. Later-Treated, Excluding 1918

	Treated Before 1922						Treated After 1921					
	(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	-2.10	0.45	0.06	-0.11	-0.17	-0.33	0.96	0.16	-0.18	0.46	-0.30*	0.22
	(6.64)	(1.73)	(0.91)	(0.58)	(0.21)	(0.22)	(2.60)	(1.38)	(0.56)	(0.63)	(0.17)	(0.24)
Year -2 and -3	-0.76	0.27	-0.29	0.04	-0.05	0.05	1.14	0.22	0.20	0.20	-0.14	0.08
	(2.91)	(1.22)	(0.69)	(0.26)	(0.14)	(0.15)	(1.80)	(0.86)	(0.51)	(0.48)	(0.13)	(0.14)
Years 0 and 1	-1.26	-0.35	-0.27	-0.02	0.06	0.13	0.22	0.01	-0.21	-0.10	0.11	0.01
	(2.56)	(0.94)	(0.54)	(0.26)	(0.10)	(0.17)	(1.62)	(0.83)	(0.42)	(0.40)	(0.13)	(0.14)
Years 2 and 3	3.06	-0.77	-0.87	0.00	0.11	0.26	-0.06	-1.21	-1.07*	-0.04	0.14	0.04
	(4.11)	(1.46)	(0.76)	(0.40)	(0.13)	(0.29)	(2.20)	(1.29)	(0.55)	(0.50)	(0.16)	(0.23)
Years 4 and 5	4.73	-0.66	-0.81	0.07	0.15	0.23	-2.14	-1.25	-1.75**	0.31	0.33	-0.09
	(5.19)	(1.64)	(0.81)	(0.55)	(0.16)	(0.34)	(2.71)	(1.75)	(0.72)	(0.72)	(0.24)	(0.26)
Years 6-9	3.84	-0.33	-0.55	0.23	0.12	0.22	-1.54	-1.29	-1.88*	0.38	0.54	-0.20
	(5.75)	(1.80)	(0.95)	(0.67)	(0.19)	(0.37)	(3.75)	(2.50)	(0.98)	(1.13)	(0.39)	(0.36)
N	2,311	4,955	4,955	4,955	4,955	4,955	1,930	3,298	3,155	3,298	3,298	3,298
Adjusted R-sq.	0.80	0.93	0.84	0.95	0.74	0.72	0.74	0.91	0.77	0.90	0.66	0.59
Mean Dep	81.5	46.4	15.5	12.6	1.9	1.8	73.3	40.4	14.5	11.5	1.4	1.2
Baseline FE	X	X	X	X	X	X	X	X	X	X	X	X
Time Trend	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 mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

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Table C.4: Heterogeneity by Race and Best State Health Departments

