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ISSN: 2365-9793

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ABSTRACT

The Phenomenon of Summer Diarrhea and Its Waning, 1910-1930

During the first two decades of the 20th century, diarrheal deaths among American infants and children surged every summer. Although we still do not know what pathogen (or pathogens) caused this phenomenon, the consensus view is that it was eventually controlled through public health efforts at the municipal level. Using data from 26 major American cities for the period 1910-1930, we document the phenomenon of summer diarrhea and explore its dissipation. We find that water filtration is associated with a 15-17 percent reduction in diarrheal mortality among children under the age of two during the non-summer months, but does not seem to have had an effect on diarrheal mortality during the summer. In general, we find little evidence to suggest that public health interventions undertaken at the municipal level contributed to the dissipation of summer diarrhea. Our results are relevant for many parts of the developing world today, where climate change is expected to affect the length and intensity of seasons as well as the incidence of diarrheal diseases.

JEL Classification: I10, I18, N3, Q54
Keywords: diarrheal mortality, infant mortality, public health

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1. INTRODUCTION

Summer diarrhea (also known as "cholera infantum" or the "disease of the season") was first described in the medical literature by Benjamin Rush (1794). According to Rush (1794, p. 160), it would sometimes begin "with a diarrhoea, which can last for several days without any other symptom...but it more frequently comes on with a violent vomiting and purging, and a high fever." He argued that it was likely caused by the "discharge of bile which generally introduces the disease…and exacerbations of the fever which accompanies it…" (Rush 1794, p. 163).

By the turn of the 20th century, physicians had gained a better understanding of how gastronomical diseases are contracted but still had not discovered why thousands of American infants and children were dying of diarrhea every summer. In fact, to this day, we can only speculate as to precisely what pathogen (or pathogens) caused the phenomenon (Meckel 1990; Thompson and Keeling 2012).

Economists and historians have argued that summer diarrhea was controlled through the combined effects of public health interventions (Meckel 1990; Fishback et al. 2011). Specifically, they point to municipal-level efforts during the early 1900s to purify water and milk supplies. Because breastfeeding was typically discontinued at an early age (Wolf 2003), and because there is anecdotal evidence that children were at the greatest risk of dying from diarrhea in their "second summer" (Condie 1858, p. 224; Moss 1903; Southworth 1904), focusing on these efforts is not without justification.[1]

[1] See also Reedy (2007, p. 42), who asserted that summer diarrhea was controlled through "handwashing and safer food-handling procedures at home and in the marketplace" along with "better built and maintained sewage treatment plants" that "helped keep infants and children from playing in and drinking contaminated water." Graham-Smith (1929) attributed the dissipation of summer diarrhea among infants in England to the introduction of the automobile, which had the effect of reducing horse manure in the streets.

In this study, we begin by documenting the phenomenon of summer diarrhea and its correlates using newly transcribed mortality data from 26 major American cities for the period 1910-1930. These data, which were originally published by the U.S. Bureau of the Census, include monthly counts of diarrheal deaths among children under the age of two. We show that 21,000 children under the age of two died of diarrhea in 1910, and 14,000 of these deaths occurred in the months of June-September. By the end of the period under study, the phenomenon of summer diarrhea had largely dissipated. Fewer than 4,000 children under the age of two died of diarrhea in 1930, and fewer than 1,500 of these deaths occurred in the summer.[2]

In the second half of the paper, we use data from these same 26 cities to estimate whether public health efforts at the municipal level contributed to the waning of summer diarrhea during the period 1910-1930.[3] We find that the construction of a water filtration plant is associated with a 15-17 percent reduction in diarrheal mortality during non-summer months, consistent with the hypothesis that transmission occurred through contaminated water. By contrast, filtration had little effect on diarrheal mortality during the hottest 4 months of the year (June-September), which suggests that transmission was most likely through contaminated food or person-to-person contact, although efforts to purify the milk supply do not appear to have affected diarrheal mortality during the summer either. In fact, we find little evidence that public health interventions can explain the waning of summer diarrhea. We conclude that the phenomenon of summer diarrhea was serious and widespread, but, contrary to the consensus view, its dissipation

[2] In 1910, the ratio of diarrheal deaths to the population of children under the age of two was .031 (21,101/678,292 = .031). By 1920, this ratio had dropped to .015; by 1930, it had dropped to .005.

[3] We focus on the period 1910-1930 because monthly-level mortality data are not available from the U.S. Bureau of the Census prior to 1910 or after 1930.

was not due to municipal-level efforts to purify the milk or water supplies or treat sewage. It is possible that improvements in the refrigeration chain, better nutrition, or some combination of these and other factors may have contributed to the dramatic reduction in diarrheal deaths among American infants and children during the summer months.

The results described above contribute to a literature comprised entirely of descriptive case studies (Cheney 1984; Condran 1988; Condran and Lentzner 2004). They also have implications for developing countries today, where climate change is expected to increase the risk of diarrheal diseases (Gray 2011; Friedrich 2013; Dhimal et al. 2016).[4] In many parts of the world, diarrheal diseases still exhibit seasonality, although the intensity of this seasonality varies with region and climate (Patel et al. 2013; Platts-Mills et al. 2015; Xu et al. 2015; Baker 2016). Understanding the determinants of summer diarrhea and its eventual waning could help identify effective intervention strategies as the length and intensity of seasons change across the globe (Kiger 2017; Santer et al. 2018; National Oceanic and Atmospheric Administration 2019).[5]

In addition to providing the first econometric analysis on the relationship between public health interventions and diarrhea seasonality, we explore heterogeneous effects by race. Beyond the work of Troesken (2001, 2002), very little is known about how public health efforts at the turn of the 20th century affected minorities. We show that the reduction in diarrheal mortality among black children was far less dramatic than that experienced by their white counterparts. Even towards the end of the 1920s, black diarrheal mortality exhibited strong seasonality; the diarrheal mortality rate among white children still peaked during the summer months but at less

[4] In tropical climates (e.g., Southeast Asian), climate change is expected to intensify already marked seasonal variation in rainfall (Christensen et al. 2007; Asian Development Bank 2009; Lyon and Camargo 2009), which could, in turn, exacerbate the incidence of diarrhea.

[5] An emerging literature has identified existing technologies that can be used to adapt to climate change (Hsiang and Narita 2012; Auffhammer and Schlenker 2014; Klein et al. 2014; Barreca et al. 2016).

than half the rate experienced by black children. Although water filtration led to a reduction in non-summer diarrheal mortality among white children, it and the other public health interventions under study were essentially unrelated to diarrheal mortality among black children.

The remainder of the paper is organized as follows. We begin with an overview of diarrheal disease and a discussion of the previous literature. In Section 3, we document the summer diarrhea phenomenon using data on the 26 most populous cities in the United States as of 1910; in Section 4, we describe our empirical strategy, report our principal estimates, and consider various robustness checks; in Section 5, we explore heterogeneous effects by race. Section 6 concludes.

2. BACKGROUND

Today, diarrheal disease is the second-leading cause of death among children under the age of 5 (Liu et al. 2015). Between 500,000 and 800,000 children under the age of 5 die of diarrhea every year, most of whom are born to mothers in developing countries (Liu et al. 2015; Kovacs et al. 2015). A wide variety of bacteria, parasites and viruses cause diarrhea and other symptoms of gastroenteritis (Hodges and Gill. 2010). Infection is usually through contaminated food or water, or person-to-person contact (Pawlowski et al. 2009). In temperate climates, bacterial infections are more common during the summer (Ramos-Alvarez and Sabin 1958; Fletcher et al. 2013), while viral gastroenteritis is more common during the winter (Pawlowski et al. 2009). In tropical climates, the incidence of diarrhea appears to peak during the rainy season (Zhang et al. 2010; Phung et al. 2015; Xu et al. 2015; Kulinkina et al. 2016; Muluken et al. 2017).

Over 70 percent of total deaths from diarrhea occur among children under of the age of two (Walker et al. 2013). Susceptibility is highest at 6-11 months, presumably because exclusive

breastfeeding protects against infection and crawling brings children into contact with human and/or animal feces (Walker et al. 2013; Mduduzi et al. 2015). Death is typically caused by dehydration and loss of electrolytes (King et al. 2003), although malnutrition is often a contributing factor (Baqui and Ahmed 2006).

2.1. Previous Literature

In the decades leading up to its dissipation, summer diarrhea received a great deal of attention from physicians, who described its symptoms, noted that its victims were often born in crowded tenement housing districts, and proposed various causes.[6] For instance, one school of thought held that exposure to summer heat was directly responsible for the annual wave of diarrheal deaths among infants and children (Miller 1879; Schereschewsky 1913), while another held that overfeeding was the cause (Burg 1902; Brennemann 1908; Tilden 1909). Even among physicians who believed that summer diarrhea was caused by bacteria, there were several competing theories as to the mode of transmission.[7]

Since its dissipation, only a handful of studies have examined the phenomenon of summer diarrhea. Cheney (1984) focused on the experience of Philadelphia during the period 1869-1921, while Condran (1988) focused on New York City during the period 1870-1919. These authors noted that infant mortality spiked every summer through the early 1900s, due principally to diarrheal diseases. By the second decade of the 20th century, the phenomenon of

[6] See, for instance, Miller (1879), Burg (1902), Kiefer (1902), McKee (1902), Moss (1903), Southworth (1904), Ostheimer (1905), Snyder (1906), Brennemann (1908), Murphy (1908), Tilden (1909), Stoner (1912), and Youmans and Youmans (1922).

[7] Zahorsky (1913, 1918) described the various theories of transmission. Hewitt (1910) and Youmans and Youmans (1922) argued that houseflies were the principal vector of transmission, a possibility that cannot be dismissed out of hand (Levine and Levine 1991; Förster et al. 2007).

summer diarrhea had begun to wane in both Philadelphia and New York City, which Cheney (1984) and Condran (1988) attributed to the purification of municipal milk supplies.

Certainly, many contemporary physicians and public health experts were convinced that purifying the milk supply was key to reducing diarrheal mortality during the summer.[8] The refrigeration chain was still missing important links during this period (Rees 2013), and bacteria such as *E. coli* and *Shigella* grow rapidly in warm, moist summer conditions (Winfield and Groisman 2003; Noor 2013; Girma 2015). It is, however, difficult to rule out the possibility that other public health measures contributed to the observed reduction. For instance, Philadelphia began the process of delivering filtered water to its residents before 1906 and began treating it with chlorine in 1910 (Anderson et al. 2018), both of which could have reduced diarrheal mortality among infants and children during the summer months; New York City began delivering clean water from the Croton Reservoir to its residents in 1907 and began treating it with chlorine in 1911 (Anderson et al. 2018).

Condran and Lentzner (2004) used data from Chicago, New Orleans, and New York for the period 1870-1917 to document the phenomenon of summer diarrhea and its waning. They found that excess mortality during the summer months fell gradually in these cities after the turn of the 20th century, but noted that identifying the cause of this phenomenon is made exceedingly difficult by the large number of public health interventions that were undertaken at the municipal level. These authors concluded that better sanitation and efforts to purify the milk and water supplies likely contributed to the decline in summer diarrhea but wrote that no single factor is "sufficient to understand either the poor life chances of infants in nineteenth-century cities or the improvements in those chances…" (Condran and Lentzner 2004, p. 352).

[8] See, for instance, Kiefer (1902), McKee (1902), Park and Holt (1904), Snyder (1906), M'Mechan (1907), Stoner (1912), and the United States Children's Bureau (1914).

3. SUMMER DIARRHEA, 1910-1930

Our focus throughout this study is on diarrheal deaths among children under the age of two in major American cities, defined as the 26 most populous cities as of 1910.[9] City-level counts of diarrheal deaths are available by month for the period 1910-1930 from *Mortality Statistics*, which was published annually by the U.S. Census Bureau.[10] These counts include deaths due to cholera infantum, colitis, enteritis, enterocolitis, gastroenteritis, summer complaint, and other similar causes (United States Bureau of the Census 1910).

In 1910, there were 21,101 diarrheal deaths among children under the age of two in the 26 most populous American cities (Figure 1), accounting for 30 percent of total mortality in this age group.[11] Two-thirds of these deaths occurred in the months of June-September. Between 1910 and 1930, diarrheal mortality fell by 83 percent, to 3,513. The reduction in diarrheal deaths during the months of June-September was even more pronounced: only 1,482 children under the age of two died from diarrhea in the summer of 1930, a reduction of almost 90 percent as compared to the summer of 1910.[12]

Figure 2 shows annual diarrheal deaths among children under the age of two per 100,000 population.[13] In 1910, there were 124 diarrheal deaths among children under the age of two per

[9] These 26 cities are listed in Appendix Table 1.

