Innovation and Health Behavior: Evidence from the American Public Bath Movement

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Abstract

The prominent decline in urban mortality rates during the late 19th and early 20th centuries in the United States is primarily attributed to reductions in deaths caused by infectious and food- and waterborne diseases. While existing literature has explored the role of public health initiatives in explaining this decline from the latter of these types, this paper focuses on the contribution of innovations in and provision of hygienic technologies and their role in eradication of the former. Specifically, we investigate the health impact of the rapid adoption and utilization of bathhouses in urban working-class neighborhoods following the technological advancement of what we recognize today as the modern-day shower. By exploiting differential timing of bathhouse openings beginning around 1890 and utilizing city-level mortality data for U.S. urban areas, we estimate the mortality effects of these facilities introduced prior to the widespread adoption of modern household sanitation infrastructure and the germ theory of disease. This paper highlights the role that hygienic infrastructure and behavior may have played in improving public health during that era, shedding light on mechanisms policy makers can utilize when designing interventions aimed at encouraging behavioral take-up today.

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"That expenditure of money for the prevention of disease is the most profitable application of public funds has become an accepted fact in modern government. In no direction would money be more beneficiently and profitably expended than in the construction of these public baths, into which the passer-by may be tempted by ease of access, promise of comfort, and freedom from expense. A river bath in summer requires some resolution, some energy; but a warm shower bath in a well-lighted, well-ventilated, and pleasantly warm room, with facilities for drying and dressing, is a luxury that may tempt the laziest and dirtiest tramp."

— Dr. Simon Baruch of the New York County Medical Society, 1889

1 Introduction

Proper hand hygiene such as washing with soap and water can help prevent contracting and spreading diarrheal and respiratory illnesses,[1] and it is estimated that its widespread adoption could spare half of a million deaths annually. Lack of sanitation infrastructure has been found to be a major obstacle by a joint report from the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) which estimated in 2020 that 2.3 billion people around the world lack a facility with water and soap to wash their hands at home with around 670 million lacking any facilities for handwashing whatsoever (UNICEF & WHO 2021).

While sanitation infrastructure is certainly a critically important condition for engagement in sanitation practices and corresponding improvements, it is not sufficient, and as Zwane and Kremer (2007) argue, more needs to be learned about how to increase take up of these behaviors. Studies in the economic and related literature have sought to improve handwashing behavioral take up among residents in high-morbidity areas with interventions such as providing handwashing infrastructure and information (Guiteras et al. 2016; Hussam et al. 2021), monitoring for compliance (Staats et al. 2017; Chen et al. 2020; Hussam et al. 2022), providing cash incentives (Hussam et al. 2022), inducing moral suasion (Bos et al. 2020), as well as altering perceptions of community compliance (Das et al. 2022).

[1] Proper handwashing techniques are emphasized by the Centers for Disease Control and Prevention (CDC n.d.) and is recommended in cases including (but not limited to): before, during, and after preparing food, after using the toilet, and before and after caring for someone who is sick with vomiting or diarrhea.

Residents of rapidly growing urban areas in nineteenth-century America faced similarly severe health consequences in the form of a generally high likelihood of perishing from these types of diseases, with mortality disproportionately concentrated among children (Haines 2001; Costa 2015). Sewerage was sometimes discharged directly into city water supplies, contributing to outbreaks of waterborne illnesses like typhoid fever and cholera (Ferrie and Troesken 2008). Over-crowded and densely settled tenement apartments lacking ventilation and light were blamed for the spread of respiratory diseases like pneumonia and tuberculosis (Biggs 1908). The prominent decline in mortality that developed throughout the second half of the nineteenth century and first half of the next has come to be known as the "epidemiological transition", the "mortality transition", or the "health transition", in which deaths shifted from infectious diseases and child mortalities toward chronic and degenerative afflictions associated with aging (Omran 1977; Haines 2001; Costa 2015).

Economists and public health scholars alike have traditionally attributed these societal welfare gains to the onset of modern economic growth and corresponding improvements in nutrition (Mckeown 1976), as well as large public health infrastructural investments such as those designed to purify water and remove harmful waste (Costa, 2015; Condran and Crimmins-Gardner 1978). Recent work, however, has challenged the overall effectiveness of these interventions in explaining the majority of this transition.[2]

We offer a complimentary hypothesis that we test in explaining the residual decline in infectious disease mortalities. Namely, that gradual changes in hygienic norms induced by technological innovations that allowed widespread access to hygienic infrastructure also played an important role. To test this, we examine the health impact of arguably the first handwashing intervention conducted at a time that predated modern handwashing advice: the innovation in and construction of public bathhouses. Notably, these bathhouses were intentionally placed in dense tenement housing districts, and provided an extremely susceptible population[3] with severely restricted access to

[2] Anderson et al. (2022a) provide a comprehensive review of findings from several evaluations of public health interventions studied in this literature as well as contribute their own reassessment of water purification efforts among 25 major cities.

[3] Crowded tenement apartments in urban areas generally housed the immigrant and working-class poor populations

bathing infrastructure a relatively clean, cheap, and perhaps even luxurious hygienic alternative essentially overnight.

We use the year in which a major city built its first bathhouse as plausibly exogenous temporal variation to estimate the effect of bathhouses on mortality. We then explicitly compare the mortality of early- versus late-adopting cities using an event-study framework to investigate the impact their introduction had on reducing prominent types of mortalities from the time. Controlling for other public health efforts to provide clean water, we find that the introduction of bathhouses in these cities is associated with a 22% and 15% decline in diarrheal disease and child mortality, respectively, four years after their introduction. Estimates for diarrheal diseases are sensitive to the inclusion or exclusion of large cities but those for child mortality are less so. We then provide evidence that unobserved improvements in water quality are unlikely to be driving our results. This study is one of the first to investigate the role of personal hygienic behaviors during the epidemiological transition[4] and we believe the unique setting can help to inform policy makers in designing effective behavioral interventions today.

The paper proceeds as follows. Section 2 provides a simple framework to illustrate factors that influence health-behavior decisions and the roles innovation and other typical interventions can play. Section 3 gives the historical context, motivating the hypothesis by detailing urban sanitary conditions and hygienic practices around the time of the transition as well as background on the public bath movement. Section 4 describes the data and empirical analysis of the impact of public baths on city mortality during the mortality transition. Section 5 presents our results and explores

of major cities where they faced especially unsanitary living conditions (Ager et al. 2023) and higher mortality (Rochester 1923).

[4]At the time of the writing of this draft, the only other studies to examine the personal hygiene side of the epidemiological transition come first from Miller (2008) who show that the expansion of women's suffrage led to increased state public health spending to fund door-to-door public health education focused on hygiene, leading to an 8-15% reduction in infectious disease mortality among children between 1900-1930. Moehling and Thomasson (2014) find that the Shepard-Towner act of 1921 which provided matching grants to states to fund maternal and infant health education initiatives contributed to a 9-21 percent reduction in infant mortality over the 1922-1929 period. Additionally, Anderson et al. (2019) find that the establishment of sanatoriums to isolate and pass along educational materials to tuberculosis patients is associated with an almost 4% decline in mortality from pulmonary tuberculosis over the 1900-1917 period.

the sensitivity of estimates through a multitude of alternate specifications. We discuss our results in Section 6 then Section 7 concludes.

2 Conceptual Framework

We adapt and augment a simple model for health behaviors as considered by Cutler et al. (2009).[5] Consider an individual at a static point in time who gains utility from consumption x and incurs costs c^s from being sick which will occur with probability π:

$$u = v(x) - \pi c^s. \tag{1}$$

Suppose the individual has an option to privately engage in some activity which reduces the probability of getting sick from π to π^ℓ but has monetary cost c^ℓ and experiential component ℓ. Knowledge about the health benefits of engaging in the behavior (i.e., information) is reflected by the individual's perception $\hat{\pi}^\ell$ of π^ℓ relative to π.

The individual will engage in the behavior if

$$v(x') + \ell - \hat{\pi}^\ell c^s - c^\ell \geq v(x) - \pi c^s \tag{2}$$

for new consumption $x' \leq x$ (holding income constant), or equivalently whenever

$$\ell \geq c^\ell - c^s(\pi - \hat{\pi}^\ell) + (v(x) - v(x')). \tag{3}$$

This simple model generates some useful intuition for understanding various levers policymakers can pull to increase engagement which can enhance social welfare in the presence of positive externalities. Availability (i.e., $c^\ell < \infty$) is a necessary condition for any take up.[6] Subsidies, cash

[5] Cutler et al. (2009) consider a two-period version.

[6] For example, imagine the costs associated with obtaining a COVID-19 vaccine in 2020.

incentives, and other monetary strategies act by lowering c^ℓ or narrowing $v(x)$ and $v(x')$.

Information interventions are designed to increase take up by augmenting perceptions about π^ℓ. If one is unaware of the health benefits of the behavior (i.e., they believe $\pi^\ell = \pi$), then the probability of engagement will only depend on whether the benefit incurred from participating in the activity outweighs its cost plus marginal utility of consumption from abstaining. If the activity is not enjoyable (i.e., $\ell \leq 0$) and costs are positive, participation will not occur.

Finally, take-up can increase by increasing the experiential component, say, from ℓ to ℓ'. Suppose some technological innovation makes engaging in the behavior more luxurious.[7] Then according to (3), this will unambiguously raise the probability of engaging in the behavior, holding all else constant. Notably, this will induce participation even in the complete absence of information about the health benefits of the activity. It is through this channel as well as lowering costs[8] that we view household bathing infrastructure as augmenting. We make the case for this throughout the following sections, though we are unable to disentangle the two mechanisms at this time.

3 Historical Context

3.1 Hygiene Practices

Despite its pervasiveness in modern health advice, handwashing's history in official recommendation and ubiquitous practice is relatively young.[9] The discovery of the benefits of hand hygiene in the medical context is credited to Dr. Ignaz Semmelweiss in Austria, whose observation in 1847 that the obstetric clinic run by medical students that often performed autopsies before assisting with childbirths experienced appallingly higher maternal mortality than an adjacent clinic run by mid-

[7] Technological innovation can also act by making the treatment more effective (i.e., by reducing π^ℓ)

[8] It is likely that bathhouses lowered the costs associated with complete personal hygiene for many, though others may have been priced out. On the one hand, public bath facilities were often free or charged a small fee (Hanger 1904), while on the other hand, the bathhouse location may have been located too far to walk, for example.

[9] There are, of course, notable cultural and religious exceptions.

wives. Attributing this to odorous particles that remained on the students' hands even after washing, he intervened by introducing soap and disinfectants to their handwashing behavior, which led to mortality rates plummeting. This discovery, however, refuted contemporary miasmatic theories of disease spread where "bad air" received culpability and was rejected by the medical community at the time (Bjerke 2004; Atamen et al. 2013).

It was not until more than a century later in the 1980s that the first national hand hygiene guidelines were published by the CDC (Bjerke 2004), though the notion that diseases spread via the hands began to appear in scientific texts around the late 1890s following the arduous process of understanding and accepting the germ theory of disease.[10] Modern handwashing advice was not seemingly dispersed to the general public via popular press until around 1917 (Cassedy 1962; Tomes 1998; Starr 1982).[11]

The timeline of the acceptance of these discoveries, however, arrive late into the observed mortality decline as demonstrated in Figure 1a. Yet, Americans began lathering their hands with soap and water decades earlier, albeit in a somewhat indirect manner. The nineteenth century ushered in bathing as a social norm among conscientious middle- and upper-class Americans that was aided by the introduction of piped water within one's home and subsequent arrival of bathrooms to American households. No longer were well-to-do Americans made to fill and empty portable water basins used for bathing from street pumps, hand faucets, or natural waterways, as the fixed tub with hot and cold water as well as draining capabilities became common place in their households by the late nineteenth century (Wilkie 1986).