	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	0.36	1.44	0.24	0.84	-0.04	0.02	1.72	3.77*	0.95	0.83	0.29	0.27*
	(2.40)	(1.89)	(1.32)	(0.70)	(0.10)	(0.18)	(4.70)	(2.04)	(1.29)	(0.91)	(0.22)	(0.15)
Year -2 and -3	-0.31	1.20	0.56	0.60	0.02	0.12	3.18	2.99*	0.91	1.00*	0.14	0.11
	(1.99)	(1.25)	(1.13)	(0.44)	(0.06)	(0.11)	(3.40)	(1.53)	(1.05)	(0.61)	(0.18)	(0.09)
Years 0 and 1	-3.81***	-2.68**	-1.72*	-0.56	0.01	0.23*	3.24	0.01	0.08	-0.46	-0.14	-0.13
	(1.13)	(1.33)	(1.02)	(0.54)	(0.07)	(0.12)	(3.12)	(1.77)	(1.13)	(0.45)	(0.18)	(0.10)
Years 2 and 3	-2.80*	-0.36	0.49	-1.06	-0.02	0.30	6.60*	-0.86	-1.21	-0.10	-0.21	0.04
	(1.56)	(2.13)	(1.14)	(0.92)	(0.08)	(0.20)	(3.98)	(1.59)	(0.99)	(0.62)	(0.18)	(0.16)
Years 4 and 5	-2.44	-1.14	-0.07	-0.69	-0.04	0.13	6.20	0.04	-1.39	0.26	-0.22	0.08
	(2.06)	(2.14)	(1.04)	(0.81)	(0.11)	(0.21)	(4.81)	(1.94)	(1.06)	(0.83)	(0.21)	(0.19)
Years 6-9	-3.00	-1.79	0.46	-1.27	-0.09	0.14	7.60	-0.07	-1.54	0.03	-0.28	0.04
	(2.84)	(3.11)	(1.44)	(1.06)	(0.17)	(0.30)	(5.97)	(2.32)	(1.20)	(1.14)	(0.27)	(0.20)
N	3,619	6,715	6,679	6,715	6,715	6,715	2,757	4,743	4,633	4,743	4,743	4,743
Adjusted R-sq.	0.87	0.93	0.92	0.92	0.73	0.68	0.72	0.93	0.87	0.94	0.75	0.56
Mean Dep	81.2	46.7	17.5	11.1	1.5	2.0	80.2	47.3	17.5	13.5	1.7	1.1
Baseline FE	X	X	X	X	X	X	X	X	X	X	X	X
Time Trend	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 mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

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Table C.5: 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	0.30	-1.90	-1.31	-0.39	-0.08	0.10	-1.17	1.04	0.13	0.59	0.05	0.05
	(2.94)	(1.52)	(1.10)	(0.56)	(0.18)	(0.16)	(2.14)	(1.46)	(1.04)	(0.50)	(0.10)	(0.14)
Year -2 and -3	0.52	-0.55	-0.43	-0.06	0.00	0.10	-1.06	0.85	0.44	0.32	-0.02	0.04
	(2.26)	(1.34)	(1.06)	(0.43)	(0.13)	(0.12)	(1.77)	(0.98)	(0.84)	(0.32)	(0.06)	(0.09)
Years 0 and 1	1.15	-1.39	-1.02	-0.50	0.13	-0.00	-2.04*	-0.65	-0.33	-0.19	-0.09	0.16
	(2.13)	(1.24)	(0.99)	(0.32)	(0.12)	(0.11)	(1.06)	(1.12)	(0.82)	(0.42)	(0.06)	(0.10)
Years 2 and 3	0.65	-1.35	-1.20	-0.24	0.12	0.09	-0.46	0.05	0.41	-0.41	-0.14	0.06
	(2.85)	(1.34)	(0.99)	(0.42)	(0.13)	(0.17)	(1.52)	(1.64)	(0.89)	(0.70)	(0.09)	(0.15)
Years 4 and 5	-0.12	0.19	-0.51	0.20	0.15	0.11	0.59	-0.80	-0.12	-0.15	-0.18	-0.12
	(3.51)	(1.60)	(1.07)	(0.56)	(0.17)	(0.20)	(2.06)	(1.68)	(0.82)	(0.64)	(0.12)	(0.15)
Years 6-9	-1.33	0.61	-0.05	0.14	0.21	0.06	1.87	-1.00	0.41	-0.47	-0.27	-0.09
	(4.43)	(1.88)	(1.30)	(0.72)	(0.22)	(0.23)	(2.72)	(2.43)	(1.15)	(0.84)	(0.17)	(0.22)
N	4,968	8,556	8,428	8,556	8,556	8,556	3,075	6,828	6,824	6,828	6,828	6,828
Adjusted R-sq.	0.74	0.88	0.80	0.91	0.53	0.41	0.89	0.94	0.92	0.94	0.79	0.72
Mean Dep	80.0	44.5	17.2	11.2	1.6	1.4	78.3	49.0	16.8	13.7	1.8	1.8
Baseline FE	X	X	X	X	X	X	X	X	X	X	X	X
Time Trend	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 mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. Robust standard errors are clustered at the city level. Significance levels (when reported) are at the 10, 5, and 1 percent.