[10] This data source has been used by other authors interested in the effects of public health interventions on mortality at the turn of the 20th century (Cutler and Miller 2005, 2018; Beach et al. 2016; Anderson et al. 2018, 2019, forthcoming; Alsan and Goldin forthcoming). Cause of death was obtained from the death certificate and coded using the *International Classification of Diseases*. When more than one medical condition was listed on the death certificate, cause of death was based on a standardized algorithm (Armstrong et al. 1999).

[11] Appendix Figure 1 shows annual diarrheal deaths as a percentage of total deaths among children under the age of two. Appendix Figure 2 shows summer diarrheal deaths as a percentage of total diarrheal deaths.

[12] In 1930, 42.2 percent of diarrheal deaths among children under the age of two occurred in the months of June-September, accounting for only 5 percent of total mortality among children in this age group.

[13] City populations for 1910, 1920, and 1930 are from *Mortality Statistics*. Population was linearly interpolated for intercensal years.

100,000 population; by 1930, the diarrhea mortality rate had fallen to 14, a reduction of 89 percent. The summer diarrheal mortality rate fell from 82 to 6 over the same period, a reduction of 93 percent.

Figure 3 shows diarrheal deaths by month among children under the age of two per 100,000 population. It is clear from this figure that seasonality waned considerably during the period under study. For instance, the diarrhea mortality rate was 3.8 in January of 1910 but reached as high as 29.1 in July of that same year, a peak-to-trough ratio of 7.7. The peak-to-trough ratio had fallen to 3.5 by 1920, and it had fallen to 2.6 by 1930.[14]

3.1. Geography, Temperature, and Summer Diarrhea

Rush (1794, p. 159) wrote that summer diarrhea went by the name of "the April and May disease" in Charlestown "from making its first appearance in those two months…" He went on to observe that it "seldom appears in Philadelphia till the middle of June, or the beginning of July…" (p. 159). Other physicians agreed with Rush, asserting that the phenomenon began earlier, and lasted longer, in the South (King 1837; Copeland 1855; Condie 1858; Smith 1905).

The top panel of Figure 4 shows diarrheal deaths per 100,000 population by month for the first half of the period under study (i.e., 1910-1920) in northern versus southern cities using the 40th parallel north as the cutoff.[15] Consistent with an observation first made by Copeland (1855), the diarrheal mortality rate was lower in southern, as compared to northern, cities.[16]

[14] In September of 1930, diarrheal deaths among children under the age of two peaked at 2.0 per 100,000 population in the 26 cities that compose our sample; in December of 1930, there were only 0.8 diarrheal deaths per 100,000 population.

[15] The cities in our sample below the 40th parallel north are Baltimore, Cincinnati, Indianapolis, Kansas City, Los Angeles, Louisville, New Orleans, Philadelphia, San Francisco, St. Louis, and Washington DC.

[16] Copeland (1855, p. 385) observed: "In our Southern cities it is even less rife than in, Philadelphia, Baltimore, and New York, which proves that it is not dependent on heat alone, which some have supposed." His observation was

Figure 4, however, provides little evidence that the phenomenon of summer diarrhea began earlier, or lasted longer, in cities located below the 40th parallel north, although mortality tended to peak in July as opposed to August.

The bottom panel of Figure 4 shows diarrheal deaths per 100,000 population by month in northern versus southern cities for the second half of the period under study (i.e., 1921-1930). During this later period, the monthly diarrheal mortality rate was, on average, slightly lower in northern cities, but again there is no evidence that the phenomenon of summer diarrhea began earlier or lasted longer in southern cities. However, it should be noted that only one of the cities in our sample (New Orleans, Louisiana) was located in the Deep South. In Figure 5, we show the monthly diarrheal mortality rate for New Orleans. During the period 1910-1920, the diarrheal mortality rate for children under the age of two in New Orleans began to climb in April and peaked in May; it peaked in June during the period 1921-1930.

We explore the relationship between temperature and diarrheal mortality in Figure 6. As discussed above, bacteria such as *E. coli* and *Shigella* grow rapidly in the heat of summer (Winfield and Groisman 2003; Noor 2013; Girma 2015), while viral infections that cause diarrhea typically peak in winter months (Pawlowski et al. 2009). It is not clear, however, whether such seasonality is due to temperature, humidity, changes in behavior, or host susceptibility (Ahmed et al. 2013).[17]

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repeated by Rogers (1869) and Maxwell (1887). For instance, Maxwell (1887, p. 538), who practiced medicine in Ocala, Florida, wrote that the town had:

> …about 2500 inhabitants and…it is entirely exempt from cholera infantum. During the last six summers I have resided and practiced medicine there, and have not seen or heard of a case of that disease.

[17] According to a recent review, noroviruses "are the most common cause of sporadic cases and outbreaks of gastroenteritis across all age groups worldwide" (Ahmed et al. 2013, p. 1). Rotavirus infections are another important cause of gastroenteritis among children under the age of 5 (Patel et al. 2013). Hospitalizations and outpatient visits for rotavirus and norovirus infections typically peak in the winter months (D'Souza, Hall and

Figure 6 shows diarrheal deaths among children under the age of two per 100,000 population for the following city-month combinations: those with an average temperature less than 60° F, those with an average temperature between 60-70° F, and those with an average temperature equal to or greater than 70° F. Several patterns are evident in Figure 6.[18] First, throughout the period under study, the diarrheal mortality rate was highest when the average temperature was at or above 70° F and lowest when the average temperature was below 60° F.[19] Second, diarrheal mortality rates exhibited steady declines across all three of the temperature bands. Lastly, these declines were most pronounced at higher temperatures. For example, diarrheal deaths at or above 70° F fell by 91 percent, from 21.5 per 100,000 population in 1910 to 2.0 in 1930. By contrast, the diarrheal mortality rate at average temperatures less than 60° F fell by 77 percent, from 4.4 in 1910 to 1.0 in 1930.

In the next section, we explore whether the waning of summer diarrhea, documented in Figures 1-6, was related to public health interventions undertaken at the municipal level. A description of these interventions can be found in Anderson et al. (2018), who were interested in

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Becker 2008; Gastañaduy et al. 2013; Patel et al. 2013). Parasitic infections, which can also cause diarrhea, are more common in the summer months (Amin 2002).

[18] Data on temperature come from the nClimDiv data set at the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA), which is available at: ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv/. Monthly temperature variables are measured at the climate division level (there are 344 climate divisions covering the entire continental United States). We mapped each city in our sample to its corresponding climate division using ArcGIS. Please see the following document for more details on the construction of the nClimDiv data set: ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv/divisional-readme.txt.

[19] This pattern is consistent with studies showing a strong, positive relationship between temperature and infant mortality in developing countries (Banerjee and Bhowmick 2016; Geruso and Spears 2018). See Barreca et al. (2016) for evidence that the positive relationship between temperature and mortality weakened during the 20th century. Barreca et al. (2016, p. 156) concluded that air conditioning was:

> …a central determinant in the reduction of the mortality risk associated with high temperatures during the twentieth century. Specifically, the diffusion of residential air conditioning after 1960 is related to a statistically significant and economically meaningful reduction in the temperature-mortality relationship at high temperatures.

whether public health interventions could explain the declines in total and infant mortality over the first decades of the 20th century.[20] Anderson et al. (2018) found that filtration was associated with a (statistically insignificant) 15 percent reduction in diarrheal deaths among children under the age of two, an estimate that falls well short of explaining the dramatic reduction in diarrheal mortality during the early 1900s. Because these authors used annual mortality data, they could not examine the determinants of seasonality.

4. PUBLIC HEALTH EFFORTS AND THE WANING OF SUMMER DIARRHEA

Economists and historians have long asserted that public health efforts undertaken at the municipal level caused the waning of summer diarrhea (Cheney 1984; Condran 1988; Meckel 1990; Fishback et al. 2011). For instance, Cheney (1984) and Condran (1988) argued that efforts to purify milk supplies caused its waning, while Meckel (1990) and Fishback et al. (2011) pointed to the combined effects of purifying milk and water supplies.[21]

[20] Using data on 25 major American cities for the period 1900-1940, Anderson et al. (2018) explored the effects of filtration and chlorination on infant and total mortality. In addition, they explored the effects of sewage treatment, projects designed to deliver clean water from further afield such as aqueducts and cribs, and municipal efforts to clean up milk supplies. Contrary to the consensus view, Anderson et al. (2018) found that none of the interventions under study contributed substantially to the observed declines in mortality.

[21] Fishback et al. (2011, p. 140) noted that as "pasteurized milk became more common and cities filtered public water supplies, the rates of typhoid and diarrhea no longer varied much by season or in response to temperature." Meckel (1990, p. 89) was considerably more cautious. He wrote:

> It is extremely difficult to assess with any certainty the effect that milk regulation and especially commercial pasteurization had on the urban infant death rate. Infant mortality is causally complex, and its reduction is usually tied to an amalgam of changes in the social and material environment. The implementation of milk regulations and the introduction of pasteurization came at a time when many municipalities were also making significant strides in improving their water supply, sewerage, and refuse removal systems…Nevertheless, infant mortality, and especially mortality from diarrheal diseases did decline concurrent with the implementation of effective milk regulations and the adoption of commercial pasteurization in America's larger cities. As one demographer has recently demonstrated, summer mortality among infants, which declined slowly between 1890 and 1910, dropped rapidly in the second decade of the century and by 1921 was all but negligible.

The remainder of this study is devoted to exploring the relationship between public health interventions at the municipal level and the phenomenon of summer diarrhea. We begin our exploration of this relationship by estimating the following regression:

$$(1) \quad \ln(Diarrhea_{ct}) = \beta_0 + \beta_1 Filtration_{ct} + \beta_2 Filtration_{ct} \times Summer_t + \beta_3 Chlorination_{ct} + \beta_4 Chlorination_{ct} \times Summer_t + \boldsymbol{X_{ct}\beta_5} + v_c + w_t + \Theta_c \cdot t + \varepsilon_{ct},$$

where *Diarrhea* is equal to diarrheal deaths per 100,000 population among children under the age of two in city *c* and month *t*, where $t = 1 \ldots 252$.[22] *Filtration* is an indicator for whether a water filtration plant was in operation and *Chlorination* is an indicator for whether the water supply was chemically treated.[23] These indicators are interacted with *Summer*, which is equal to 1 for the months of June-September and equal to zero for the non-summer months.

Demographic controls, based on information from the 1910, 1920, and 1930 Censuses (and linearly interpolated for intercensal months), are represented by the vector $\boldsymbol{X_{ct}}$ and are listed in Table 1, along with descriptive statistics and definitions. City-level characteristics include the natural log of population and percentages of the population by gender, race, foreign-born status, and age group. City and month-by-year fixed effects are represented by the terms v_c and w_t, respectively. The city fixed effects control for determinants of diarrheal mortality that were constant over time, and the month-by-year fixed effects control for common shocks. City-

[22] Our data cover the period 1910-1930 (12 x 21 = 252).

[23] Water filtration technology was originally developed to reduce discoloration and turbidity, but gained support as the study of bacteriology advanced and city governments came under increasing pressure to protect their citizens from infectious diseases (McCarthy 1987; Melosi 2008). Unlike water filtration, the chlorination process was simple and inexpensive: water was added to calcium hypochlorite, which was then mixed with the water supply before delivery (Hooker 1913). See Melosi (2008) and Anderson et al. (2018) for more information on the history and technical aspects of these two interventions.

specific linear time trends, represented by the term $\Theta_c \cdot t$, account for the possibility that diarrheal mortality evolved at different rates in the 26 cities that compose our sample. All regressions are weighted by city populations and standard errors are corrected for clustering at the city level (Bertrand et al. 2004).

Our primary interest is in the parameters β_1 through β_4. β_1 represents the effect of filtration on diarrheal mortality in the non-summer months, while $\beta_1 + \beta_2$ represents the effect of filtration in the months of June-September; likewise, β_3 represents the effect of chlorination on diarrheal mortality in the non-summer months, while $\beta_3 + \beta_4$ represents the effect of chlorination in the months of June-September. During the period 1910-1930, 8 cities adopted filtration technology, and 24 cities began treating their water with chlorine (Appendix Table 1).

Estimates of β_1 through β_4 are reported in the first column of Table 2. Filtration is associated with a 16 percent reduction in the diarrheal mortality rate during the non-summer months ($e^{-.176} - 1 = .161$), which is consistent with the hypothesis that transmission in the non-summer months occurred through contaminated water. By contrast, we find little evidence that filtration was effective in the months of June-September: the estimate of β_2 is positive and almost entirely offsets the estimate of β_1.[24] Neither the estimate of β_3 nor the estimate of β_4 is statistically distinguishable from zero.