Advice extolling the health benefits of bathing well precede that of regular hand hygiene,

[10] See Breiter (1897), for example. Also, Plunkett (1885) published a comprehensive guide for sanitation within the household that, while recognizing and devoting substantial discussion to the new germ theory of disease, makes no mention of person-to-person contagion and devotes only a single sentence that alludes to handwashing for nurses leaving the sick room of a typhoid patient. Rather, the publication focuses on the environment, such as the dangers of emanating sewer gas, the arrangement of rooms in the house, and the condition of soil underneath the house, highlighting the slow onset of understanding of the mechanisms of disease spread and reluctance to dismiss prior miasmatic theories.

[11] Specifically, advice to always wash hands before eating and after using the toilet.

though for different reasons than we might attribute them today. Most accepted advice given by mid-nineteenth century contemporaries had evolved from complete abstinence to suggest restorative and regenerative benefits of a "cold plunge" for a few seconds. Bathing in warm water, especially as a means for relaxation, was nearly universally condemned. Some individuals upon installation of new waterwork apparatuses in their homes, however, acknowledged the new luxuries these innovations provided. For instance, as noted in Williams (1991 p. 12), one New York man wrote in 1843 that he "Tried our new bath room last night for the first time and propose to repeat the experiment this evening. It's a great luxury – worth the cost of the whole building." Two weeks later, he remarks that, "I've led rather an amphibious life for the last week, paddling in the bathing tub every night and constantly making new discoveries in the art and mystery of ablution. Taking a shower bath upside down is the last novelty."

Soap was a rarely advised accompaniment (Wilkie 1986) and not commonly used for personal cleansing until after the mid-nineteenth century (Ierley 1999; Bushman and Bushman 1988). Industrialization and subsequent mass production capabilities met 'The Father of Advertising' Thomas J. Barratt in the 1880s soap industry who helped popularized soap for personal use (as opposed to industrial or laundering uses), capitalizing on the decreasing tolerance for malodors among the upper class (Dijk 2011; Ward 2019 (pp. 107-130)). Ad campaigns typically associated soap with beauty and rhetoric of nation, religion, and race, though did not concern themselves with the health benefits of soap despite growing recognition of the germ theory of disease (Ward 2019 (pp. 123-130)).

3.2 The Public Bath Movement

Household bathing infrastructure arrived in homes at a gradual rate, with only just over half of American homes equipped with a bath and dedicated room with hot and cold running water capabilities at the time the census began to track this in 1940 (Ward 2019, p. 159). While most in middle to upper-class homes had bathtubs by the 1890s, those residing in urban tenements lacked

access to bathtubs or private place to bathe (Glassberg 1979). In 1892 the Massachusetts Bureau of Statistics of Labor conducted a tenement-house census of Boston concluding that only around a quarter of this population were equipped with bathrooms, and in certain wards the proportion was less than one percent (Hanger 1904). A Federal Bureau of Labor study in 1893 investigated the issue more extensively, finding that in "the most congested slum districts of Baltimore, Chicago, New York, and Philadelphia" the percent having bathrooms in their houses or tenements stood at 9.21, 3.79, 6.51, and 18.05, respectively (Hanger 1904). One of the most widely discussed exhibits of a 1900 social exhibition on the conditions of New York City tenement housing illustrated the conditions of a single tenement district, in which 39 tenement buildings on two acres housed 2781 people who shared among them just 264 water closets and only a single portable bathtub photographed hanging from an air-shaft window (Lubove 1961; Riis 1902). An 1884 commission formed to inspect and report on the conditions of New York City tenement houses recommended the establishment of free winter baths throughout these districts, though no action was taken by city authorities at the time (Hanger 1904).

Much of the reason for indifference and apathy on behalf of city governments in constructing and maintaining baths may have been due to the exorbitant costs of providing them as efforts were constrained by the available technology at the time. Municipalities initially responded by establishing free beach and "floating" baths along natural waterfronts open during the summer months, though pollution of these water bodies gave them the reputation as being "floating sewers" (Glassberg 1979); it was remarked that the purpose of the breaststroke was to "push the garbage away" (Renner 2008). The Committee on Public Hygiene of the American Medical Association along with other progressive reformers in the mid-nineteenth century clamored for public baths to be open year-round, arguing that frequent bathing would eliminate "a prominent cause of disease and contribute to [their] moral, as well as physical improvement." However, these pleas were ignored by city governments who were encumbered by the infancy of other municipal services such as water and sewage systems, street cleaning and garbage removal, and the establishment of police

and fire departments (Williams 1991 (pp.13-15)).

The innovation allowing public baths to become feasible domestically came from abroad with the debut of the *Volksbad*, or People's Baths at the Berlin Public Health Exhibition of 1883 from German doctor Oscar Lassar (Gerhard 1908). This was a bath intended for lower-class use that featured novel "rain baths" among private stalls in which water emanated from above allowing for efficient and hygienic baths to be taken (Renner 2008).

Upon studying the design of the *Volksbad* in Vienna, Dr. Simon Baruch, chairman of the committee on hygiene of the New York County Medical Society, pleaded in an 1889 report for the adoption of this type of bath for the urban poor (Hanger 1904). Among the advantages of the shower bath over the normal bathtub, as he states, include "avoidance of filling, emptying, and necessary scrubbing of the tub for each bath...the time necessary for a cleansing shower bath is far less...cleansing is much more thorough," and that "The economy of water is enormous. The tub bath requires...200 liters of water, while for the rain bath 10 liters are ample." (Hanger 1904). This sentiment was echoed among progressive reformers at the time, as renowned sanitary engineer William Paul Gerhard writes that, "What our large cities require, however, is cheap spray or rain baths for the masses of working people, who lack bathing facilities in the tenements. It is the duty of every municipality to provide cheap bath houses or people's baths, for they tend to reduce the general mortality rate of a city, and the number of sick in the city hospitals ...." (Gerhard 1908).

In late 1891, the "People's Baths", the first bathhouse in America of its kind,[12] opened in New York City by a coalition of charities spearheaded by the Association for Improving the Condition of the Poor, providing soap, a towel, and the use of one of 18 first floor showers for a 5 cent charge or one of its nine basement shower baths for free (Glassberg, 1979). Advocates and official delega-

[12]In our dataset we observe two bathhouses meeting our definition that opened earlier, but were housed in gymnasiums. The Charlesbank Gymnasium in Boston opened in 1889 and contained 9 shower baths, was opened year-round, had hot- and cold-water capabilities. The natatorium on the West Side in Milwaukee opened in 1890 and was the first known year-round public bath which provided facilities for swimming as well as shower baths (Hanger 1904). San Francisco opened a public bath that contained 60 baths (40 for men and 20 for women) but none were shower baths as it was reported that "the tub baths answer every requirement" (Hanger 1904). Our analysis is not sensitive to dropping these using instead the first constructed bathhouse not housed in a gymnasium.

tions from other cities also interested in constructing similar bathhouses visited and inspected these baths, and by 1904, thirty-four U.S. cities had, "more or less adequate provision for bathing for the people." (Gerhard 1908 p. 72; Williams 1991 p. 32). By 1914, New York City and Brooklyn had a combined 30 bathhouses operating shower baths constructed by the municipality or philanthropic institutions (Renner 2008), and in Chicago, 20 free bathhouses were constructed and maintained by the city by 1918 (Robertson, 1919). The golden era of public baths, however, ended soon after with the expansion of private bathrooms in most urban homes and apartments, resulting in most cities closing down their public baths within a couple of decades following World War II (Williams 1991).

4 Data and Empirical Strategy

As noted in Section 1, handwashing can prevent the spread of diarrheal and respiratory diseases, and these causes constituted some of the primary causes of death prior to the mortality transition. Therefore, it is natural to focus on the mortality rates from these causes as primary outcomes of interest. Moreover, much of the decline in urban mortality was driven by reductions in mortality from children, hence we include child[13] mortality as a second primary outcome. Current disease-specific data limitations do not allow the examination of annual deaths from respiratory diseases at the city level over the 1880-1915 time period, so we focus on death rates from diarrheal diseases and the deaths of children in the analysis that follows.

Mortality data are collected from annual city- and state-level health reports for the years before 1900 and come from *Mortality Statistics* published by the U.S. Census Bureau in the post-1900 period.[14] Population data come from the decennial census and are imputed linearly for inter-

[13]Defined as those younger than the age of five.

[14]These data are used by Anderson et al. (2022b) and Anderson et al. (2022c), though our sample of cities differs from theirs. The pre-1900 data were obtained from a variety of sources, with much of them transcribed from physical documents housed at the National Library of Medicine among other libraries throughout the nation.

censal years to derive a crude death rate for each city-year.[15] Deaths from diarrheal diseases in the pre-1900 period are reported differently across cities. We aggregate the causes of death that are reported consistently around the event-time of the first bathhouse opening and do not change our defition of diarrheal disease until our data source changes to *Mortality Statistics*, which reports "Diarrhea and Enteritis" as a single category to encompass all diarrheal diseases. Appendix Table A2 describes the specific pre-1900 diarrheal disease deaths that define this outcome for each city.

Data on bath openings also come from a variety of sources, the majority of which come from a report on public baths in the United States by the U.S. Bureau of Labor in Hanger (1904). The table within tabulates all baths constructed prior to 1904 and contains detailed information including the name of the bath, type of bath,[16] the year each bath opened, the city it is located in, whether the bath was in service year-round, number of showers and tubs, and whether hot water was supplied. Additional information such as ownership (municipal or private[17]), amount charged per bath, number of baths during that year, as well as annual revenue and expenses are also included. Data for bathhouses that opened after 1904 come from a table in Gerhard (1913), which contains a condensed summary of free public bathhouses of from each city that responded to a survey the author sent. Importantly, it includes the date in which the first bathhouse opened in each city.

Our key right-hand side variable is the year in which a city opened its first bath, which we define bath for our purposes as those equipped with showers with hot water capabilities like the People's Bath in New York City. From the 1904 cross-section, baths not meeting these criteria are, as expected, various pool, beach, and floating baths. We summarize descriptive statistics of all baths meeting our definition from this source in the Appendix Table A4 and present select

[15] Births were not enumerated as consistently as deaths and therefore death rates by age due to the lack of population of children data cannot be ascertained broadly.

[16] There are four types of baths enumerated within the report: beach, floating, shower, and pool, as well as hybrids (e.g., shower and pool). The beach and floating baths (discussed in the previous section) were constructed along natural waterways and were intended for recreation rather than bathing with soap and water. Pool baths were also enumerated, as the public bathhouse movement coincided with the birth of the municipal pool movement. In few cases, bathhouses held pools and showers. It is the baths containing showers in which we are interested.

[17] Private includes those run by charities as well as firms.

bathhouse usage time-series data in Appendix Figures A1-A2.[18] Next, we take the year of each city's first bathhouse then append the data with the year of first bathhouse opening from those in the Gerhard (1913) dataset that could be corroborated with primary or secondary sources as having been a bath to fit our definition. This results in 24 cities. Pre- and post-mortality data are unavailable for Brookline, MA,[19] so this city is dropped from our sample resulting in a total of 23 cities.[20] Appendix Table A1 lists these cities, the year their first bathhouse opened, as well as the interval for which mortality data are available for each outcome we consider. Figure 2 shows a visual representation of the timing of bathhouse openings. All cities have pre- and post-intervention mortality data available, and while the data is not perfectly balanced in event time, it is nearly balanced.[21]

To test the impact of introducing bathing infrastructure to the poor- and working-class, we leverage the differential timing of the first opened bathhouse in each city and model the dynamics of the intervention around this event time in a difference-in-differences event study analysis:

$$y_{ct} = \alpha_c + \alpha_t + \sum_{e=-K}^{-2} \beta_e Bathhouse_t(e) + \sum_{e=0}^{J} \beta_e Bathhouse_t(e) + \boldsymbol{X}_{ct}\lambda + \varepsilon_{ct},$$

Our outcome is modeled as mortality rate y_{ct}. City and year fixed effects are given by α_c and α_t, respectively. The variable *Bathhouse* is an event-time indicator that takes the value of one when e years have passed since city c opened its first bathhouse and is equal to zero otherwise. Our main coefficients of interest β_e are estimated over a series of leads and lags given by event

[18] While most of the baths in this dataset are not used in the analysis as these include all bathhouses built in each city by 1904, it is useful to gain a sense of some overall characteristics of the bath movement in terms of its magnitude, timeline, and economic circumstances. Estimating a first stage (i.e., who used the baths and how often) is not possible with the available data, however, we summarize what data are available to get a sense of take-up.