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Table C.6: Heterogeneity by Physician Access

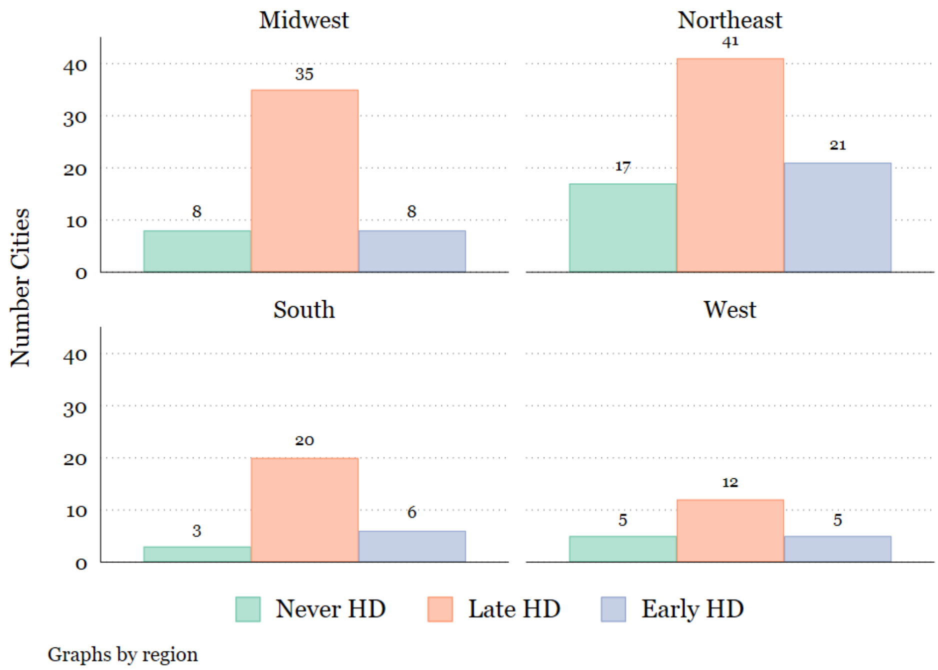
	Low Physician Access						High Physician Access					
	(1) Infant	(2) Infect	(3) Flu	(4) TB	(5) Typh	(6) Diph	(7) Infant	(8) Infect	(9) Flu	(10) TB	(11) Typh	(12) Diph
Years up to -4	-0.88	0.32	-0.27	0.54	0.02	0.06	-0.67	0.70	0.55	-0.47	0.30	0.10
	(1.90)	(1.30)	(0.91)	(0.45)	(0.09)	(0.12)	(4.07)	(1.99)	(1.29)	(0.84)	(0.23)	(0.18)
Year -2 and -3	-0.63	0.38	0.12	0.29	-0.02	0.07	-0.55	0.29	0.34	-0.17	0.11	0.01
	(1.54)	(0.87)	(0.74)	(0.29)	(0.05)	(0.08)	(3.42)	(1.71)	(1.24)	(0.52)	(0.20)	(0.14)
Years 0 and 1	-1.48	-0.86	-0.64	-0.13	-0.07	0.15*	1.45	-0.74	-0.34	-0.46	0.08	-0.04
	(0.96)	(0.99)	(0.75)	(0.36)	(0.06)	(0.09)	(3.26)	(1.32)	(0.94)	(0.42)	(0.17)	(0.13)
Years 2 and 3	-0.66	-0.20	0.14	-0.43	-0.10	0.06	3.98	-0.22	-0.42	0.43	-0.15	0.15
	(1.33)	(1.40)	(0.78)	(0.59)	(0.08)	(0.13)	(4.10)	(1.57)	(0.99)	(0.49)	(0.18)	(0.23)
Years 4 and 5	0.03	-0.54	-0.14	-0.08	-0.12	-0.07	3.73	1.17	0.04	0.96	-0.28	0.15
	(1.81)	(1.47)	(0.73)	(0.56)	(0.11)	(0.13)	(5.10)	(2.05)	(1.07)	(0.69)	(0.22)	(0.27)
Years 6-9	0.81	-0.79	0.32	-0.42	-0.22	-0.06	3.51	1.86	0.52	1.20	-0.37	0.14
	(2.38)	(2.14)	(1.01)	(0.75)	(0.15)	(0.20)	(6.40)	(2.38)	(1.21)	(0.89)	(0.27)	(0.29)
N	4,889	10,310	10,298	10,310	10,310	10,310	3,135	5,069	4,951	5,069	5,069	5,069
Adjusted R-sq.	0.87	0.93	0.91	0.93	0.75	0.68	0.63	0.90	0.82	0.92	0.58	0.49
Mean Dep	80.1	48.8	17.1	13.1	1.8	1.8	78.1	42.0	16.7	10.9	1.4	1.1
Baseline FE	X	X	X	X	X	X	X	X	X	X	X	X
Time Trend	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 mortality, which is per 1,000 births. Infant mortality is weighted by the number of births. The remainder of mortality measures 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 share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. 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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