In the second column of Table 2, we introduce two additional municipal-level public health interventions and their interactions with the summer indicator. The first, *Clean Water Project*, is equal to 1 if a new aqueduct or underground tunnel was built to deliver clean water (and is equal to zero otherwise).[25] The second, *Sewage Treated*, is an indicator for whether the

[24] The sum of these two estimates, -.016, is not statistically significant at conventional levels.

[25] Identification comes from water projects undertaken by 4 cities during the period under study (Buffalo, Los Angeles, Providence, and Newark). See Appendix Table 2 for more information.

city treated its sewage before discharging it into local waterways.[26] With their inclusion as controls, water filtration is associated with a 17 percent reduction in the diarrheal mortality rate during the non-summer months. However, the estimated coefficients of *Clean Water Project*, *Sewage Treated*, and their interactions are not statistically significant at conventional levels.

In the third and final column of Table 2, we introduce an indicator for whether city *c* required milk sold within its limits to meet a strict bacteriological standard. This indicator also appears on the right-hand side of the estimating equation interacted with *Summer*. During the period 1910-1930, 15 cities passed ordinances requiring that milk sold within their limits meet a bacteriological standard (see Appendix Table 4). Because such ordinances were difficult to meet without resorting to pasteurization (Meckel 1990, pp. 88-89), they are often referred to as "pasteurization ordinances" (Harding 1917, p. 57; Swinford 2016, p. 254; Komisarow 2017, p. 131). For instance, New York passed an ordinance, effective on January 1, 1912, requiring that "certified" raw milk have less than 30,000 bacteria per cubic centimeter, and that "inspected" raw milk have less than 60,000 bacteria per cubic centimeter.[27]

[26] Identification comes from sewage treatment plants built by 8 cities during the period under study (Baltimore, Chicago, Cleveland, Indianapolis, Jersey City, Milwaukee, Newark, and Rochester). Following Anderson et al. (2018), we code our sewage treatment indicator as equal to zero for cities that were treating less than 25 percent of their effluent (Mohlman 1940). See Appendix Table 3 for more information. With the exception of Anderson et al. (2018), previous studies have focused on estimating the effects of providing sewerage (i.e., the building and extending of sewer systems) as distinct from treating sewage (i.e., using chemical or biological processes to remove contaminants from waste water) before its discharge. See, for instance, Kesztenbaum and Rosenthal (2017) and Alsan and Goldin (forthcoming).

[27] Pasteurized "selected milk" was required to have less than 50,000 bacteria per cubic centimeter (New York 1912; New York Department of Health 1913). Other cities explicitly exempted pasteurized milk from having to meet the bacteriological standard or allowed higher levels of bacteria in raw milk that was to be pasteurized before being sold. During the period 1910-1930, only two cities in our sample (Detroit and Chicago) required that all milk sold within their limits be pasteurized. Detroit passed its pasteurization ordinance in 1915 without first requiring that milk meet a bacteriological standard and that it come from tuberculin-tested cows (Kiefer 1911; Clement and Warber 1918). One year later, the Chicago commissioner of health, worried about an outbreak of Polio, ordered that all milk sold in the city be pasteurized (Czaplicki 2007).

Anderson et al. (2018) found little evidence that setting a bacteriological standard for milk reduced infant mortality. Our results are consistent with theirs. Specifically, the estimated coefficient of the bacteriological standard indicator is actually positive and statistically significant at the .10 level. By contrast, the estimated coefficient of the interaction between *Bacteriological Standard* and the summer indicator is negative and larger in absolute magnitude, but it is not sufficiently precise to reject the null.[28]

4.1. Robustness Checks

Rapid industrialization during the period under study led to substantial increases in purchasing power (Bry 1960; Rees and Jacobs 1961). In the first column of Table 3, we explore whether the filtration estimates described above are robust to controlling for the real manufacturing wage, which can be thought of as measuring the purchasing power of urban workers.[29] The estimated coefficient of the filtration indicator retains its magnitude and significance (specifically, water filtration is associated with a 14 percent reduction in diarrheal mortality during the non-summer months), suggesting that the negative relationship between filtration and diarrheal mortality in the non-summer months cannot be explained by changes in the purchasing power of urban workers.

In addition to including the manufacturing wage on the right-hand side of equation (1), we experiment with controlling for region-by-year fixed effects, not weighting by population,

[28] In Appendix Table 5, we replace the *Summer* indicator with a variable equal to 1 if the average temperature in city *c* during month *t* was equal to or great than 70° F. The results from this exercise are qualitatively similar to those reported in Table 2.

[29] Data on the manufacturing wage come from the *Biennial Census of Manufactures*. The manufacturing wage is linearly imputed for missing years and deflated using price indices in Rees and Jacobs (1961) and the Bureau of Labor Statistics (1973).

dropping the most populous city (i.e., New York City) from the sample, dropping the years 1917-1920 to avoid potential confounding from the effects of the 1918 Spanish flu pandemic, and specifying the dependent variable in levels. The results of these robustness checks, which are shown in the remaining columns of Table 3, suggest that the negative relationship between water filtration and diarrheal mortality in the non-summer months is not an artifact of specification or sample choice.

Next, we estimate a modified version of equation (1) in which the filtration indicator is decomposed into a series of mutually exclusive lags. The results are reported in the first two columns of Table 4. They suggest that the effect of water filtration on diarrheal deaths occurring during non-summer months was immediate. Specifically, filtration is associated with a 15 percent decrease in diarrheal mortality in the year of implementation (*Year 0*); after 5 or more years, it is associated with a 19 percent decrease. Consistent with the results discussed above, there is little evidence that filtration affected diarrheal deaths in the months of June-September.

In the last two columns of Table 4, we replace the filtration indicator with a series of its leads and lags. The lagged effects are similar to those described above. In *Year 0*, filtration is associated with a 15 percent decrease in non-summer diarrheal mortality; after 5 or more years, filtration is associated with a 20 percent decrease in non-summer diarrheal mortality. Again, there is no evidence that filtration had an impact on diarrheal deaths in the months of June-September. Consistent with the parallel-trends assumption, the coefficient estimates on the leads of the filtration indicator are not statistically distinguishable from zero. Figures 7 and 8 reproduce the results reported in columns (3) and (4) of Table 4, respectively.[30]

[30] There is reason to believe that the effect of opening a water filtration plant might, at least initially, be muted. For instance, the Cleveland filtration plant mixed its output with "raw" (i.e., unfiltered) water before delivery during its first 6 months of operation (Unknown Author 1918). The effort to provide filtered water to every neighborhood in Philadelphia took more than seven years (Cutler and Miller 2018). Cutler and Miller (2018) argued that the

5. RACE AND SUMMER DIARRHEA

Public health experts at the turn of the 20th century recognized that black infants were more likely to die from diarrheal diseases, including "cholera infantum," than their white counterparts (Billings 1883; Du Bois 1899; Miller 1906). The reasons for this discrepancy, however, were fervently debated. For instance, in an infamous treatise published by the American Economic Association, Hoffman (1896) argued that "excessive infant mortality among the colored population is largely the result of individual neglect, as well as in part due to inherited organic weakness…" (p. 69). Hoffman (1896) went on to recommend that philanthropic efforts not be directed toward reducing the black infant mortality rate for fear that such efforts would make blacks "even more dependent on the white race at the present time than…previous to emancipation" (p. 329). Other observers argued that the discrepancy was due to "matters of condition" as opposed to "racial traits and tendencies" (Miller 1906, p. 90). Citing Du Bois (1899), Miller went on to list the conditions that explained why black children in Philadelphia were not as healthy as white children. Among them were a lack of education, the fact that "66 per cent of Philadelphia Negro woman work", and bad water (Miller 1906, p. 90).

With only a few exceptions, historical studies on the provision of clean water and mortality have not provided estimates by race. Among these exceptions, Troesken (2001) found that switching from privately to publicly owned water companies narrowed the black-white waterborne-disease mortality gap in 14 North Carolina towns during the period 1889-1908.[31]

Philadelphia water filtration indicator should "turn on" in 1909, the year in which the largest filtration facility (Torresdale) began providing the majority of Philadelphia residents with clean drinking water. The pre-treatment trends in Figures 7 and 8 looked similar when we experimented with turning on the Philadelphia filtration indicator in 1909 as opposed to 1906.

[31] Troesken's (2001) outcome of interest was the sum of mortality rates for the following waterborne diseases: cholera, diarrhea, dysentery, and typhoid.

Analyzing a sample of 33 U.S. cities at the turn of the 20th century, Troesken (2002) found that municipal water filtration was associated with a more than 50 percent reduction in typhoid mortality among blacks. However, it is worth noting that typhoid deaths represented only a small proportion of total mortality and never amounted to more than half of mortality from diarrhea/enteritis. In 1914, among the black population in the United States, there were 35.9 typhoid deaths per 100,000 population and 109 diarrhea/enteritis deaths per 100,000 population; in 1920, the black typhoid and diarrheal mortality rates were 18.8 and 68.1, respectively; in 1930, the black typhoid and diarrheal mortality rates were 13.7 and 43.7, respectively.[32]

Figure 9 shows annual diarrheal mortality rates among children under the age of two by race for the years 1910-1930.[33] During this period, diarrheal mortality data were available by race for 19 of the 26 cities under study.[34] The black diarrheal mortality rate in these cities was clearly on a downward trend, but it was always considerably higher than the corresponding white rate. For instance, 131.9 black children under the age of two died of diarrhea per 100,000 population in 1910, while 88.0 white children died of diarrhea that same year. By 1930, the last year for which we have mortality counts at the monthly level, 30.4 black children under the age of two died of diarrhea per 100,000 population as compared to 10.2 white children.

[32] These rates are based on the overall "registration area" in the United States, come from *Mortality Statistics*, and were first published in 1914. The black diarrheal mortality rate among children under the age of two in 1914, 1920, and 1930 was 87.8, 54.2, and 33.7, respectively.

[33] Municipal-level mortality counts by race (white versus nonwhite) are available from *Mortality Statistics*. Although not strictly correct, we refer to "nonwhites" as "blacks." During this period, over 95 percent of the minority population in the United States was black (Gibson and Jung 2002). Population estimates by race for the cities in our sample and the years 1910, 1920, and 1930 are also available from *Mortality Statistics*. Population was linearly interpolated to produce diarrheal mortality rates by race at the city-month-year level.

[34] Diarrheal mortality data by race are unavailable for Buffalo, Jersey City, Milwaukee, Minneapolis, Providence, Rochester, and St. Paul for the entire period under study. Diarrheal mortality data by race are unavailable for 1911 regardless of the city under study. Appendix Table 6 lists the years of data available for each of the cities used in the analysis.

Figure 10 shows black versus white diarrheal deaths per 100,000 population by month for the period 1910-1930. During the non-summer months of the first decade under study (1910-1920), black children were more likely to die of diarrhea than their white counterparts, but the difference in rates was not substantial.[35] In the summer months (June-September), diarrheal deaths among black children were much more prevalent than among white children. For instance, the black diarrheal mortality rate peaked at 12.3 per 100,000 population in 1919, while the white diarrheal mortality rate peaked at 6.9 that same year.

During the second decade under study (1921-1930), there was marked decline in diarrheal mortality among white children, which took place throughout the year regardless of the season. There was also a decline in black diarrheal mortality, but it was not nearly as dramatic. Moreover, even towards the end of the period under study, black diarrheal mortality clearly exhibited seasonality.

In Table 5, we explore the relationship between public health interventions and summer diarrhea by race. Specifically, we estimate equation (1) for white and black children separately. Given the results reported in Tables 2 and 3, our focus will be on the parameters β_1 and β_2, where β_1 represents the effect of water filtration on diarrheal mortality in the non-summer months and $\beta_1 + \beta_2$ represents its effect in the months of June-September.

Water filtration is negatively related to non-summer diarrheal mortality among white children. Specifically, filtration led to a 9.4 percent reduction in the white diarrheal mortality rate during the non-summer months ($e^{-.099} - 1 = -.094$), although the estimate of β_2 more than offsets the estimate of β_1. Among black children, neither the estimate of β_1 nor the estimate of β_2

[35] Appendix Figure 3 shows that the black-white diarrheal mortality gap clearly spiked during the summer months, sometimes exceeding 5 deaths per 100,000 population. In the non-summer months, however, the annual mean difference between black and white diarrheal mortality was usually 1 to 2 deaths per 100,000 population (Appendix Figure 4).

is statistically distinguishable from zero. Moreover, both of these estimates are actually positive. Consistent with the results first reported in Table 2, we find little evidence that the other public health interventions under study reduced diarrheal mortality among children, black or white.

6. CONCLUSION

Although progress has been made over the last few decades, diarrheal disease is still the second-leading cause of death among children under the age of 5 (Liu et al. 2015), and it continues to exhibit pronounced seasonality in many parts of the developing world (Zhang et al. 2010; Phung et al. 2015; Xu et al. 2015; Kulinkina et al. 2016; Muluken et al. 2017). Because this seasonality is expected to intensify with climate change (Christensen et al. 2007; Asian Development Bank 2009; Lyon and Camargo 2009), understanding its causes is taking on a new urgency.