[19] We would likely choose to exclude this city regardless as the bathhouse in Brookline was large and elaborate, built in an affluent suburb, and "probably the only public bath for the middle class." (Williams 1991 p. 37).

[20] Brooklyn and New York City merged in 1898, though statistics were recorded separately for Brooklyn after the merge. Brooklyn data is differenced from New York City after the merge to obtain a mutually exclusive mortality series for each city. An analogous case exists for Allegheny and Pittsburgh, PA, which merged in 1907. The data is censored for these two cities after 1907 as Allegheny data do not exist, and could therefore not be differenced from Pittsburgh data.

[21] A minor exception is the lack of pre-event child mortality data for Milwaukee, WI, Troy, NY, and Yonkers, NY. Dropping these cities from our analysis do not discernably change the estimates or interpretation.

window $[-K, J]$ and we omit event time $e = -1$ as our reference period. The matrix $\boldsymbol{X}_{ct}$ includes controls for potential confounders evolving over place and time such as the introduction of filters or chlorination to the water supply, the completion of major clean water projects, or severe epidemics.[22]

In our primary specification, we compare newly-treated cities to not-yet treated cities explicitly by constructing a stacked dataset in the style of Deshpande and Li (2019), relying on parallel trends in untreated potential outcomes as our identifying assumption. This approach circumvents the issue of negative weights in traditional two-way fixed effects models with staggered treatment timing in the presence of treatment effect heterogeneity across time and place, as noted by Goodman-Bacon (2021) and Sun and Abraham (2021).[23] We achieve this by constructing separate datasets for each treatment cohort in which the newly treated cities serves as our treated group and cities not treated until after our cohort year plus J serve as "never-treated" units within each dataset. Already-treated cohorts are always excluded so that problematic comparisons (i.e., newly treated vs. already treated) are avoided. We then saturate our city and year fixed effects with indicators for each dataset to stack them before estimation via traditional two-way fixed effects.[24]

5 Results

Figure 3a shows the dynamic effects of bathhouse introduction on diarrheal disease mortality while Figure 3b shows the same for child mortality. We weight observations by average city population over the time period to account for potential population-size related heterogeneity (Solon et al. 2015). We cluster the standard errors at the city level (Bertrand et al. 2004). The year prior to the

[22] Specifically, we add an indicator for a major typhoid epidemic in Chicago from 1891-1893 prior to its first bathhouse opening. Sources and dates for clean water interventions can be found in Appendix Table A3.

[23] It seems reasonable to expect treatment effect heterogeneity as tenement housing conditions and on-average within-home bathing infrastructure availability varied over place and time. Moreover, the bathhouse movement grew in popularity with many additional bathhouses constructed after the first within some cities but not in others.

[24] Gardner (2021) shows that the stacked estimator identifies an average of cohort-specific average treatment effects weighted by the relative sizes of each cohort-specific dataset and variance of treatment status within them.

bathhouse openings is omitted so point estimates are interpreted as effects relative to that year for the treated group relative to the control group. We set K equal to 5 and J equal to 4 in our primary analysis. Using four years of lags implies that cities treated more than four years in the future are used as our clean control units.[25]

There is little evidence that treated cities trended differently than control cities prior to the introduction of bathhouses, and both outcomes exhibit a sharp, persistent, and statistically significant (at conventional levels) decrease beginning in the year after the bathhouse opened. Results do not appreciably differ depending on whether controls are included to account for public health efforts to provide clean water. Table 1 reports the coefficients derived from the two regressions with controls added and shows that the introduction of bathhouses is associated with 23 fewer deaths per 100,000 of the population from diarrheal diseases and 81 fewer child deaths per 100,000 of the population in the year after the bathhouse was constructed, evolving to 40 fewer deaths per 100,000 of the population from diarrheal diseases and 111 fewer child deaths per 100,000 of the population four years after their introduction (or, a 22% and 15% decline from baseline mortality rates, respectively).

5.1 Sensitivity Analysis

We begin by examining whether our estimates for both diarrheal disease and child mortality are sensitive to not weighting by average city population in Appendix Figure B1. While the signs of four out of five post-treatment point estimates for diarrheal disease mortality remain negative, the treatment effects are statistically indistinguishable from zero and their magnitudes are much smaller than those reported in Table 1. The magnitude on child mortality coefficients in the post-period also shrink considerably with the year after the bathhouse constructed associated with a decrease of 45 deaths per 100,000 per population, which is significant at the 10 percent level but remain statistically indistinguishable from zero in the rest of the post-treatment years. All but one

[25] Results are qualitatively similar for alternative maximum lag values (See Appendix Figure B2).

point estimate remain negative.

Differences between the weighted and unweighted estimates suggest that effects may be driven by the largest cities in our sample. We explore this heterogeneity directly by restricting our sample to those in roughly the top tercile of average population[26]. We then re-estimate our estimating equation without population weights in this restricted sample and compare the outcome to our main results in Figure 4. In Figure 4a, we see that the point estimates in the restricted, unweighted regressions with diarrheal disease as the outcome track similarly with those from the primary results, though firm conclusions are hard to draw due to large standard errors. In Figure 4b, however, we see that the point estimates again align very closely with the original estimates and are able to reject the null of no effect in years one and three after the intervention in the case of child mortality. We conclude that our original estimates seem to pick up on the heterogeneity across city types quite well and thus rely on weighted results for the remainder of the sensitivity analysis.

We next drop each of the six most populous cities one-by-one in Appendix Figure B3 for diarrheal diseases and Appendix Figure B4 for child mortality and re-estimate our weighted event-study specification. Panel A of Appendix Figure B3 reveals that removing New York City from the sample effectively eliminates any observable treatment effects for diarrheal disease mortality. Removing other large cities suggests that observed effects may be driven by differential trends in New York City's diarrheal disease mortality rates or some other unobserved city-specific shock affecting diarrheal disease mortality that is correlated with the timing of the bathhouse opening. Results for child mortality presented in Appendix Figure B4 are more robust to the exclusion of each major city suggesting that our estimates are not driven by a single city alone.

Appendix Figure B5 explores these trends further by extending our leads to the maximum allowed in our sample. The left side displays the effects on diarrheal diseases removing each of the three largest cities one at a time, and the right displays similar plots for child mortality. There is

[26]Specifically, we restrict our sample to the cities with an average population greater than 400,000: New York City, Chicago, Philadelphia, Brooklyn, St. Louis, Boston, Baltimore, and Cleveland.

a large and persistent change in trend for child mortality in each specification associated with the year of bathhouse opening, though the magnitude of changes in diarrheal disease mortality rates again seem sensitive to the exclusion of New York City or Chicago.

6 Discussion

Taken together, the diarrheal disease mortality reductions apparent in our main results may be driven by differential trends or correlations between other factors that reduced diarrheal disease mortalities and the construction of a city's first bathhouse, chiefly in New York City where its exclusion effectively eliminates any observable effect. Child mortality, on the other hand, appears to react strongly around the bathhouse opening date and is relatively insensitive to a multitude of specification choices. It is perhaps plausible, however, that true average effects are in fact driven by changes in mortality rates in New York City and Chicago due to the construction of baths. After all, these large and relatively dense cities had some of the most severely restricted access to hygienic infrastructure among tenement dwellers and responded strongest to the bath movement by each building over a dozen bathhouses.

One important question is whether public health efforts to supply clean water outside our observed sample of controls could have attributed to the (albeit sensitive) observed reductions in diarrheal disease mortalities.[27] In turn, these may have reduced mortalities from other diseases as documented in the context of the Mills-Reincke phenomenon potentially explaining our results on child mortality. The proposition of the Mills-Reinke phenomenon developed due to the observation that efforts to provide clean water sharply reduced mortality from typhoid fever, a notorious waterborne disease[28] that was primarily diagnosed in adults (Anderson et al. 2022b), yet also

[27] Diarrheal diseases manifesting from cholera and norovirus, for example, are spread via contamination of food and water supplies, while others such as rotavirus and shigella are spread predominately via person-to-person contact (Garza and Cohen, 2011)

[28] Many studies confirm that the death rate from typhoid fever is highly sensitive to water purification efforts. So much so, that the typhoid death-rate is often used as a proxy for water quality (e.g., Beach et al. (2016) and Crimmins and Condran (1983)

seemingly drastically reduced mortalities from non-waterborne diseases such as tuberculosis and pneumonia (Sedgewick and MacNutt 1910; Ferrie and Troesken 2008).[29] Indeed, regressing the child mortality rate on typhoid mortality rate in our original dataset, we see in Table 2 that these two numbers consistently move together within each city on average and are statistically significant at conventional levels.

We test the impact of bathhouses on the typhoid fever mortality rate which plummeted over the time period for the cities in our sample (see Figure 1c). Figure 5 shows weighted results with and without controls.[30] There does not appear to be any meaningful or statistically significant impact on typhoid mortality around the time of bathhouse openings from these figures. We therefore conclude that it is unlikely any substantial unobserved water improvement correlated with the timing of bathhouse openings can explain our results on child mortality in the context of the Mills-Reincke phenomenon.

Another important question is why we should expect any effects on children (as defined as aged 4 years or younger at the time of their passing) when those utilizing bathhouses were almost certainly older than these age groups. From Figure 1a we note that total death rates fell in line with the crude child death rate, which is consistent with other literature on demographic changes in mortality during the transition. Given that this age group is too young for school or engagement in other independent social activities, it is likely the reduction in deaths occurring for this group resulted from an improvement in the pathogenic environment at home through better sanitation and hygiene. While we can only speculate as to the exact mechanisms through which our results operate, it is plausible that the introduction of soap and new, luxurious hygienic infrastructure may have altered hygiene for a subset of the population directly or indirectly through changing social

[29] Inoue and Ogasawara (2020) test this phenomenon in the context of early 20th century Japan and find that one percent decrease in typhoid mortality corresponds to a 0.742-2.942 percent decrease in non-waterborne diseases following the enactment water purification measures.Ferrie and Troesken (2008) find similar results for Chicago over the 1850-1925 period where for every one death prevented from typhoid, three or more were prevented from seemingly unrelated diseases.

[30] Recall that we control for a severe typhoid epidemic occurring in Chicago just prior to their first constructed bathhouse from 1891-1893.

norms, preventing some transmission of disease and saving lives relative to the counterfactual.

7 Conclusion

What were the effects of personal hygiene on the U.S. epidemiological transition? This question has received little empirical attention in the public health economics literature, and as Costa (2015) states, the impact of changes in household behavior on the health transition remains unclear. We contribute to the topic by exploiting a natural experiment that leverages the development and rapid adoption of a new technology that may have induced take-up of better personal hygiene by lowering costs and potentially enhancing its benefits. The public bath movement introduced showers with soap and hot water capabilities to the working masses deprived of modern hygienic infrastructure in densely settled tenement houses at a time that predated modern handwashing advice and widespread recognition of the germ theory of disease. This setting also provide a unique perspective on ways in which to increase engagement of some socially desired behavior that has, to our knowledge, been absent from the discussion on effective intervention design.

Explicitly comparing cities which build their first bathhouse to cities that build them soon in the future, we estimate that the timing of their opening is associated with a 22% decline in the diarrheal disease mortality rate and a 15% decrease in the child mortality rate. There is evidence to suggest that these effects are driven by large cities but limited evidence that unobserved clean water improvements drove them. While estimates on diarrheal diseases are sensitive to weighting and the inclusion of these large cities, effects on child mortality are less so, which may be consistent with children perishing less from both diarrheal and non-diarrheal diseases that can be mitigated with changes in hygiene behavior within their household.