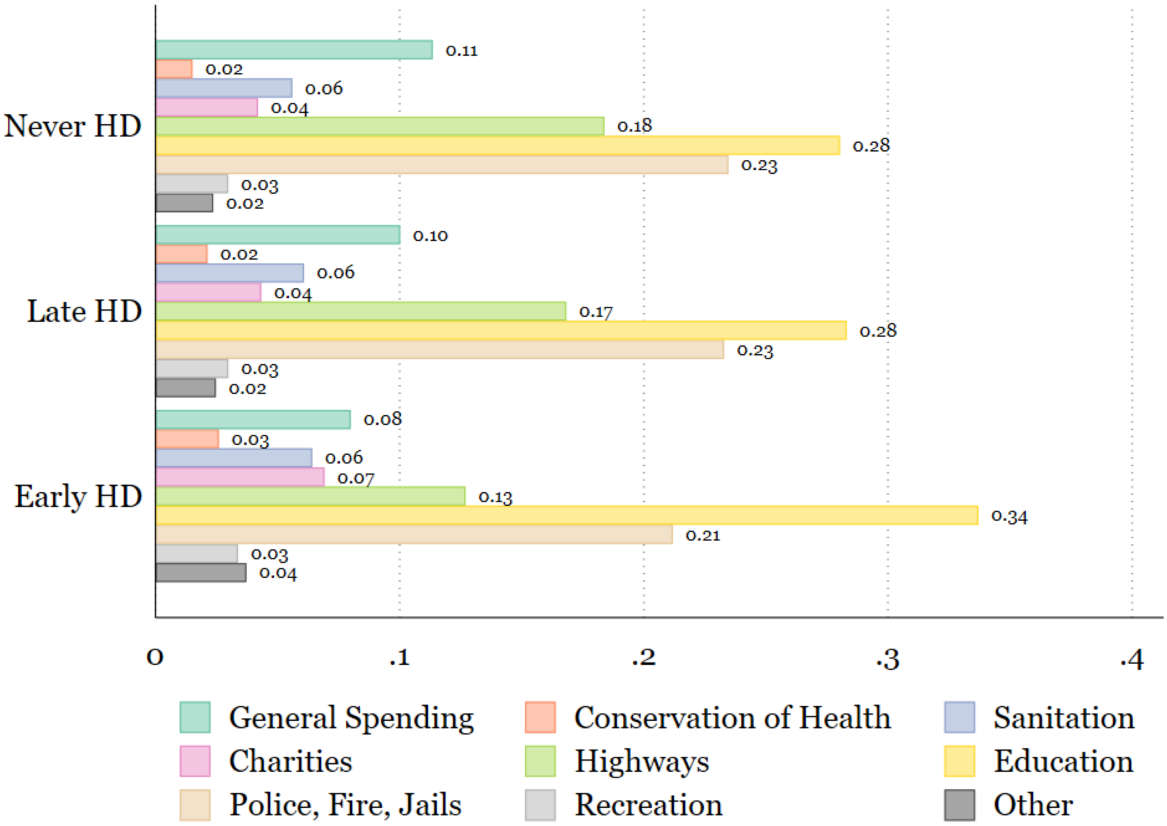
D Expenditure Analysis

Figure D.1: Number Cities in the Statistics of Cities by Region