In the United States at the turn of the 20th century, tens of thousands of American children would die from diarrhea-related disease every summer. One of the principal contributions of this study is to simply document the scale of this phenomenon. Using newly transcribed diarrheal mortality data at the monthly level for the 26 most populous American cities as of 1910, we find that summer diarrhea was a major contributor to child mortality. For instance, in 1910 there were over 21,000 diarrheal deaths among children under the age of two in these cities, accounting for 30 percent of total mortality in this age group; two-thirds of diarrheal deaths among these children occurred in the months of June-September.

The phenomenon of summer diarrhea had largely dissipated by 1930. In that year, only 3,513 children under the age of two died from diarrhea in the 26 cities under study, and only

1,482 of these deaths occurred in the summer months. The precise cause of summer diarrhea was never isolated and the memory of its toll eventually receded.

Economists and historians generally believe that the dissipation of summer diarrhea was due to public health efforts undertaken at the municipal level (Cheney 1984; Condran 1987; Meckel 1990; Fishback et al. 2011). Evidence for this belief, however, is anecdotal or based on a handful of case studies (Cheney 1984; Condran 1987; Condran and Lentzner. 2004). In addition to documenting the phenomenon of summer diarrhea, we explore whether its waning over the period 1910-1930 was, in fact, related to public health interventions undertaken at the municipal level. We find that the building of a water filtration plant is associated with a 15-17 percent reduction in diarrheal mortality during non-summer months. By contrast, there is no evidence that water filtration led to a reduction in diarrheal mortality during the months of June-September, nor is there evidence that other municipal-level public health efforts (including sewage treatment plants and setting strict bacteriological standards for milk) resulted in the dissipation of summer diarrhea. This pattern of results is consistent with those of Anderson et al. (forthcoming) and Anderson et al. (2018), who concluded that public health efforts at the municipal level were not important drivers of the urban mortality transition.

Finally, because the U.S. Bureau of the Census published diarrheal mortality counts by race, we are able to document that the decline in diarrheal mortality among black children was much less dramatic than that experienced by their white counterparts. Even at the end of the period under study, black diarrheal mortality still exhibited strong seasonality and generally peaked at more than double the white rate. While we show that the adoption of water filtration technology reduced non-summer diarrheal mortality among white children, it seems to have had no effect on diarrheal mortality among black children, regardless of the season.

Our results suggest that public health interventions at the municipal level did not contribute to the dissipation of summer diarrhea in the United States, nor did they contribute to the pronounced decline in diarrheal mortality among black children. Perhaps other, more difficult-to-measure factors, such as nutrition, improvements in medical care, the adoption of more hygienic practices, or better living conditions were responsible for the waning of summer diarrhea.

REFERENCES

Ahmed, Sharia M., Benjamin A. Lopman, and Karen Levy. 2013. "A Systematic Review and Meta-Analysis of the Global Seasonality of Norovirus." *PLoS ONE*, 8(10): e75922. https://doi.org/10.1371/journal.pone.0075922

Alsan, Marcella and Claudia Goldin. Forthcoming. "Watersheds in Child Mortality: The Role of Effective Water and Sewerage Infrastructure, 1880 to 1920." *Journal of Political Economy*.

Amin, Omar M. 2002. "Seasonal Prevalence of Intestinal Parasites in the United States during 2000." *The American Journal of Tropical Medicine and Hygiene*, 66(6): 799 – 803.

Anderson, D. Mark, Kerwin Kofi Charles, Claudio Las Heras Olivares, and Daniel I. Rees. Forthcoming. "Was the First Public Health Campaign Successful? The Tuberculosis Movement and its Effect on Mortality." *American Economic Journal: Applied Economics*.

Anderson, D. Mark, Kerwin Kofi Charles, and Daniel I. Rees. 2018. "Public Health Efforts and the Decline in Urban Mortality." NBER WP No. 25027.

Anderson, D. Mark, Kerwin Kofi Charles, and Daniel I. Rees. 2019. "Public Health Efforts and the Decline in Urban Mortality: Reply to Cutler and Miller." Available at: https://www.nber.org/data-appendix/w25027rejoinder/ACR_Rejoinder_01_04_19.pdf.

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

Asian Development Bank. 2009. "Building Climate Resilience in the Agricultural Sector of Asia and the Pacific." Asian Development Bank.

Auffhammer, Maximilian and Wolfram Schlenker. 2014. "Empirical Studies on Agricultural Impacts and Adaptation." *Energy Economics*, 46(C): 555-561.

Baker, Tess. 2016. "Burden of Community Diarrhoea in Developing Countries." *Lancet Global Health*, 4(1): e25.

Banerjee, Rakesh and Riddhi Bhowmick. 2016. "Heat, Infant Mortality and Adaptation: Evidence from India." Working paper, Rice University. Available at: https://dornsife.usc.edu/assets/sites/524/docs/Seminars_Fall_2016/Rakesh_Temperature_Draft_1.pdf

Baqui, Abdullah H and Tahmeed Ahmed. 2006. "Diarrhoea and Malnutrition in Children." *British Medical Journal*, 332(7538): 378.

Barreca, Alan, Karen Clay, Olivier Deschenes, Michael Greenstone, Joseph S Shapiro. 2016. "Adapting to Climate Change: The Remarkable Decline in the US Temperature-Mortality Relationship over the Twentieth Century." *Journal of Political Economy*, 124(1): 105-159.

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

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. 2004. "How Much Should We Trust Difference-In-Difference Estimates?" *Quarterly Journal of Economics*, 119(1): 249-275.

Billings, John S. 1883. "Papers on Vital Statistics." 1883. *The Sanitary Engineer*, 9(1): 15-16.

Brennemann, Joseph. 1908. "Remarks on the Feeding of the Healthy Infant." *Journal of the American Medical Association*, 51(2): 101-105.

Bry, Gerhard. 1960. *Wages in Germany, 1871-1945*. Princeton, NJ: Princeton University Press.

Bureau of Labor Statistics. 1873. *Handbook of Labor Statistics, 1973*. U.S. Department of Labor, Washington, D.C.: U.S. Government Printing Office.

Burg, S. 1902. "Cholera Infantum." *Texas Medical Journal*, 18(3): 98-105.

Cheney, Rose A. 1984. "Seasonal Aspects of Infant and Childhood Mortality: Philadelphia, 1865-1920." *Journal of Interdisciplinary History*, 14(3): 561-585.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W. Kwon, R. Laprise, V. Magaa Rueda, C. G. Menndez, J. Risnen, A. Rinke, A. Sarr, and P. Whetton. 2007. "Regional Climate Projections." In Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (editors). *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY: Cambridge University Press.

Clement, Clarence Elbert and Gustav Paul Warber. 1918. "The Market Milk Business of Detroit, Mich., in 1915." *United States Department of Agriculture Bulletin No. 639* (February 15).

Condie, David Francis. 1858. *A Practical Treatise on the Diseases of Children.* Philadelphia: Blanchard and Lea.

Condran, Gretchen A. 1988. "Declining Mortality in the United States in the late Nineteenth and Early Twentieth Centuries." *Annales de Démographie Historique*, 1: 119-141.

Condran, Gretchen A. and Harold R. Lentzner. 2004. "Early Death: Mortality among Young Children in New York, Chicago, and New Orleans." *Journal of Interdisciplinary History*, 34(3): 315-354.

Copeland, James. 1855. *A Dictionary of Practical Medicine.* New York: Harper and Brothers.

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

Cutler, David M. and Grant Miller. 2018. "Comment on 'Public Health Efforts and the Decline in Urban Mortality'." Available at: http://ngmiller.people.stanford.edu/sites/g/files/sbiybj4811/f/comment_1.pdf.

Czaplicki, Alan. 2007. "Pure Milk Is Better Than Purified Milk": Pasteurization and Milk Purity in Chicago, 1908-1916." *Social Science History*, 31(3): 411-433

Dhimal, Meghnath, Khem Karki, Krishna Kumar Aryal et al. 2016. "Assessment of Effects of Climate Factors on Diarrheal Diseases at National and Sub-national Levels in Nepal." Nepal Health Research Council (NHRC) and WHO Country Office, Nepal.

D'Souza R.M., G. Hall, and N.G. Becker. 2008. "Climatic Factors Associated with Hospitalizations for Rotavirus Diarrhoea in Children under 5 Years of Age." *Epidemiol Infection*, 136(1): 56–64.

Du Bois, William Edward Burghardt 1899. *The Philadelphia Negro: A Social Study*. Philadelphia: University of Pennsylvania.

Fishback, Price, Werner Troesken, Trevor Kollmann, Michael Haines, Paul Rhode, and Melissa Thomasson. 2011. "Information and the Impact of Climate and Weather on Mortality Rates During the Great Depression." In Libecap, Gary and Richard H. Steckel (editors). *The Economics of Climate Change: Adaptations Past and Present*. Chicago, IL: University of Chicago Press.

Fletcher, Stephanie M., Mary-Louise McLaws, and John T. Ellis. 2013 "Prevalence of Gastrointestinal Pathogens in Developed and Developing Countries: Systematic Review and Meta-Analysis." *Journal of Public Health Research*, 2(1): 42–53.

Förster, Maike, Sven Klimpel, Heinz Mehlhorn, Kai Sievert, Sabine Messler, and Klaus Pfeffer. 2007. "Pilot Study on Synanthropic Flies (e.g. *Musca*, *Sarcophaga*, *Calliphora*, *Fannia*, *Lucilia*, *Stomoxys*) as Vectors of Pathogenic Microorganisms." *Parasitology Research*, 101(1): 243–246.

Friedrich, M.J. 2013. "Climate Change Linked with Increase in Diarrheal Disease." *JAMA*, 309(19): 1985.

Gastañaduy, Paul A., Aron J. Hall, Aaron T. Curns, Umesh D. Parashar, and Benjamin A. Lopman. 2013. "Burden of Norovirus Gastroenteritis in the Ambulatory Setting—United States, 2001–2009." *The Journal of Infectious Diseases*, 207(7): 1058–1065.

Geruso, Michael and Dean Spears. 2018. "Heat, Humidity, and Infant Mortality in the Developing World." NBER Working Paper No. 24870.

Girma, Gosa. 2015. “Prevalence, Antibiogram and Growth Potential of Salmonella and Shigella in Ethiopia: Implications for Public Health: A Review.” *Research Journal of Microbiology*, 10: 288-307.

Gibson, Campbell and Kay Jung. 2002. “Historical Census Statistics on Population Totals by Race, 1790 to 1990, and by Hispanic Origin, 1970 to 1990, for the United States, Regions, Divisions, and States.” Population Division Working Paper No. 56, U.S. Census Bureau, Washington, D.C.

Graham-Smith, G.S. 1929. “The Relation of the Decline in the Number of Horse-drawn Vehicles, and Consequently of the Urban Breeding Grounds of Flies, to the Fall in Summer Diarrhoea Death-rate.” *Journal of Hygiene*, 29(2): 132-138.

Gray, Jeff. 2011. “Examining the Connections between Climate Change and Diarrheal Disease.” *Global Health Matters*, 10(6): 3.

Harding, H.A. 1917. “City Milk and the Public Health.” *Annual Report of the Illinois Farmers’ Institute*, 22: 52-58.

Hewitt, Gordon. 1910. “House-Flies and Disease.” *Nature*, 84(2123) 73-75.

Hodges, Kim and Ravinder Gill. 2010. “Infectious Diarrhea: Cellular and Molecular Mechanisms.” *Gut Microbes*, 1(1): 4–21.

Hoffman, Frederick Ludwig. 1896. *Race Traits and Tendencies of the American Negro*. New York: American Economic Association.

Hooker, Albert H. 1913. *Chloride of Lime in Sanitation*. New York, NY: John Wiley and Sons.

Hsiang, Solomon and Daiju Narita. 2012. “Adaptation to Cyclone Risk: Evidence from the Global Cross-Section.” *Climate Change Economics*, 3(2): 1250011.

Kesztenbaum, Lionel and Jean-Laurent Rosenthal. 2017. “Sewers’ Diffusion and the Decline of Mortality: The Case of Paris, 1880–1914.” *Journal of Urban Economics*, 98(March): 174-186.

Kiefer, Guy L. 1902. “Milk as a Conveyer of Disease.” *Teacher's Sanitary Bulletin*, 5(8): 55-60.

Kiefer, Guy L. 1911. “Report of the Milk Inspector.” *Thirtieth Annual Report of the Board of Health of the City of Detroit for the Fiscal Year Ending June 30, 1911*. Detroit, MI: Board of Health, pp. 94-106.