Next steps for investigating further include the collection of non-diarrheal disease mortalities for this sample to test whether these large reductions in child mortality can perhaps be attributed to all-disease mortality changes around the time of first-bathhouse openings. Further, a within-city

analysis may be possible with ward-level mortality data, some of which has been digitized in the Historical Urban Ecological dataset (Fogel et al. 2014), in which the mortality effects of bathhouse openings can be studied at a more granular level.

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Figure 1a. Average Death Rates 1880-1915

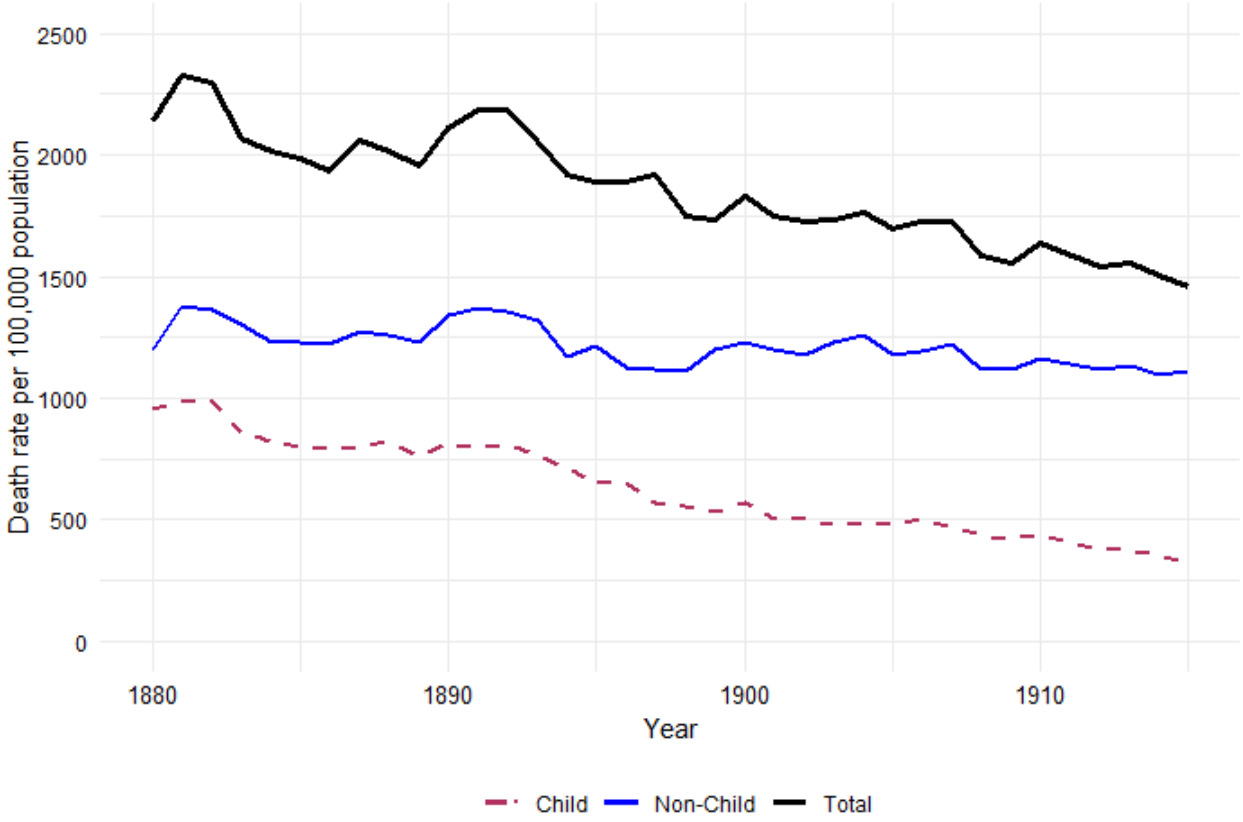


Figure 1a depicts the average total, child (<5 years of age), and non-child death rates for each year across the 23 cities in our sample. Data come from annual city and state health reports from 1880-1899 and *Mortality Statistics* from 1900-1915.

Figure 1b. Average Diarrheal Disease Death Rate 1880-1915

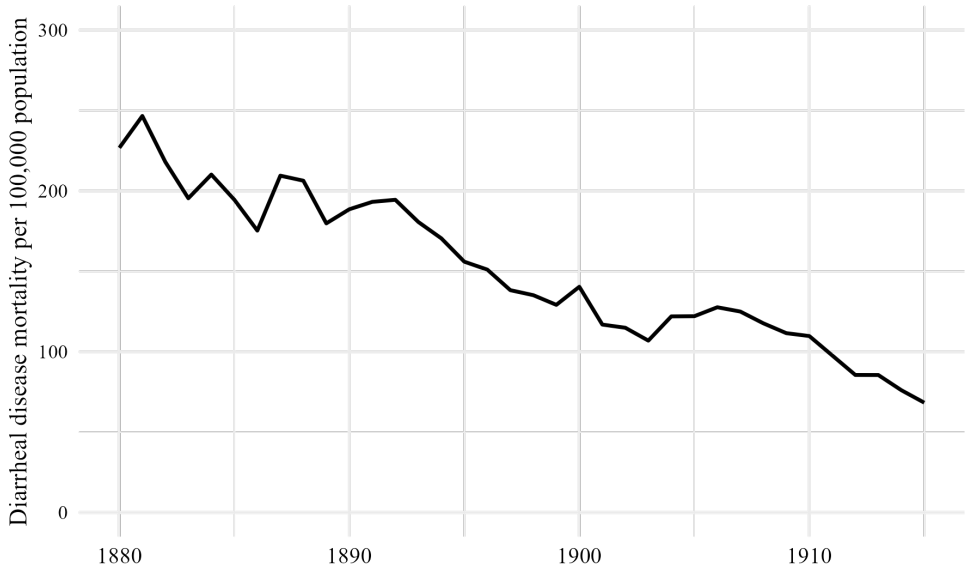
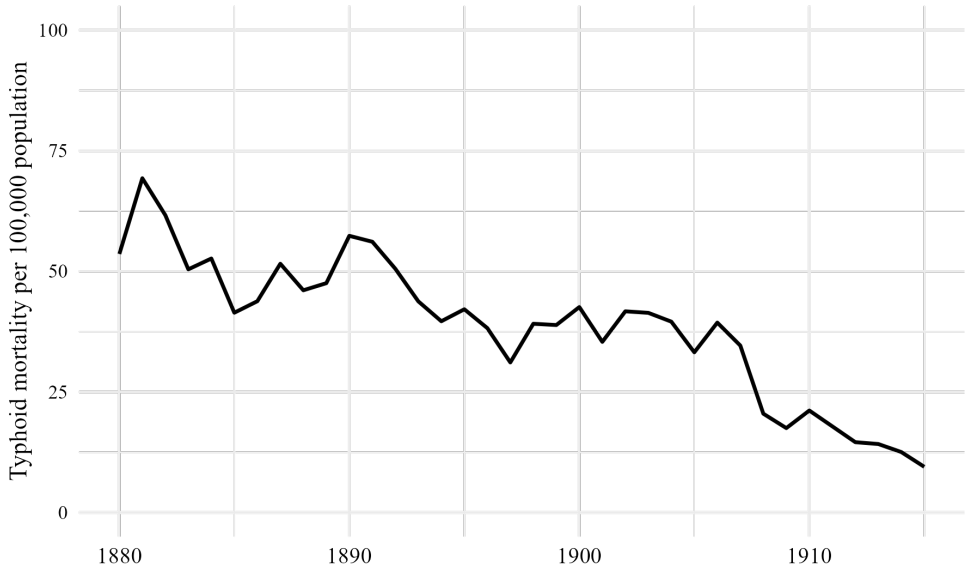
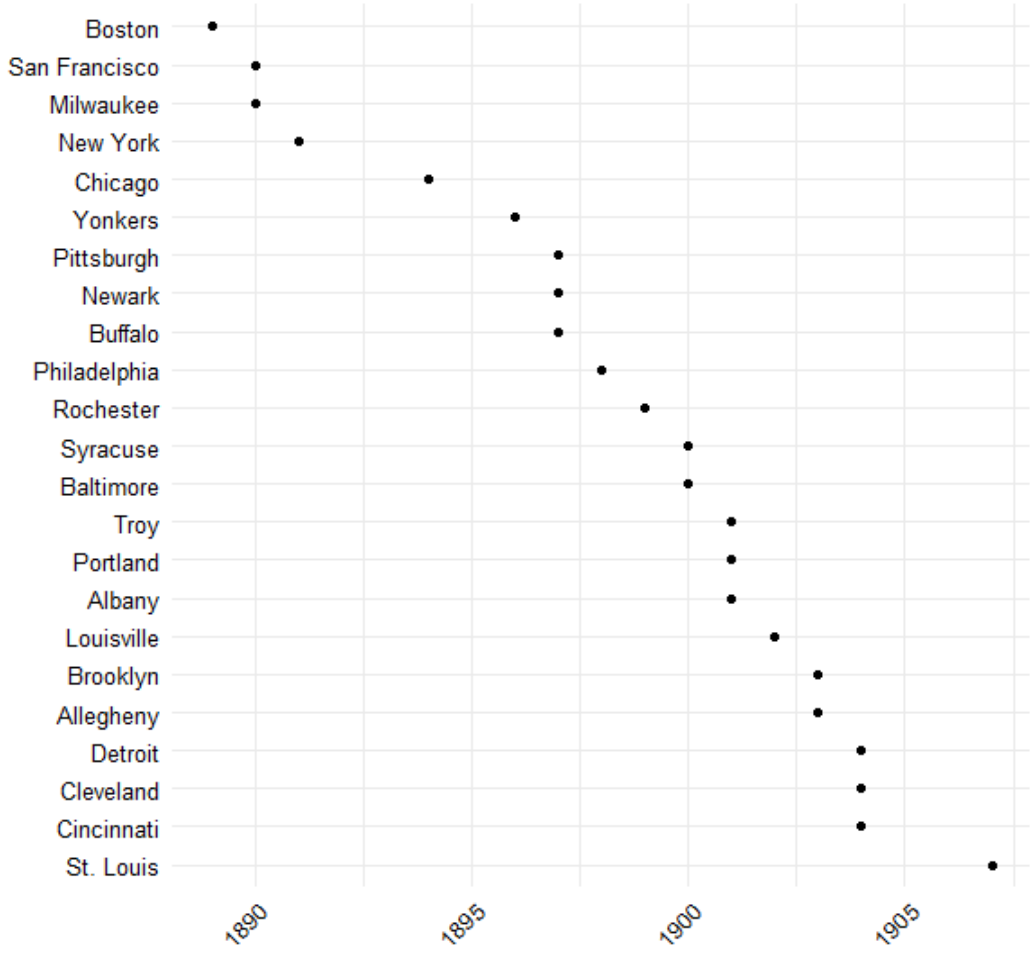


Figure 1c. Average Typhoid Death Rate 1880-1915



Figures 1b and 1c plot average death rates in each year across all 23 cities in our sample from diarrheal disease and typhoid mortality, respectively. Data come from annual city and state health reports from 1880-1899 and *Mortality Statistics* from 1900-1915.

Figure 2. Year of First Bathhouse Opening



This figure shows the year in which each city in our sample opened its first bathhouse. Based on data from Hanger (1904) and Gerhard (1913).