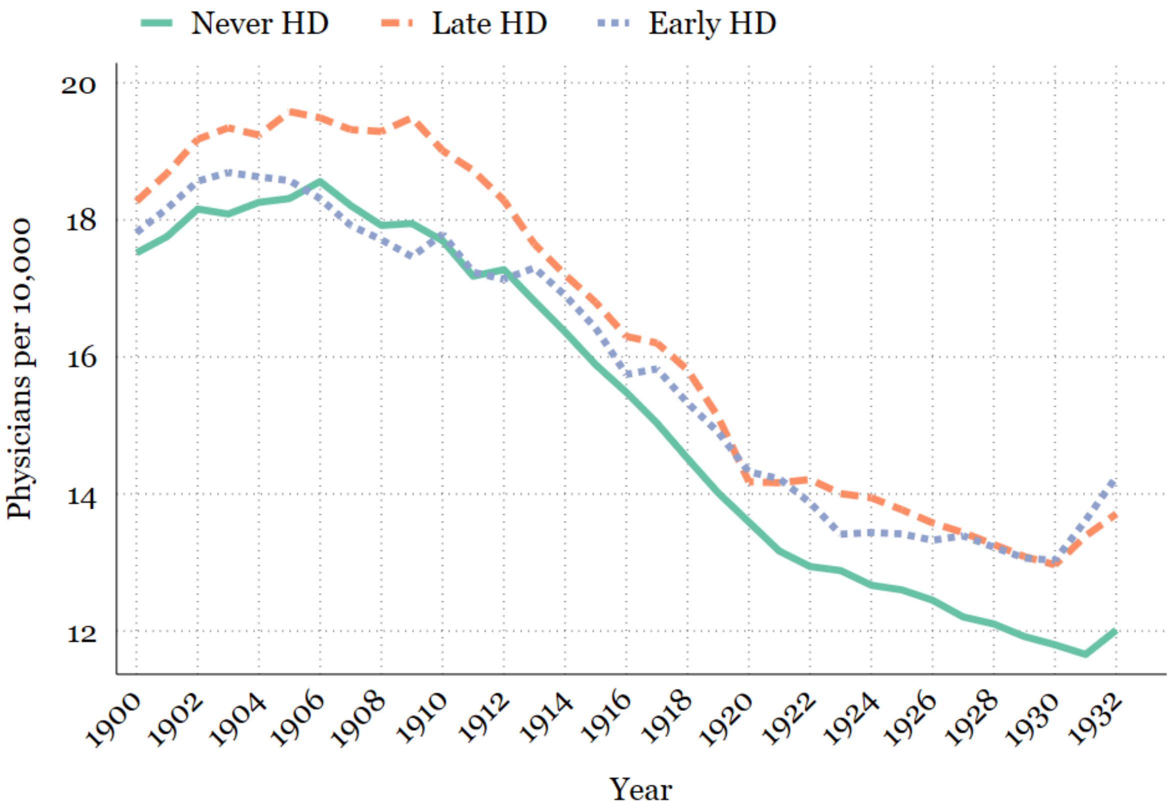
SOURCES: Financial Statistics of Cities having a Population of Over 30,000 for 1912,1915-1919,1921-31.