Kiger, Patrick. 2017. “As Earth’s Climate Changes, Is It Time to Redefine the Four Seasons?” *HowStuffWorks*, August 28. Available at: https://science.howstuffworks.com/nature/climate-weather/atmospheric/climate-change-four-seasons-redefine.htm.

King, David. 1837. “Cholera Infantum, Causes and Treatment.” *Boston Medical and Surgical Journal*, 17(8): 117-123.

King, Caleb K., Roger Glass, Joseph S. Bresee, Christopher Duggan. 2003. “Managing Acute Gastroenteritis Among Children.” *MMWR*, 52(RR16): 1-16.

Klein, Richard J.T., Guy F. Midgley, Benjamin L. Preston, Mozaharul Alam, Frans G.H. Berkhout, Kirstin Dow, and M. Rebecca Shaw. 2014. In Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (editors). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, U.K. and New York, NY: Cambridge University Press.

Komisarow, Sarah. 2017. “Public Health Regulation and Mortality: Evidence from Early 20th Century Milk Laws.” *Journal of Health Economics*, 56(December): 126-144.

Kovacs, Stefanie D., Kim Mullholland, Julia Bosch, Harry Campbell, Mohammad H. Forouzanfar, Ibrahim Khalil, Stephen Lim, Li Liu, Stephen N. Maley, Colin D. Mathers, Alastair Matheson, Ali H. Mokdad, Kate O’Brien, Umesh Parashar, Torin T. Schaafsma, Duncan Steele, Stephen E. Hawes, and John T. Grove. 2015. “Deconstructing the Differences: A Comparison of GBD 2010 and CHERG’s Approach to Estimating the Mortality Burden of Diarrhea, Pneumonia, and their Etiologies.” *BMC Infect Disease*, 15:16

Kulinkina, Alexandra V., Venkat R. Mohan, Mark R. Francis, Deepthi Kattula, Rajiv Sarkar, Jeanine D. Plummer, Honorine Ward, Gagandeep Kang, Vinohar Balraj, and Elena N. Naumova. 2016. “Seasonality of Water Quality and Diarrheal Disease Counts in Urban and Rural Settings in South India.” *Scientific Reports*, 6, Article Number 20521.

Levine, Orin S. and Myron M. Levine. 1991. “Houseflies (*Musca domestica*) as Mechanical Vectors of Shigellosis. *Reviews of Infectious Diseases*, 13(4): 688–696.

Liu, Li, Shefali Oza, Daniel Hogan, Jamie Perin, Igor Rudan, Joy E Lawn, Simon Cousens, Colin Mathers, and Robert E Black. 2015. “Global, Regional, and National Causes of Child Mortality in 2000–13, with Projections to Inform Post-2015 Priorities: An Updated Systematic Analysis.” *Lancet*, 385(9966): 430–440.

Lyon, Bradfield and Suzana Camargo. 2009. “The Seasonally-varying Influence of ENSO on Rainfall and Tropical Cyclone Activity in the Philippines.” *Climate Dynamics*, 32(1): 125-141.

Maxwell, George Troupe. 1887. “The Influence of Climate on the Production of Cholera Infantum.” *Transactions of the International Medical Congress*, 4: 534-539.

McCarthy, Michael P. 1987. *Typhoid and the Politics of Public Health in Nineteenth-century Philadelphia*. Philadelphia, PA: American Philosophical Society.

McKee, James H. 1902. “The Treatment of Infantile Diarrheas of the Summer Season.” *The Philadelphia Medical Journal*, 10(4): 118-123.

Mduduzi N. N. Mbuya Naume V. Tavengwa Rebecca J. Stoltzfus Valerie Curtis Gretel H. Pelto Robert Ntozini Rukundo A. Kambarami Dadirai Fundira Thokozile R. Malaba Diana Maunze Peter Morgan Goldberg Mangwadu Jean H. Humphrey. 2015. “Design of an Intervention to Minimize Ingestion of Fecal Microbes by Young Children in Rural Zimbabwe.” *Clinical Infectious Diseases*, 61(7): S703–S709.

Meckel, Richard A. 1990. *Save the Babies: American Public Health Reform and the Prevention of Infant Mortality, 1850-1929.* Baltimore, MD: Johns Hopkins University Press.

Melosi, Martin V. 2008. *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present*. Pittsburgh, PA: The University of Pittsburgh Press.

Miller, Herbert A. 1906. “Some Psychological Considerations on the Race Problem.” In Du Bois, William Edward Burghardt (editor). *The Health and Physique of the Negro American: Report of a Social Study Made Under the Direction of Atlanta University*. Atlanta, GA: Atlanta University Press, pp. 53-111.

Miller, T. Clark. 1879. “A Contribution to the Etiology, Pathology and Therapeutics of Cholera Infantum.” *American Journal of Obstetrics and Diseases of Women and Children*, 12(2): 236-251.

M’Mechan, Hoeffer F. 1907. “Summer Complaint: Its Differential Diagnosis and Selective Therapy.” *The Cincinnati Lancet-Clinic*, 97: 697-702.

Mohlman, F. W. 1940. “Sewage Treatment in Large American Cities.” *Sewage Works Journal*, 12(1): 168-171.

Moss, Willis R. 1903. “Second Summer Complaint of Infants.” *The Medical Age*, 21(19): 725-730.

Muluken, Azage, Abera Kumie, Alemayehu Worku, and Amvrossios C. Bagtzoglou. 2017. “Effect of Climatic Variability on Childhood Diarrhea and its High Risk Periods in Northwestern parts of Ethiopia.” *PLoS ONE*, 12(10): e0186933. https://doi.org/10.1371/journal.pone.0186933

Murphy, Walter Graham. 1908. “A Summer Camp for the Treatment of Sick Babies.” *Journal of the American Medical Association*, 51(9): 745-746.

National Oceanic and Atmospheric Administration. 2019. “Changing Seasons.” National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Available at: https://www.noaa.gov/education/resource-collections/climate-education-resources/changing-seasons.

New York (NY). 1912. “Milk. Production, Care, and Sale. With Special Reference to Pasteurization.” *Public Health Reports* (1896-1970), 27(12): 434-438.

New York (NY), Department of Health. 1913. *Weekly Bulletin of the Department of Health of the City of New York*, 2(44): 1-3.

Noor, Rashed, Zahidul Islam, Saurab Kishore Munshi and Farjana Rahman. 2013. “Influence of Temperature on Escherichia coli Growth in Different Culture Media.” *Journal of Pure and Applied Microbiology*, 7(2): 899-904.

Ostheimer, Maurice. 1905. “The Prevention of Summer Diarrhea.*” Journal of the American Medical Association*, 45(9): 594-597.

Park, WM. H. and L. Emmett Holt. 1904. “Report Upon the Results in Infant Feeding with Different Kinds of Pure an Impure Milk in Tenement Houses of New York City.” *New York State Journal of Medicine*, 4(8): 279-288.

Patel, Manish M., Virginia Pitzer, Wladimir J. Alonso, David Vera, Ben Lopman, Jacqueline Tate, Cecile Viboud, and Umesh D. Parashar. 2013. “Global Seasonality of Rotavirus Disease.” *Pediatric Infectious Disease Journal*, 32(4): e134-47.

Pawlowski, Sean W., Cirle Alcantara Warren, and Richard Guerrant. 2009. “Diagnosis and Treatment of Acute or Persistent Diarrhea.” *Gastroenterology*, 136(6): 1874–1886.

Phung Dung, Cunrui Huang, Shannon Rutherford, Cordia Chu, Xiaoming Wang, Minh Nguyen, Nga Huy Nguyen, Cuong Do Manh, and Trung Hieu Nguyen. 2015. “Association between Climate Factors and Diarrhoea in a Mekong Delta Area.” *International Journal of Biometeorology*, 59(9): 1321–1331.

Platts-Mills, James, Sudhir Babji, Ladaporn Bodhidatta et al. 2015. “Pathogen-Specific Burdens of Community Diarrhoea in Developing Countries: A Multisite Birth Cohort Study (MAL-ED).” *Lancet Global Health*, 3: e564-e575.

Ramos-Alvarez, M., and Albert B. Sabin. 1958. “Enteropathogenic Viruses and Bacteria: Role in Summer Diarrheal Diseases of Infancy and Early Childhood.” *Journal of the American Medical Association*, 167(2): 147–156.

Reedy, Elizabeth A. 2007. *American Babies: Their Life and Times in the 20th Century*. Westport, CT: Praeger Publishers.

Rees, Jonathan. 2013. *Refrigeration Nation*. Baltimore, M.D.: Johns Hopkins Press.

Rees, Albert and Donald P. Jacobs. 1961. *Real Wages in Manufacturing, 1890-1914.* Princeton, NJ: Princeton University Press.

Rogers, Steven. 1869. “Summer Mortality in the Cities of the United States.” *Bulletin of the New York Academy of Medicine*, 3(June): 424-441.

Rush, Benjamin. 1794. “An Inquiry into the Cause and Cure of the *Cholera Infantum*.” *Medical Inquiries and Observations*, 1: 159-169.

Santer, Benjamin D., Stephen Po-Chedley, Mark D. Zelinka, Ivana Cvijanovic, Celine Bonfils, Paul J. Durack, Qiang Fu, Jeffrey Kiehl, Carl Mears, Jeffrey Painter, Giuliana Pallotta, Susan Solomon, Frank J. Wentz, and Cheng-Zhi Zou. 2018. “Human Influence on the Seasonal Cycle of Tropospheric Temperature.” *Science*, 361(6399): eaas8806.

Schereschewsky, J.W. 1913. “Heat and Infant Mortality.” *Transactions of the Fourth Annual Meeting of the American Association for the Study and Prevention of Infant Mortality*, 4: 99-128.

Smith, William A. 1905. “Gangrenous Stomatitis.” *Journal of the South Carolina Medical Association*, 1(4): 113-114.

Southworth, Thomas S. 1904. “The Management of Summer Diarrhea.” *Journal of the American Medical Association*, 43: 1936-1939.

Snyder, Ross J. 1906. “Suggestions for Reducing the Prevalence of Summer Diarrhea in Children.” *Clinical Excerpts*, 12(4-5): 97-102.

Stoner, H.W. 1912. “The Milk Problem.” *Maryland Medical Journal*, 55(10): 240-247.

Swinford, Michael. 2016. “Urban-Rural Tensions, 1880-1930.” In: Riney-Kehrberg, Pamela (editor), *The Routledge History of Rural America*. New York, NY: Routledge.

Thompson, Mary E. and Arlene A. Keeling. 2012. “Nurses’ Role in the Prevention of Infant Mortality in 1884-1925: Health Disparities Then and Now.” *Journal of Pediatric Nursing*, 27(5): 471-478.

Tilden, John Henry. 1909. *The Etiology of Cholera Infantum with the Hygienic and Dietetic Treatment as Applied by John H. Tilden, M.D.* Denver, C.O.: The Merchants Publishing Company.

Troesken, Werner. 2001. “Race, Disease, and the Provision of Water in American Cities, 1889-1921.” *Journal of Economic History*, 61(3): 750-776.

Troesken, Werner. 2002. “The Limits of Jim Crow: Race and the Provision of Water and Sewerage Services in American Cities, 1880-1925.” *Journal of Economic History*, 62(3): 734-772.

Unknown Author. 1918. “Cleveland’s New Filtration Plant in Operation.” *Municipal Journal*, 44(13): 266-267.

United States Bureau of the Census. 1910. *Mortality Statistics*. Washington, D.C.: United States Government Printing Office.

United States Children's Bureau. 1914. *Baby-Sitting Campaigns: A Preliminary Report on what American Cities are Doing to Prevent Infant Mortality*. Washington D.C.: U.S. Government Printing Office.

Walker, Christa L. Fischer, Igor Rudan, Li Liu, Harish Nair,Evropi Theodoratou, Zulfiqar A Bhutta, Katherine L O'Brien,Harry Campbell, and Robert E Black. 2013. "Global Burden of Childhood Pneumonia and Diarrhoea." *Lancet*, 381(9875): 1405-1416.

Winfield, Mollie D. and Eduardo A. Groisman. 2003. "Role of Nonhost Environments in the Lifestyles of Salmonella and Escherichia coli." *Applied and Environmental Microbiology*, 69(7): 3687-3694.

Wolf, Jacqueline H. 2003. "Low Breastfeeding Rates and Public Health in the United States." *American Journal of Public Health*, 93(12): 2000-2010.

Xu Zhiwei, Wenbiao Hu, Yewu Zhang, Xiaofeng Wang, Maigeng Zhou, Hong Su, Cunrui Huang, Shilu Tong, and Qing Guo. 2015. "Exploration of Diarrhoea Seasonality and its Drivers in China." *Scientific Reports*, 5, Article Number 8241.