Figure 3a. Effect on Diarrheal Disease Mortality

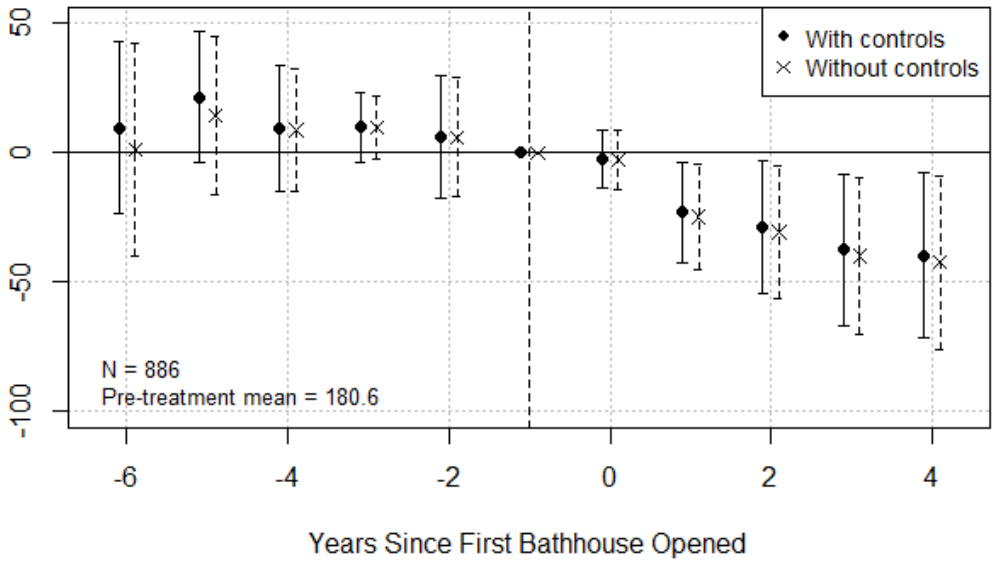


Figure 3b. Effect on Child Mortality

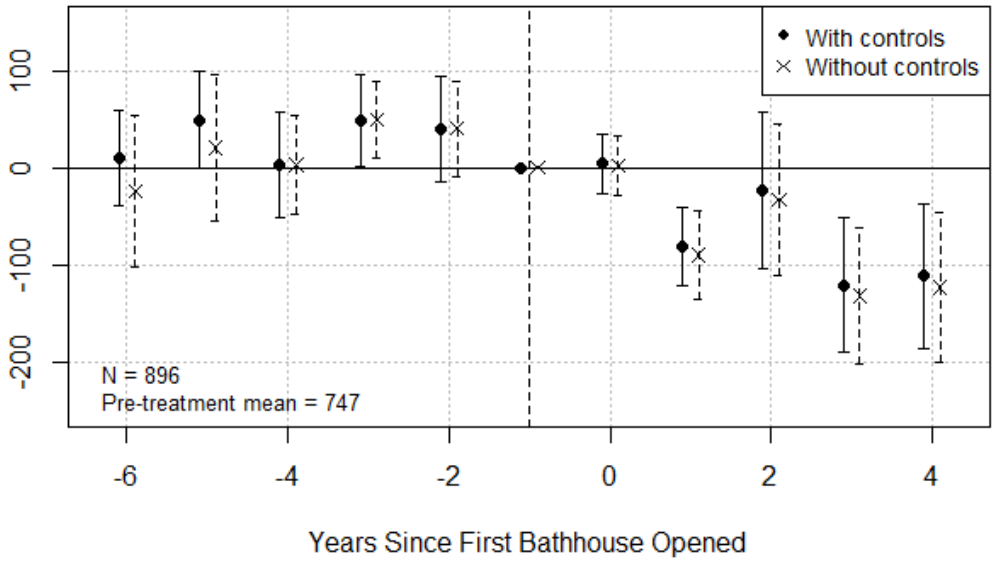


Figure 3 presents two-way fixed effects estimates of effects on diarrheal diseases (3a) and child mortality (3b) per 100,000 of the population with and without the controls detailed in Appendix Table A3 as well as controlling for the typhoid epidemic that occurred in Chicago from 1891-1893, along with their 95% confidence intervals. Estimates are weighted by average city population. Standard errors are clustered at the city level.

Figure 4a. Effect on Diarrheal Disease Mortality

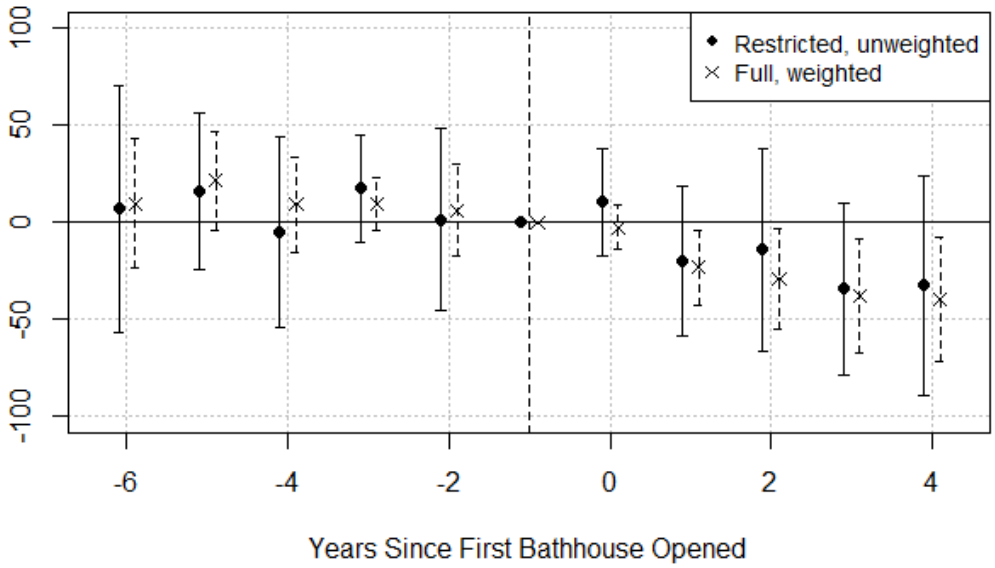


Figure 4b. Effect on Child Mortality

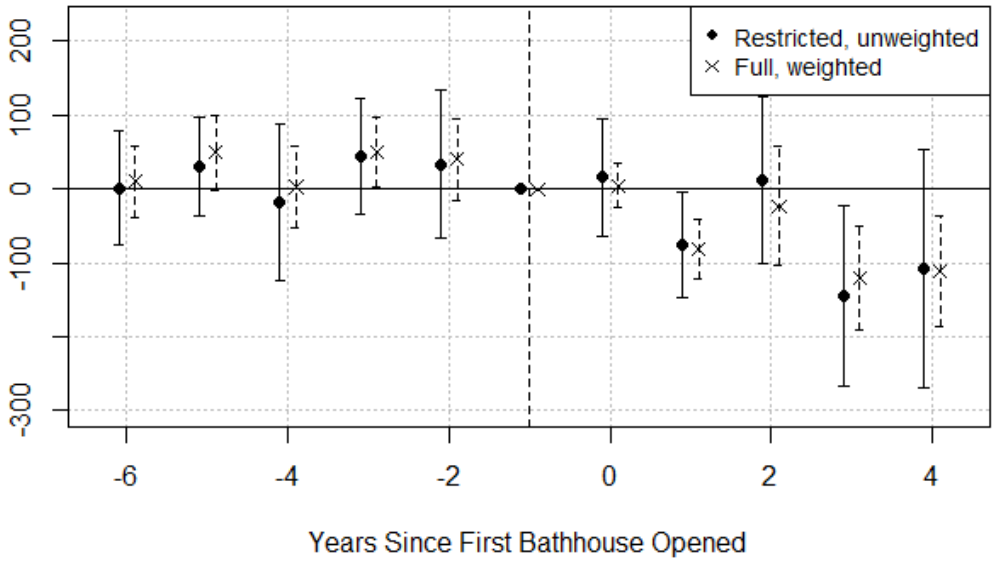


Figure 4 presents two-way fixed effects estimates of effects on diarrheal diseases (4a) and child mortality (4b) per 100,000 of the population with the controls detailed in Appendix Table A3 as well as controlling for the typhoid epidemic that occurred in Chicago from 1891-1893, along with their 95% confidence intervals. The black dots represent unweighted estimates from our sample of cities with average population greater than 400,000, and the black x's represent the same estimates with controls given in Figure 3 and are plotted to serve as a comparison. Standard errors are clustered at the city level.

Figure 5. Effect on Typhoid Mortality

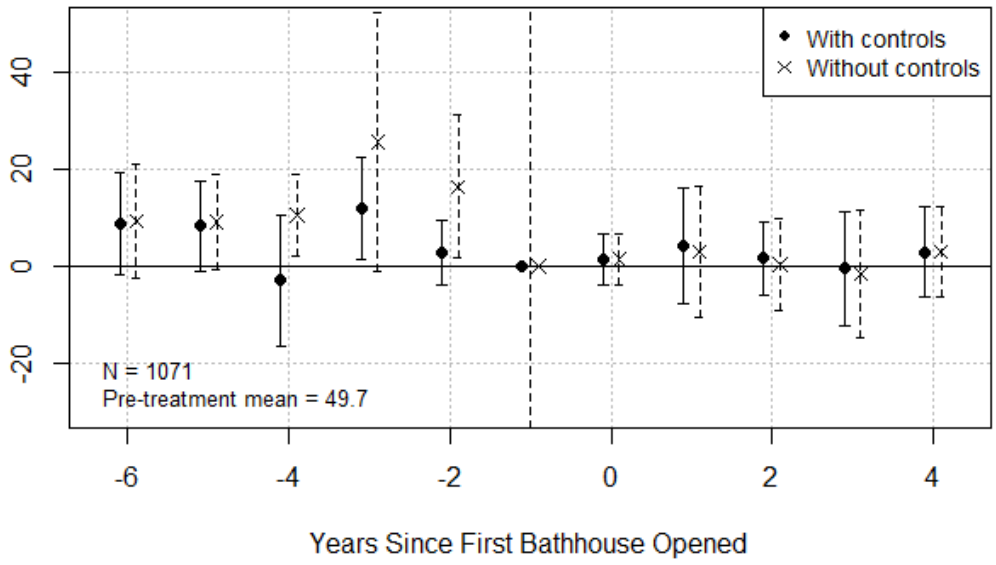


Figure 5 presents two-way fixed effects estimates of the effects on the typhoid death rate per 100,000 of the population with and without the controls detailed in Appendix Table A3 and the severe typhoid epidemic in Chicago from 1891-1893, along with their 95% confidence intervals. Estimates are weighted by average city population. Standard errors are clustered at the city level.

Table 1: The Effects of First Bathhouse Openings on Diarrheal Disease and Child Mortality

Dependent Variables:	Diarrheal Disease Mortality	Child Mortality
Variables		
Event time = -6	9.762	9.748
	(16.93)	(25.09)
Event time = -5	21.56	48.98*
	(12.89)	(25.53)
Event time = -4	9.290	2.577
	(12.40)	(27.73)
Event time = -3	9.820	49.34*
	(6.979)	(24.14)
Event time = -2	6.320	40.14
	(12.12)	(28.15)
Event time = 0	-2.385	4.302
	(5.842)	(15.35)
Event time = 1	-23.05**	-80.81***
	(9.813)	(20.66)
Event time = 2	-28.73**	-23.13
	(13.14)	(40.86)
Event time = 3	-37.46**	-120.7***
	(15.04)	(35.42)
Event time = 4	-39.78**	-111.4***
	(16.25)	(38.05)
Controls	Yes	Yes
Fixed-effects		
year-cohort	Yes	Yes
city-cohort	Yes	Yes
Fit statistics		
Observations	886	896
R^2	0.84022	0.91772

Clustered (city) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

This table shows the coefficients and standard errors from our principal analysis weighted by average city population for diarrheal disease mortality and child mortality.

Table 2: Regressing Child Mortality Rate on the Typhoid Mortality Rate

Dependent Variable:	Child Mortality Rate			
Model:	(1)	(2)	(3)	(4)
Variables				
Typhoid Mortality Rate	5.346***	0.6355	1.618***	1.508**
	(0.8944)	(0.8752)	(0.4957)	(0.5995)
Controls				
Linear Time Trend		Yes	Yes	Yes
Clean Water Intervention				Yes
Chlorinated Water				Yes
Chicago Typhoid Epidemic				Yes
Fixed-effects				
city	No	No	Yes	Yes
Fit statistics				
Observations	614	614	614	614
R^2	0.23837	0.72914	0.80952	0.81460

Clustered (city) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

This table shows results from a regression of child mortality on typhoid mortality in the original dataset. The first specification does not include any controls. Subsequent specifications include linear time trends. City fixed-effects are added in (3) and (4), and controls used in the principal analysis are included in the final specification.