Figure D.2: Share of Budget Dedicated to Each Category



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

Figure D.3: Physician Access by Adoption Type



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

Table D.1: Per Capita Spending and Adoption of a Health Department, 1912-1931

	1(Health Department)																	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
P.C. Sanitation	-0.016	-0.034	-0.017															
	(0.043)	(0.042)	(0.024)															
P.C. HD Spending				0.059	0.165	0.052												
				(0.232)	(0.238)	(0.137)												
P.C. Child Spending							-0.385***	-0.309**	-0.035									
							(0.146)	(0.131)	(0.099)									
P.C. Prevention Spending										-0.101	-0.102*	-0.013						
										(0.062)	(0.058)	(0.032)						
P.C. General Spending													-0.033*	-0.031**	-0.028**			
													(0.017)	(0.012)	(0.012)			
P.C. Education																-0.015	-0.010	-0.003
																(0.009)	(0.007)	(0.004)
Observations	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880	1,880
Adjusted R-sq.	0.76	0.78	0.90	0.76	0.78	0.90	0.76	0.78	0.90	0.76	0.78	0.90	0.76	0.78	0.90	0.76	0.78	0.90
F-statistic	0.14	2.58	1.64	0.07	2.67	1.65	7.00	3.29	1.59	2.64	2.70	1.61	3.72	3.72	3.77	2.48	2.69	1.80
Baseline FE	X	X	X	X	X	X	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
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 size of the population, the share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. 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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table D.2: Per Capita Spending and Infant Mortality, 1912-1931

	Infant Mortality																	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
P.C. Sanitation	-0.027	-0.149	-1.250															
	(1.059)	(0.911)	(0.848)															
P.C. HD Spending				-23.928**	-17.992*	-13.418*												
				(10.837)	(9.115)	(7.273)												
P.C. Child Spending							-11.945	-8.909	0.281									
							(8.214)	(6.449)	(2.774)									
P.C. Prevention Spending										-1.403	-0.382	-3.598						
										(2.837)	(2.904)	(2.439)						
P.C. General Spending													-0.308	0.196	-0.140			
													(0.500)	(0.489)	(0.262)			
P.C. Education																-0.394*	0.016	-0.265**
																(0.231)	(0.200)	(0.134)
Observations	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562	1,562
Adjusted R-sq.	0.86	0.87	0.90	0.86	0.87	0.90	0.86	0.87	0.90	0.86	0.87	0.90	0.86	0.87	0.90	0.86	0.87	0.90
F-statistic	0.00	5.96	3.57	4.88	5.85	2.80	2.11	5.55	2.47	0.24	7.26	2.63	0.38	6.01	2.45	2.91	6.39	2.81
Baseline FE	X	X	X	X	X	X	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
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 size of the population, the share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. 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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.

Table D.3: Interaction of Spending with Health Department and Infant Mortality 1912-1931, Subsamples

	Infant Mortality						
	(1) Best States	(2) Other States	(3) Midwest	(4) South & West	(5) North-east	(6) NY	(7) MA
P.C. HD Spending	11.257	-10.461	-27.151	-8.423	20.947	5.579	22.641
	(15.638)	(19.714)	(28.548)	(27.900)	(16.818)	(15.682)	(53.505)
HD=1	7.469*	-5.034	-10.116	-11.175	9.713**	7.855	14.103
	(4.008)	(5.282)	(6.152)	(9.494)	(3.870)	(6.562)	(12.953)
HD=1 × P.C. HD Spending	-44.477**	21.566	40.167	36.009	-49.625***	-40.315*	-83.942
	(17.119)	(19.072)	(30.815)	(27.298)	(16.860)	(19.683)	(48.949)
N	655	487	379	117	631	168	168
Adjusted R-sq.	0.87	0.85	0.86	0.90	0.86	0.86	0.73
Baseline FE	X	X	X	X	X	X	X
Weights	X	X	X	X	X	X	X
Controls	X	X	X	X	X	X	X
No Early-Treated	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 size of the population, the share of the population that is white, the share of the population under five and over 65, the share female, the share of household heads that own their homes, the average occupational score, and the physicians per 10,000 persons. 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 1916-1932. Vital statistics are from the U.S. Vital Statistics. City-level demographic characteristics are calculated from the IPUMs Restricted Complete Count U.S. Census data.