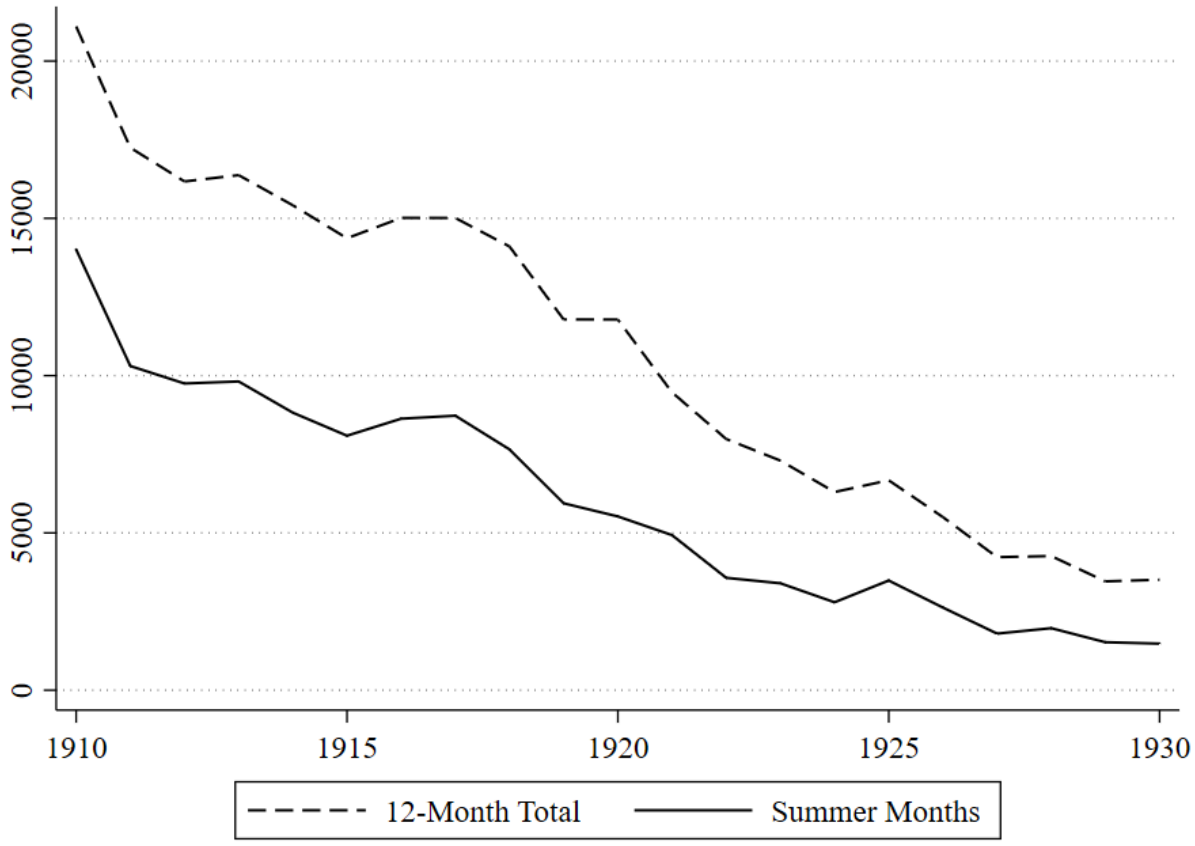
Youmans, L.E. and John B. Youmans. 1922. "A Disease Clinically Representing Epidemic Dysentery." *Journal of the American Medical Association*, 78(23): 1798-1801.

Zahorsky, John. 1913. "Heat and Summer Diarrhea." *American Journal of Diseases of Children*, 6(5): 289-318.

Zahorsky, John. 1918. "Evidence that Summer Diarrhea is an Infectious Enteritis." *American Journal of Diseases of Children*, 15(6):413-420.

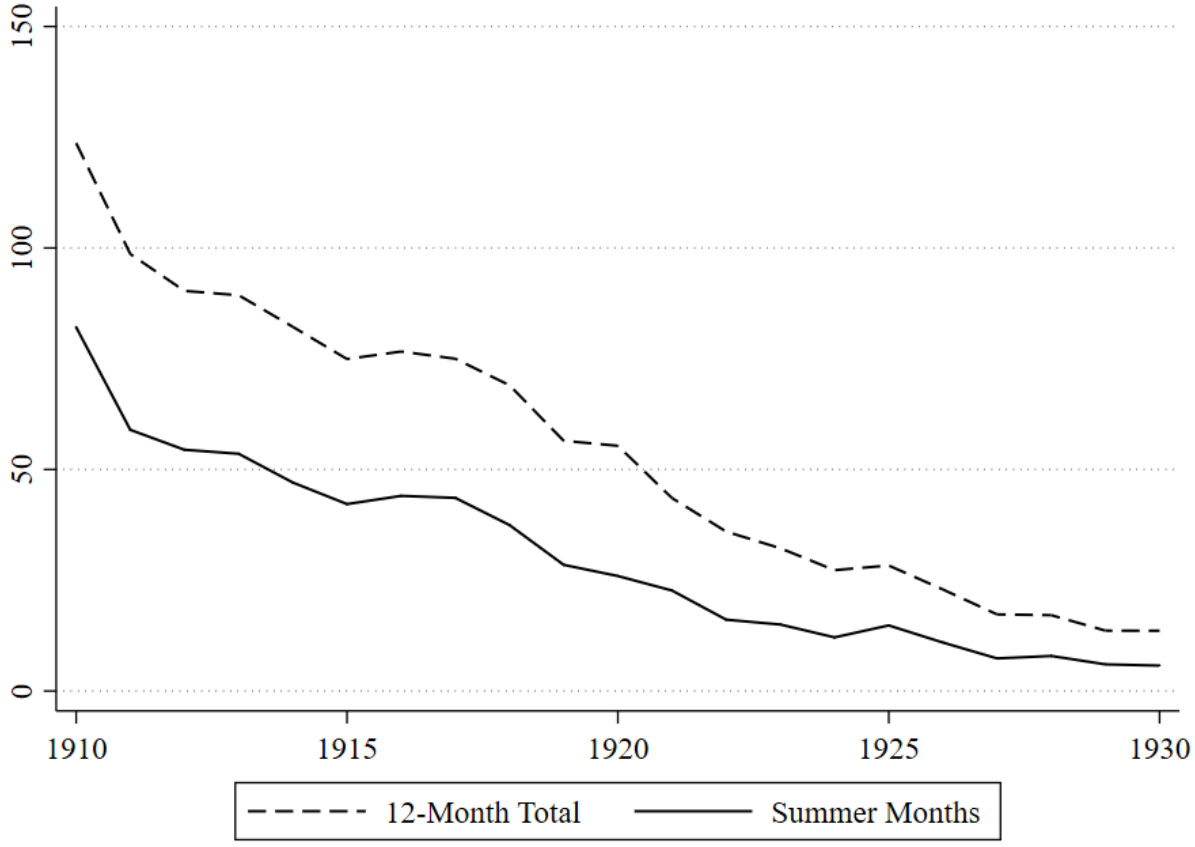
Zhang Ying, Peng Bi, and Janet E. Hiller. 2010. "Climate Variations and *Salmonella* Infection in Australian Subtropical and Tropical Regions." *Science of the Total Environment*, 408(3): 524–530.

Figure 1. Diarrheal Mortality Among Children Under the Age of Two



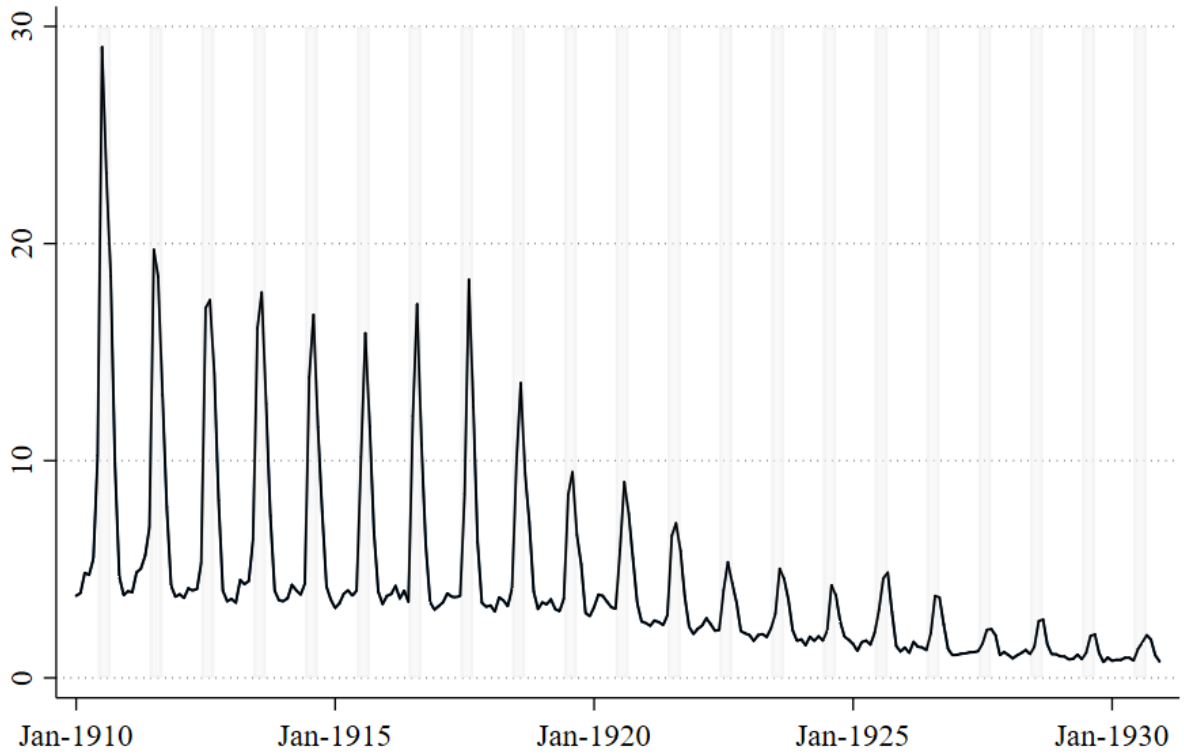
Notes: Based on data from *Mortality Statistics* for the 26 cities under study, published by the U.S. Census Bureau. The summer months are defined as June through September.

Figure 2. Diarrheal Mortality Among Children Under the Age of Two per 100,000 Population



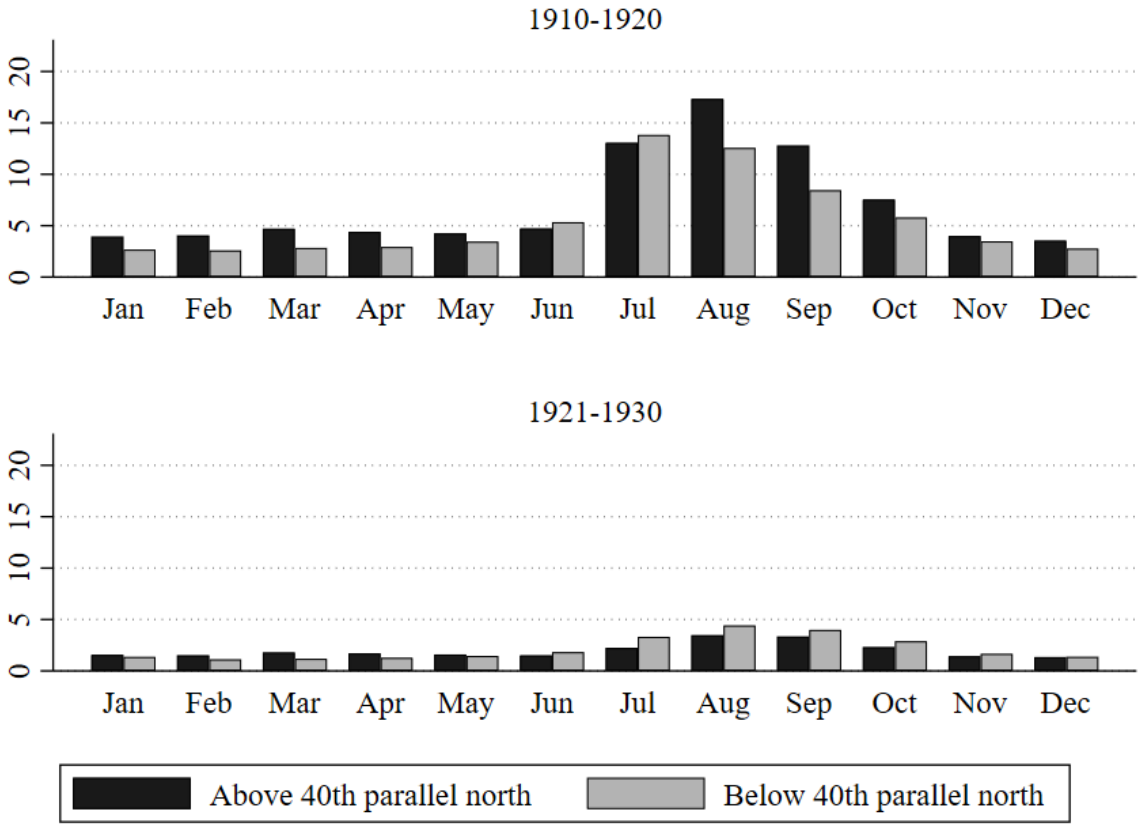
Notes: Based on data from *Mortality Statistics* for the 26 cities under study, published by the U.S. Census Bureau. The summer months are defined as June through September.