APPENDIX A

Appendix Table A1. Bathhouse Construction Dates and Data Availability

City and state	Year bathhouse constructed	Years covered for diarrheal disease mortality	Years covered for child mortality	Years covered for typhoid mortality
Albany, NY	1901	1891-1910, 1912-1915	1891, 1900-1910, 1912-1915	1891-1910, 1912-1915
Allegheny, PA	1903	1900-1907	1900-1907	1900-1907
Baltimore, MD	1900	1880-1910, 1912-1915	1880-1910, 1912-1915	1880-1910, 1912-1915
Boston, MA	1889	1880-1910, 1912-1915	1880-1910, 1912-1915	1880-1910, 1912-1915
Brooklyn, NY	1903	1880-1910, 1880-1910, 1912-1915	1898-1899, 1901-1910, 1901-1910, 1912-1915	1880-1910, 1880-1910, 1912-1915
Buffalo, NY	1897	1881-1910, 1912-1915	1881-1910, 1912-1915	1881-1910, 1912-1915
Chicago, IL	1894	1880-1910, 1912-1915	1880-1910, 1912-1915	1880-1910, 1912-1915
Cincinnati, OH	1904	1880-1910, 1912-1915	1880-1910, 1912-1915	1880-1910, 1912-1915
Cleveland, OH	1904	1896-1910, 1912-1915	1896-1910, 1912-1915	1896-1910, 1912-1915
Detroit, MI	1904	1898-1910, 1912-1915	1898-1910, 1912-1915	1898-1910, 1912-1915
Louisville, KY	1902	1892-1895, 1898-1910, 1912-1915	1892-1895, 1898-1910, 1912-1915	1880-1881, 1883-1884, 1886-1910, 1912-1915
Milwaukee, WI	1890	1880-1910, 1912-1915	1892-1910, 1912-1915	1885-1910, 1912-1915
New York, NY	1891	1880-1910, 1912-1915	1880-1899, 1901-1910, 1912-1915	1880-1910, 1912-1915
Newark, NJ	1897	1880-1910, 1912-1915	1880-1910, 1912-1915	1880-1910, 1912-1915
Philadelphia, PA	1898	1880-1910, 1912-1915	1880-1910, 1912-1915	1880-1910, 1912-1915
Pittsburgh, PA	1897	1880-1907	1880-1907	1880-1907
Portland, ME	1901	1900-1910, 1912-1915	1900-1910, 1912-1915	1900-1910, 1912-1915
Rochester, NY	1899	1891-1910, 1912-1915	1891-1910, 1912-1915	1891-1910, 1912-1915

Appendix Table A1. Bathhouse Construction Dates and Data Availability (continued)

City and state	Year bathhouse constructed	Years covered for diarrheal disease mortality	Years covered for child mortality	Years covered for typhoid mortality
San Francisco, CA	1890	1881-1897, 1900-1910, 1912-1915	1881-1897, 1900-1910, 1912-1915	1881-1897, 1900-1910, 1912-1915
St. Louis, MO	1907	1880-1896, 1900-1910, 1912-1915	1880-1896, 1900-1910, 1912-1915	1880-1896, 1900-1910, 1912-1915
Syracuse, NY	1900	1891-1901, 1903-1910, 1912-1915	1891-1901, 1903-1910, 1912-1915	1891-1901, 1903-1910, 1912-1915
Troy, NY	1901	1891-1910, 1912-1915	1891-1910, 1912-1915	1891-1910, 1912-1915
Yonkers, NY	1896	1891-1910, 1912-1915	1891, 1900-1910, 1912-1915	1891-1910, 1912-1915

This table presents the year each city constructed its first bathhouse and provides a summary of the data availability used in our analysis.

Appendix Table A2. Diarrheal Disease Definitions

City and state	Categories included in diarrheal mortality pre-1900
Albany, NY	diarrheal diseases
Allegheny, PA	...
Baltimore, MD	diarrhea, cholera infantum, dysentery, gastroenteritis, enterocolitis
Boston, MA	diarrhea, cholera infantum, dysentery, cholera morbus, gastroenteritis, enterocolitis
Brooklyn, NY	diarrheal diseases
Buffalo, NY	cholera infantum
Chicago, IL	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, gastroenteritis, enterocolitis
Cincinnati, OH	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, gastroenteritis, enterocolitis
Cleveland, OH	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, enterocolitis
Detroit, MI	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, gastroenteritis, enterocolitis
Louisville, KY	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, gastroenteritis, enterocolitis
Milwaukee, WI	diarrheal diseases
New York, NY	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, enterocolitis
Newark, NJ	diarrheal diseases
Philadelphia, PA	diarrhea, cholera infantum, dysentery, cholera morbus
Pittsburgh, PA	diarrhea, cholera infantum, dysentery, enteritis, gastroenteritis
Portland, ME	cholera infantum, dysentery
Rochester, NY	diarrheal diseases
San Francisco, CA	diarrhea, cholera infantum, dysentery, cholera morbus, enterocolitis
St. Louis, MO	diarrheal diseases, enteritis
Syracuse, NY	diarrheal diseases
Troy, NY	diarrheal diseases
Yonkers, NY	diarrheal diseases

Pre-1900 Data come from various city and state health reports. Our category of mortality from diarrheal diseases are aggregated for related diseases which are consistently reported throughout our pre- and post-event time period for each city. Starting in 1900, mortality from diarrheal diseases come from *Mortality Statistics*, which report a single category, "Diarrhea and Enteritis", which encompass all diarrheal diseases for each city.

Appendix Table A3. Clean Water Intervention Sources

City and state	Date Clean Water	Date Chlorination	Sources
Albany, NY	1899	1911	Hazen 1899; Bureau of the Census 1915
Allegheny, PA	1908	1910	Anderson et al. 2022a
Baltimore, MD	1915	1911	Anderson et al. 2022a
Boston, MA	...	...	Anderson et al. 2022a
Brooklyn, NY	1907	1911	Anderson et al. 2022a
Buffalo, NY	1913	1914	Anderson et al. 2022a
Chicago, IL	1893	1912	Ferrie and Troesken 2008; Anderson et al. 2022a
Cincinnati, OH	1907	...	Anderson et al. 2022a
Cleveland, OH	1904	1911	Anderson et al. 2022a
Detroit, MI	...	1914	Anderson et al. 2022a
Louisville, KY	1909	1913	Anderson et al. 2022a
Milwaukee, WI	...	1910	Anderson et al. 2022a
New York, NY	1907	1911	Anderson et al. 2022a
Newark, NJ	...	...	Anderson et al. 2022a
Philadelphia, PA	1906	1910	Anderson et al. 2022a
Pittsburgh, PA	1908	1910	Anderson et al. 2022a
Portland, ME	...	...	Portland Water District 1916
Rochester, NY	...	...	Anderson et al. 2022a
San Francisco, CA	...	...	Anderson et al. 2022a
St. Louis, MO	1915	1913	Anderson et al. 2022a
Syracuse, NY	1894	...	Robinson 2015; Horton 1919
Troy, NY	...	...	Troy 1990
Yonkers, NY	1903	...	Baldwin 1903

This table lists water-related controls used in the analysis. Sources are provided in the last column. The cities of Allegheny and Brooklyn are assumed to take on the clean water interventions of their absorbing cities (Pittsburgh and New York City, respectively), as these interventions occurred after annexation.

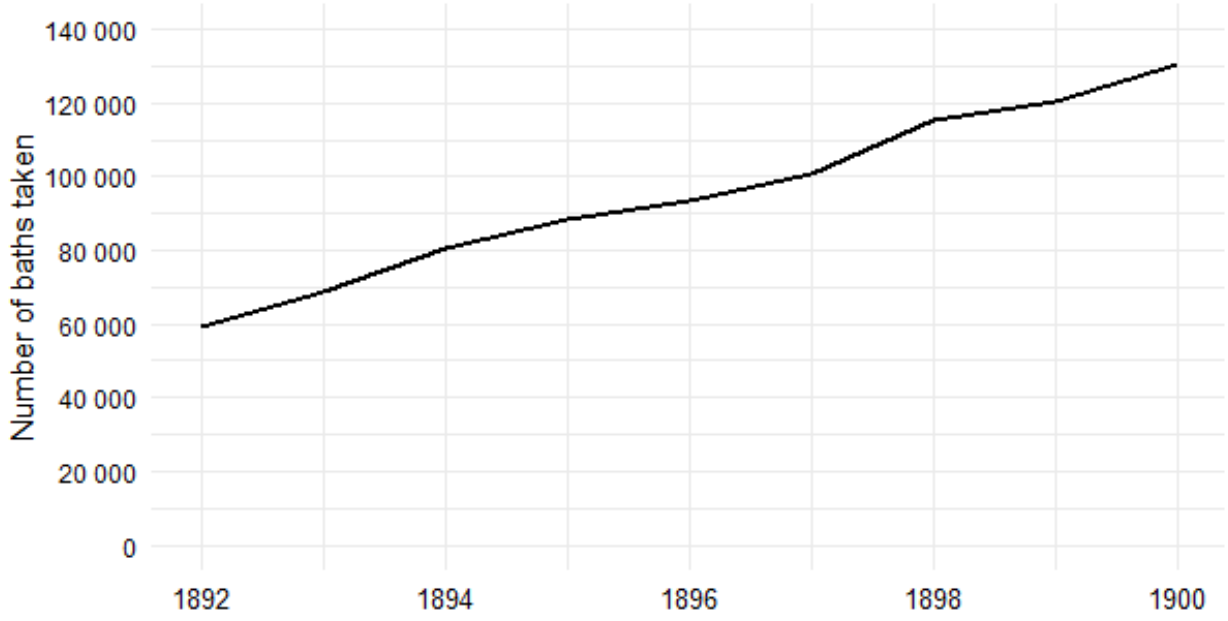
Appendix Table A4. Summary of Bathhouses from 1904 Cross-Section

Data come from Hanger (1904). Attendance is for the fiscal year. Price is per bath for all bathhouses with exceptions given in the footnotes.