Figure 3. Monthly Diarrheal Mortality Among Children Under the Age of Two per 100,000 Population



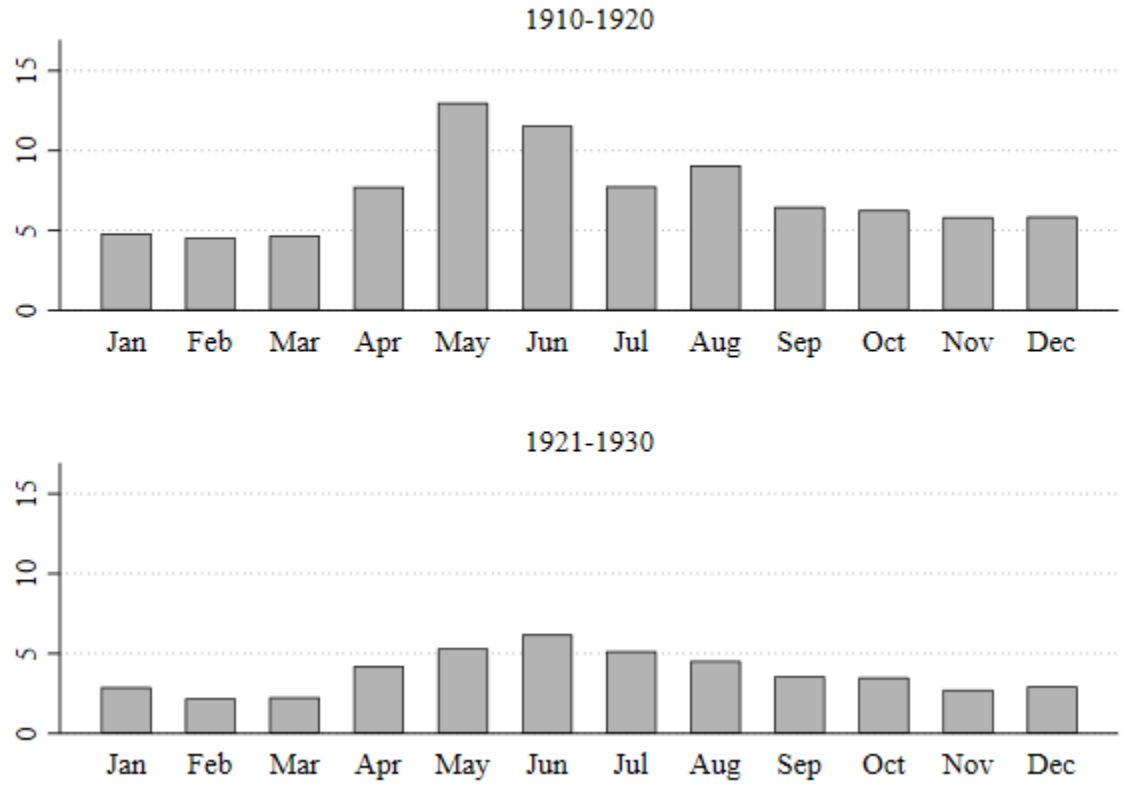
Notes: Based on data from *Mortality Statistics* for the 26 cities under study, published by the U.S. Census Bureau. The shaded vertical bars indicate the summer months (June-September).

Figure 4. Monthly Diarrheal Mortality Among Children Under the Age of Two per 100,000 Population, Above and Below 40th Parallel North



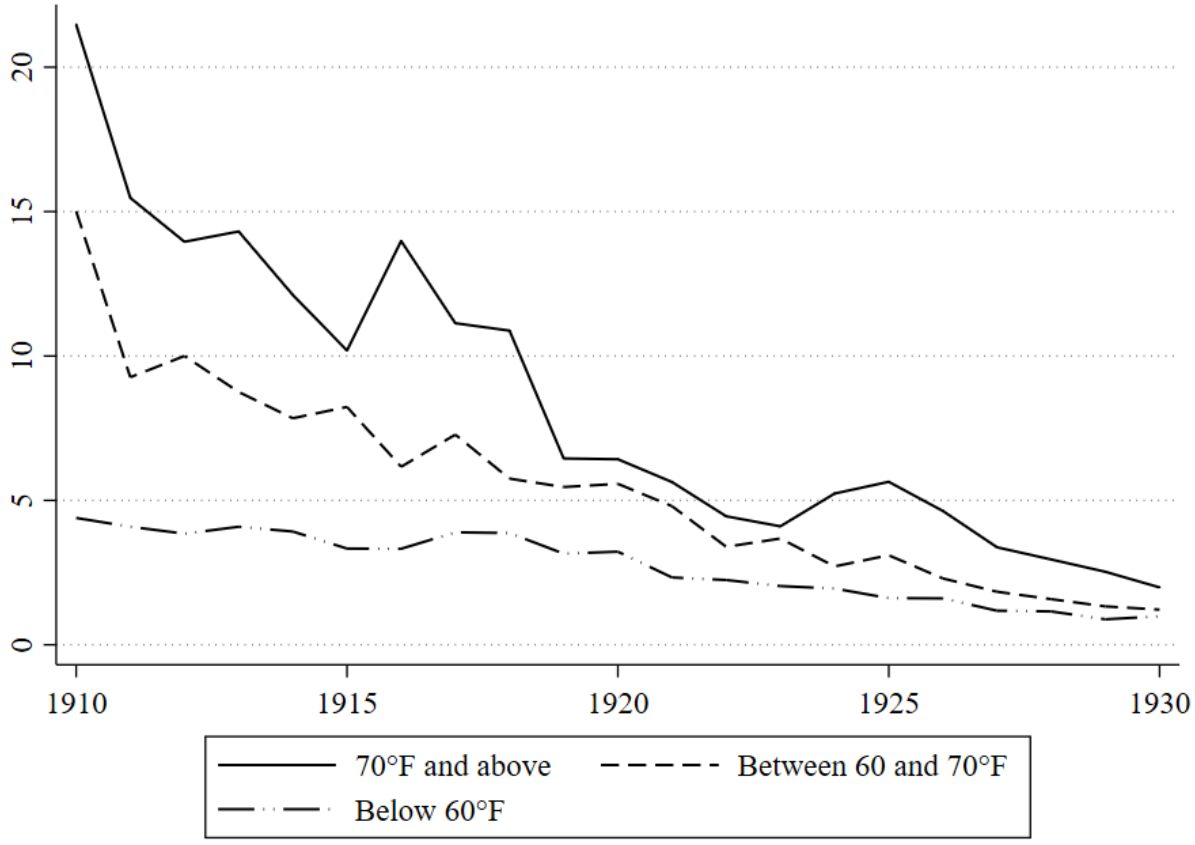
Notes: Based on data from *Mortality Statistics* for the 26 cities under study, published by the U.S. Census Bureau.

Figure 5. Monthly Diarrheal Mortality Among Children Under the Age of Two per 100,000 Population in New Orleans



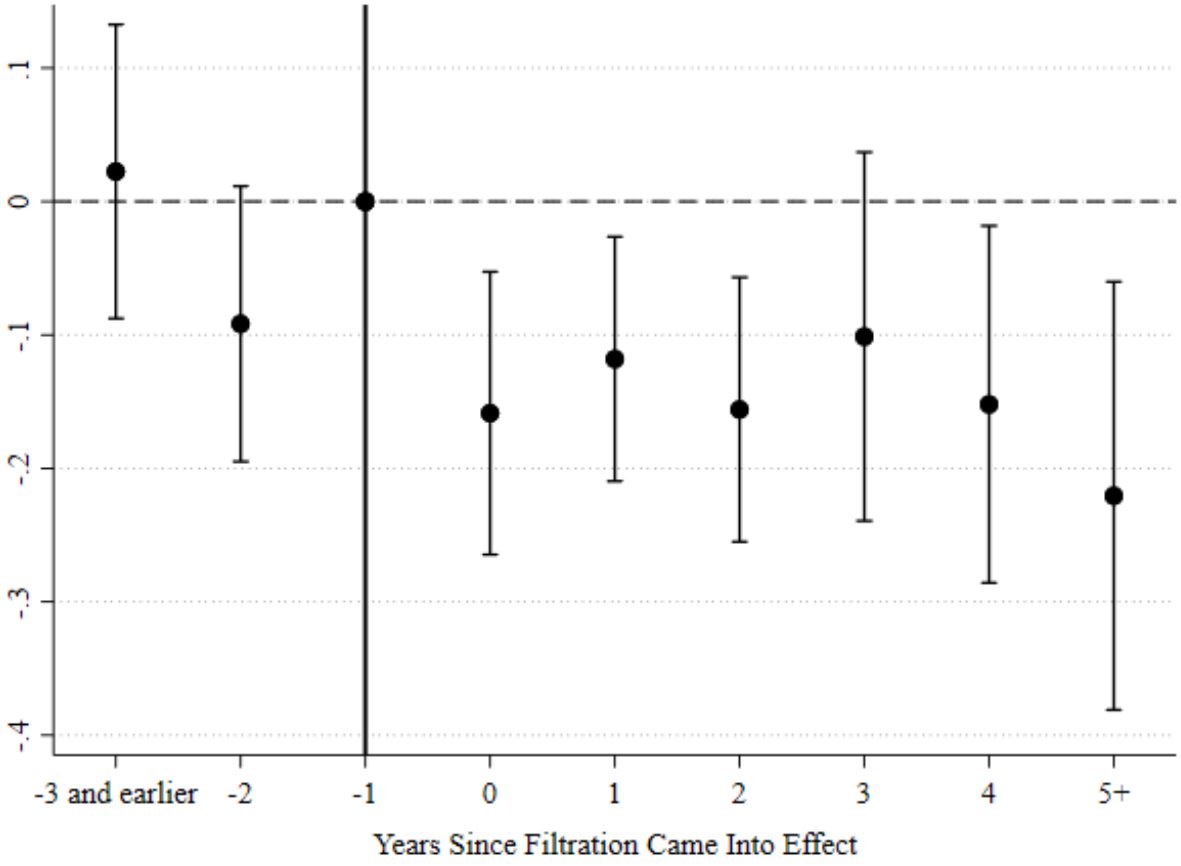
Notes: Based on data from *Mortality Statistics* for New Orleans, Louisiana, published by the U.S. Census Bureau.