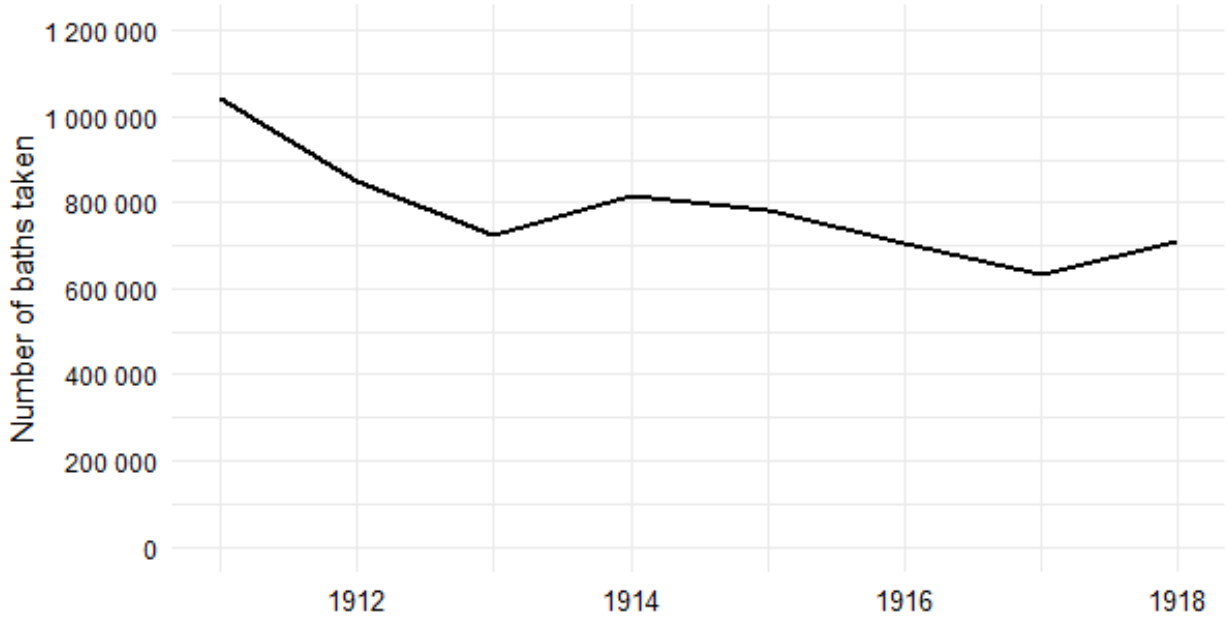
City and state	No. Bathhouses	Attendance	Male	Female	Proportion public	No. free baths	Price per bath
Albany, NY	1	44044	39791	4253	1	25456	10¢[a]
Allegheny, PA	1	20021	18060	1961	0	0	5¢
Baltimore, MD	2	123910	97035	26875	1	0	3¢[b]
Boston, MA	13	696314[c]	465157	231157	0.92	57573[d]	2¢[e]
Brooklyn, NY	2	NA	NA	NA	1	0	NA
Buffalo, NY	2	194650	171360	23290	1	194650	Free
Chicago, IL	9	692114[f]	520372	121742	1	692114	Free
Cleveland, OH	1	NA	NA	NA	1	NA	NA
Louisville, KY	1	14139	10180	3959	1	14139	Free
Milwaukee, WI	3	567625[g]	171406	53407	1	567625	Free
New York, NY	5	939555[c]	669107	270448	0.6	782712	Free[h]
Newark, NJ	2	87920	77034	10886	1	80698	NA
Philadelphia, PA	3	62377[c]	55704	6673	0	3923	5¢
Pittsburgh, PA	2	109792	96277	13515	0	15152	5¢
Portland, ME	1	30000	28000	2000	1	30000	Free
Rochester, NY	1	53000	44500	8500	1	53000	Free
San Francisco, CA	2	55710[f]	NA	NA	0	NA	10¢[i]
Syracuse, NY	1	69667	64537	3187	1	67724	Free
Troy, NY	1	74092	44205	29887	1	74092	Free
Yonkers, NY	2	26169	NA	NA	1	NA	5¢

[a] Free 3 days each week to residents.
[b] Charge is 1¢ for children.
[c] Attendance data is unavailable for 2 bathhouses.
[d] Most data on free baths given unavailable.
[e] Charge is 1¢ for towel and 1¢ for soap, if furnished by the establishment. Price data for private establishment unavailable.
[f] Total attendance data unavailable for 1 bathhouse. Attendance by sex unavailable for one additional bathhouse in Chicago.
[g] Attendance and price data unavailable for 1 bathhouse.
[h] The two non-public establishment (the People's Bath and Riverside Association Bath) charged 5¢. The People's Bath offered free baths to those who could not afford the fee.
[i] Price is for the bath in our dataset. The other bath opening was considerably more expensive at 50¢per shower.

Appendix Figure A1. Bathhouse Usage: People's Bath in NYC

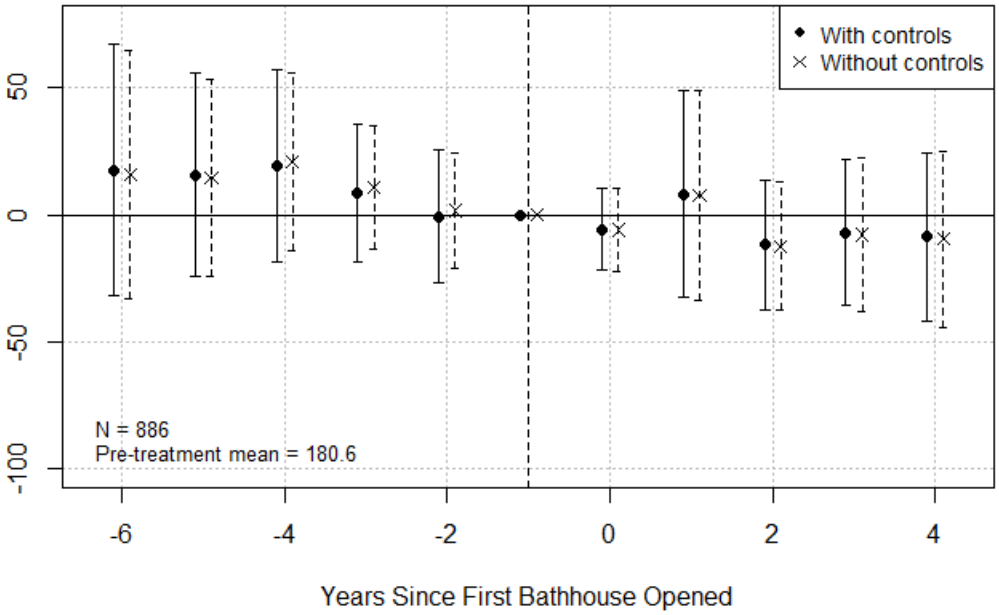


Appendix Figure A2. Bathhouse Usage: All Chicago Public Baths

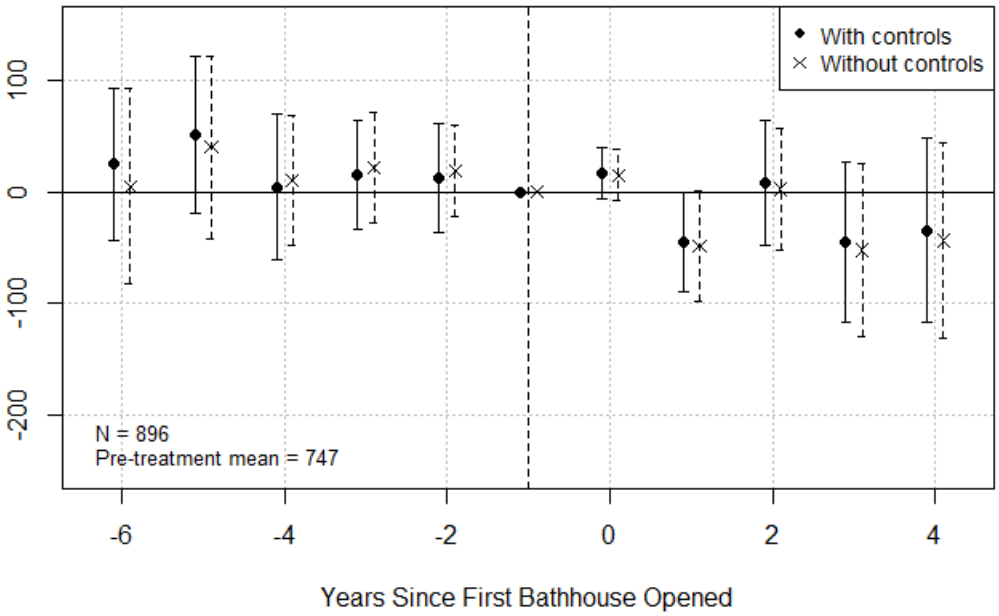


APPENDIX B

Appendix Figure B1a. Effect on Diarrheal Disease Mortality: Unweighted

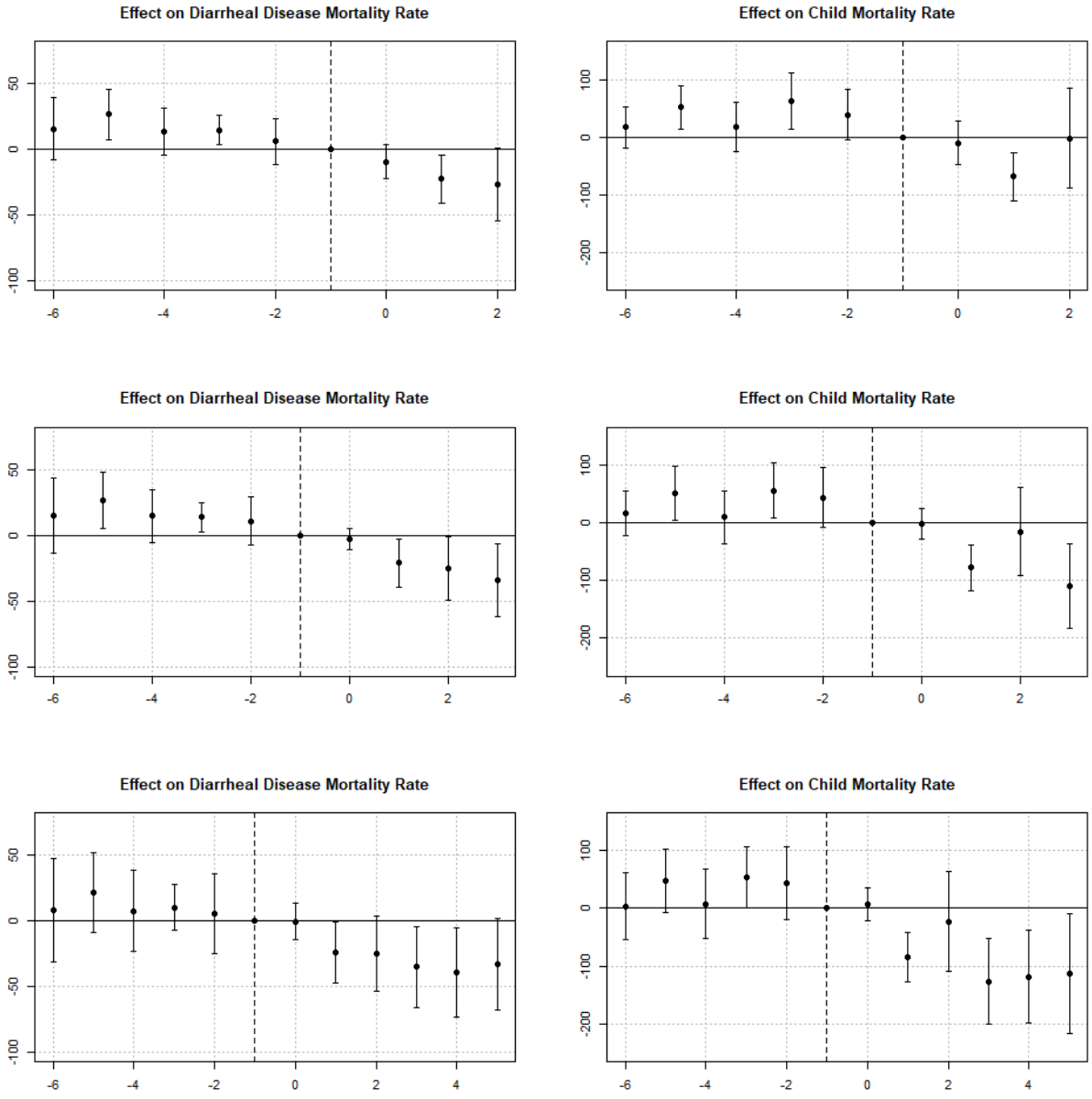


Appendix Figure B1b. Effect on Child Mortality: Unweighted



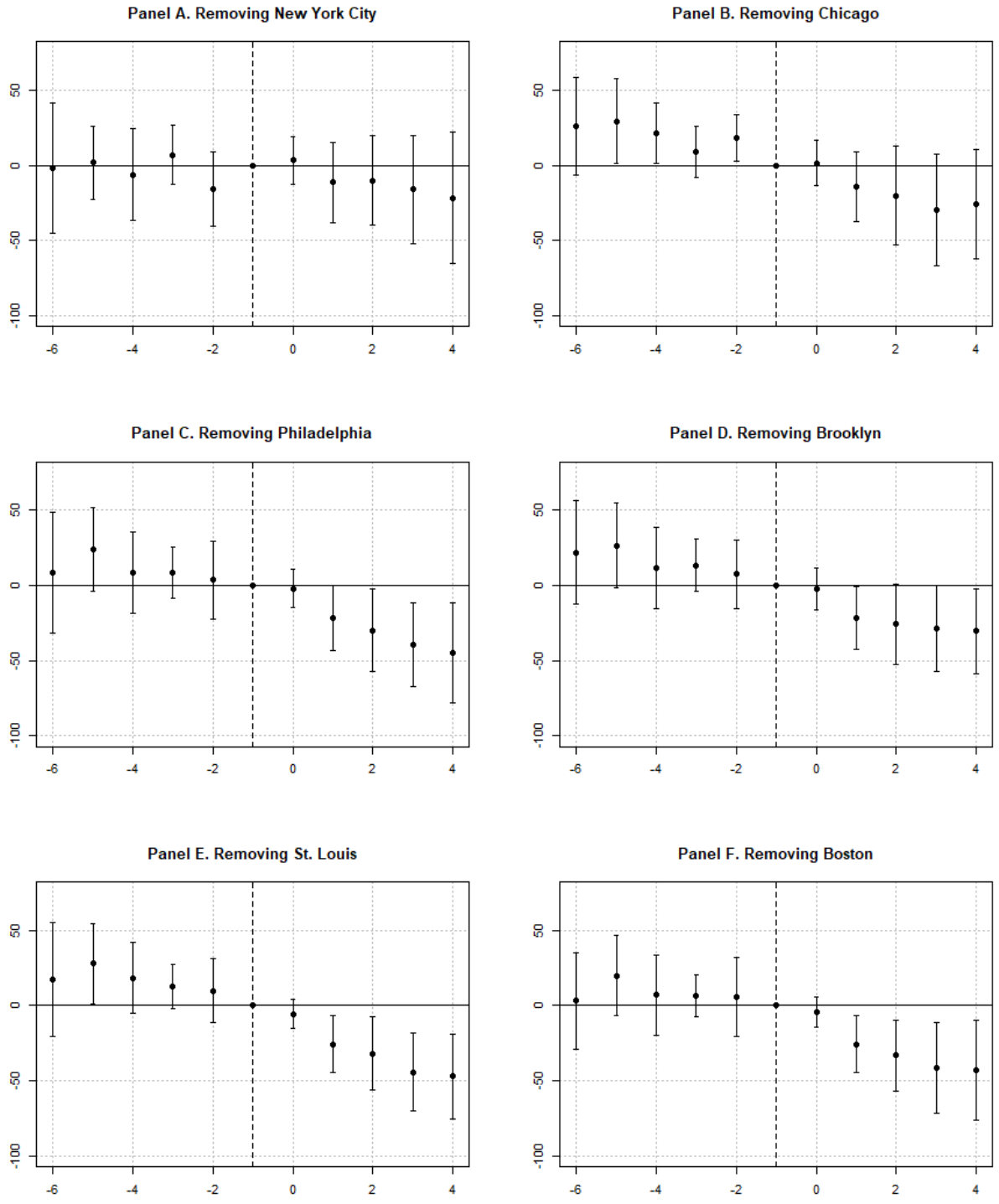
The figures above presents two-way fixed effects OLS estimates of diarrheal diseases (B1a) and child mortality (B1b) per 100,000 of the population with the controls detailed in Appendix Table A3 as well as controlling for the typhoid epidemic that occurred in Chicago from 1891-1893, along with their 95% confidence intervals. These are our main results without weighting by average population. Standard errors are clustered at the city level.

Appendix Figure B2. Alternate Lags



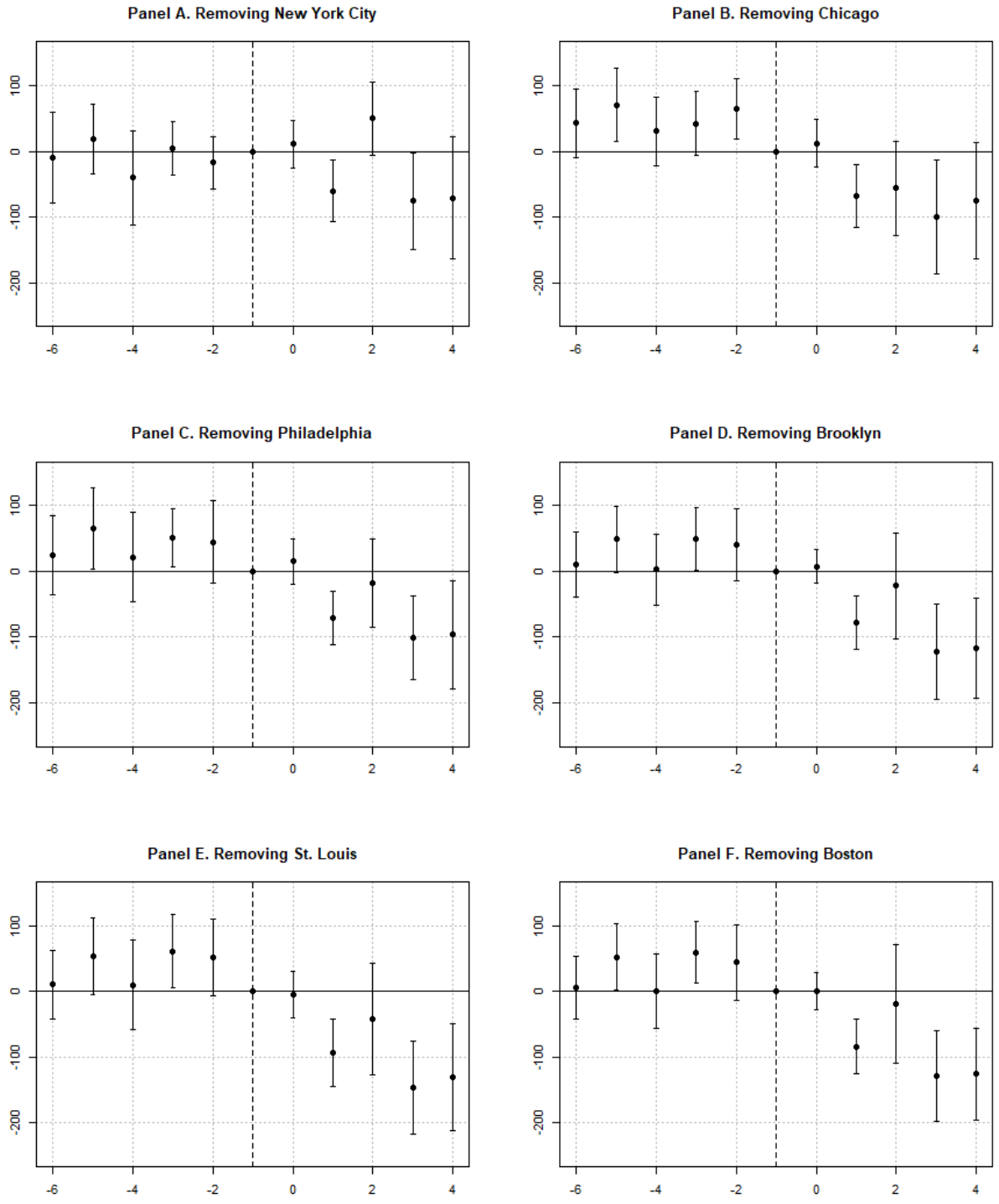
These figures show results from diarrheal disease mortality (left) and child mortality (right) using two years, three years, and five years of leads, respectively, in each row. Changing the leads effectively changes the comparison group as cities that did not yet establish a bathhouse are used as our clean control units in each specification. Estimates are weighted by average city population. We display 95% confidence intervals.

Appendix Figure B3. Effects on Diarrheal Disease: Dropping Most-Populous Cities



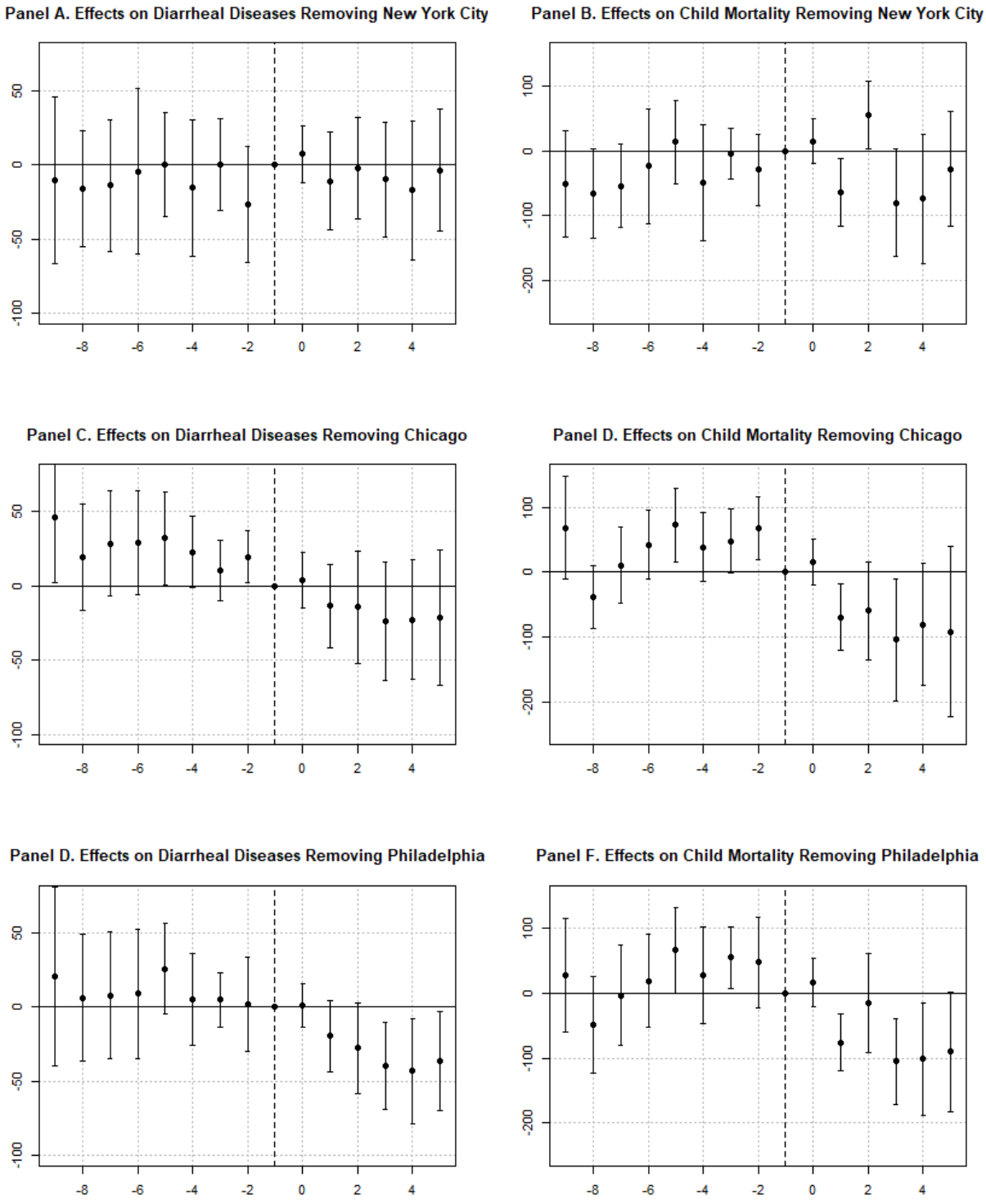
These figures show results from diarrheal disease mortality dropping each of the six most populous cities in our data. Estimates are weighted by average city population. We display 95% confidence intervals.

Appendix Figure B4. Effects on Child Mortality: Dropping Most-Populous Cities



These figures show results from child mortality dropping each of the six most populous cities in our data. Estimates are weighted by average city population. We display 95% confidence intervals.

Appendix Figure B5. Extended Leads and Dropping Most Populous Cities



These figures show results from diarrheal diseases (left) and child mortality (right), dropping each of the three most populous cities and extending the leads to 9, the maximum allowed in our data. Estimates are weighted by average city population. We display 95% confidence intervals.