Figure 6. Diarrheal Mortality Among Children Under the Age of Two per 100,000 Population by Average Temperature



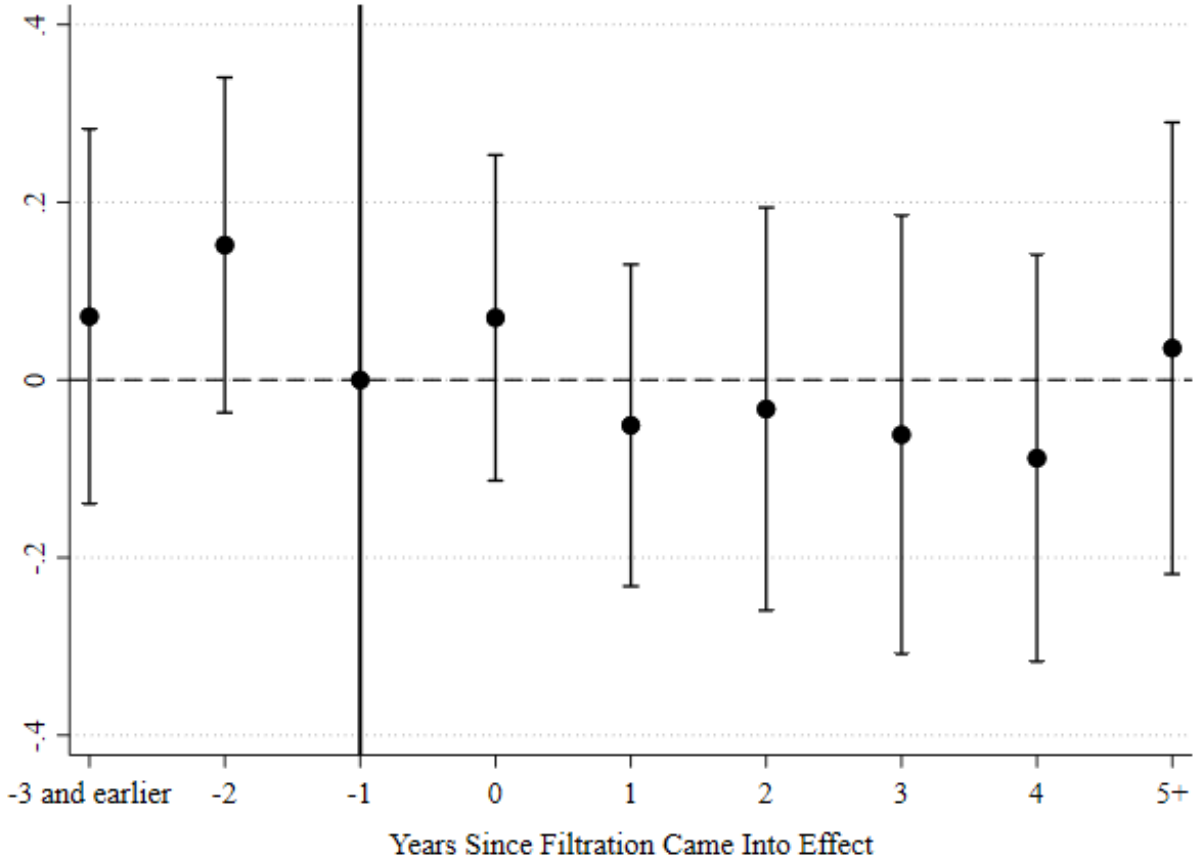
Notes: Based on data from *Mortality Statistics* for the 26 cities under study, published by the U.S. Census Bureau.

Figure 7. Pre- and Post-Filtration Trends in Diarrheal Mortality During Non-Summer Months



Notes: OLS coefficient estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the natural log of the number of diarrheal deaths among children under the age of two per 100,000 population in city *c* and month *t*. Controls include the city characteristics listed in Table 1, city fixed effects, month-by-year fixed effects, and city-specific linear trends. Regressions are weighted by city population. Standard errors are corrected for clustering at the city level.

Figure 8. Pre- and Post-Filtration Trends in Diarrheal Mortality During Summer Months

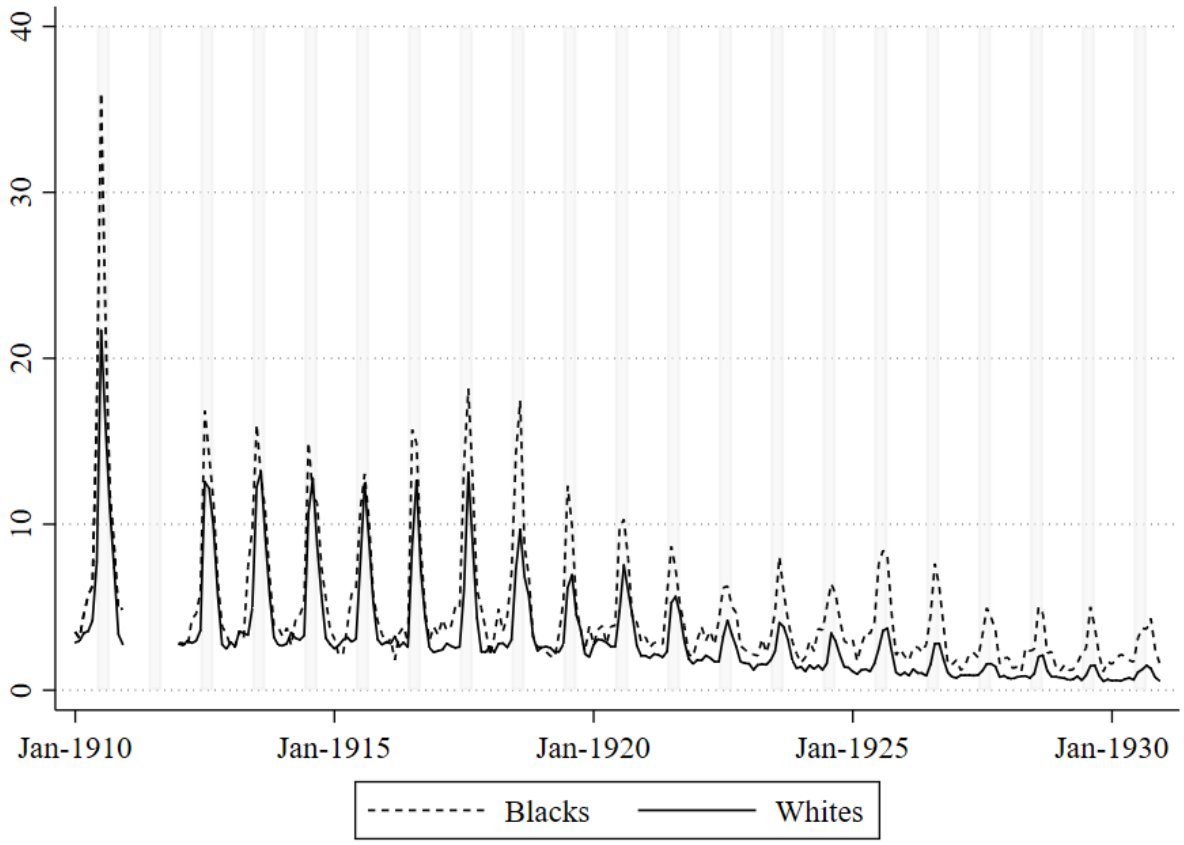


Notes: OLS coefficient estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the natural log of the number of diarrheal deaths among children under the age of two per 100,000 population in city *c* and month *t*. Controls include the city characteristics listed in Table 1, city fixed effects, month-by-year fixed effects, and city-specific linear trends. Regressions are weighted by city population. Standard errors are corrected for clustering at the city level.

Figure 9. Diarrheal Mortality Among Children Under the Age of Two per 100,000 Population by Race

Notes: Based on data from *Mortality Statistics* for the 19 cities under study, published by the U.S. Census Bureau. Diarrheal mortality counts by race are unavailable for 1911.

Figure 10. Monthly Diarrheal Mortality Among Children Under the Age of Two per 100,000 Population by Race



Notes: Based on data from *Mortality Statistics* for the 19 cities under study, published by the U.S. Census Bureau. The shaded vertical bars indicate the summer months (June-September). Diarrheal mortality counts by race are unavailable for 1911.

Table 1. Descriptive Statistics

	Mean (SD)	Description
Diarrhea	4.08 (5.16)	Monthly diarrheal mortality per 100,000 population among children under the age of two
ln(Population)	13.2 (.762)	Natural log of the city population
Percent Female	.500 (.018)	Percent of the city population that was female
Percent Nonwhite	.072 (.072)	Percent of the city population that was nonwhite
Percent Foreign	.212 (.096)	Percent of the city population that was foreign born
Percent Age < 15	.253 (.031)	Percent of the city population that was less than 15 years of age
Percent Age 15-44	.529 (.025)	Percent of the city population that was 15-44 years of age
Percent Age 45+	.218 (.030)	Percent of the city population that was 45 years of age or older
N = 6,552		

Notes: Unweighted means with standard deviations in parentheses.

Table 2. Public Health Interventions and Summer Diarrhea, 1910-1930

	(1)	(2)	(3)
		ln(*Diarrhea*)	
Filtration	-.176***	-.186***	-.161***
	(.056)	(.047)	(.047)
Filtration × *Summer*	.160**	.214**	.190*
	(.077)	(.100)	(.099)
Chlorination	-.021	-.017	-.029
	(.067)	(.059)	(.062)
Chlorination × *Summer*	.078	.069	.081
	(.100)	(.081)	(.081)
Clean Water Project	…	.102	.120
		(.132)	(.131)
Clean Water Project × *Summer*	…	.106	.116
		(.097)	(.094)
Sewage Treated	…	.038	.034
		(.077)	(.074)
Sewage Treated × *Summer*	…	.004	.017
		(.109)	(.109)
Bacteriological Standard	…	…	.111*
			(.060)
Bacteriological Standard × *Summer*	…	…	-.135
			(.085)
N	6,552	6,552	6,552
R^2	.856	.857	.858

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

Notes: Based on annual data from *Mortality Statistics* for the period 1910-1930, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the number of diarrheal deaths among children under the age of two per 100,000 population in city *c* and month *t*. Controls include the city characteristics listed in Table 1, city fixed effects, month-by-year fixed effects, and city-specific linear trends. Regressions are weighted by city population. Standard errors, corrected for clustering at the city level, are in parentheses.

Table 3. Robustness Checks: Water Purification Efforts and Summer Diarrhea

	(1)	(2)	(3)	(4)	(5)	(6)
	Control for wages	Control for region-by-year fixed effects	Unweighted	Drop New York City	Drop years 1917-1920	Dependent variable in levels
Filtration	-.149***	-.192***	-.106*	-.154***	-.149***	-1.08***
	(.043)	(.047)	(.053)	(.044)	(.049)	(.351)
Filtration × *Summer*	.191*	.179*	.140	.209**	-.159*	1.17
	(.099)	(.092)	(.095)	(.099)	(.087)	(.699)
Chlorination	-.033	-.048	-.026	.007	-.037	-.466
	(.060)	(.046)	(.052)	(.057)	(.063)	(.430)
Chlorination × *Summer*	.079	.080	.076	.027	.096	1.52*
	(.080)	(.077)	(.090)	(.090)	(.083)	(.792)
N	6,529	6,552	6,552	6,300	5,304	6,552
R^2	.859	.865	.787	.836	.865	.802

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

Notes: Based on annual data from *Mortality Statistics* for the period 1910-1930, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. In columns (1)-(5), the dependent variable is equal to the natural log of the number of diarrheal deaths among children under the age of two per 100,000 population in city *c* and year *t*. In column (6), the dependent variable is equal to the number of diarrheal deaths among children under the age of two per 100,000 population in city *c* and year *t*. Controls include the city characteristics listed in Table 1, the other policy interventions (*Clean Water Project*, *Sewage Treated*, and *Bacteriological Standard*) and their interaction with *Summer*, city fixed effects, month-by-year fixed effects, and city-specific linear trends. In columns (1)-(2) and (4)-(6), regressions are weighted by city population. Standard errors, corrected for clustering at the city level, are in parentheses.

Table 4. Diarrheal Mortality and Leads and Lags of Water Filtration

	(1)	(2)	(3)	(4)
	ln(*Diarrhea*)		ln(*Diarrhea*)	
	Non-Summer Months	Summer Months	Non-Summer Months	Summer Months
3 or More Years Prior to Filtration	...	...	.022	.071
			(.065)	(.123)
2 Years Prior to Filtration	...	...	-.092	.149
			(.060)	(.110)
1 Year Prior to Filtration	...	...	...	...
Year 0	-.168**	.045	-.159**	.070
	(.065)	(.093)	(.062)	(.107)
1 Year After Filtration	-.124**	-.075	-.118**	-.051
	(.059)	(.093)	(.054)	(.106)
2 Years After Filtration	-.161**	-.052	-.156**	-.033
	(.067)	(.124)	(.058)	(.133)
3 Years After Filtration	-.103	-.081	-.101	-.062
	(.075)	(.140)	(.081)	(.144)
4 Years After Filtration	-.152*	-.105	-.152*	-.088
	(.076)	(.128)	(.078)	(.134)
5 or More Years After Filtration	-.216**	.022	-.221**	.036
	(.097)	(.148)	(.094)	(.149)
N	6,552	6,552	6,552	6,552
R^2	.859	.859	.860	.860

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

Notes: Based on annual data from *Mortality Statistics* for the period 1910-1930, published by the U.S. Census Bureau. Columns (1)-(2) represent the results from an OLS regression where the omitted category is all years prior to filtration. Columns (3)-(4) represent results from an OLS regression where the omitted category is 1 year prior to filtration. The even-numbered columns represent results based on the sum of the coefficient estimate on the indicated lead (or lag) and the coefficient estimate on the interaction between the indicated lead (or lag) and *Summer*. The dependent variable is equal to the natural log of the number of diarrheal deaths among children under the age of two per 100,000 population in city *c* and month *t*. Controls include the city characteristics listed in Table 1, the other policy interventions (*Clean Water Project*, *Sewage Treated*, and *Bacteriological Standard*) and their interaction with *Summer*, city fixed effects, month-by-year fixed effects, and city-specific linear trends. Regressions are weighted by city population. Standard errors, corrected for clustering at the city level, are in parentheses.

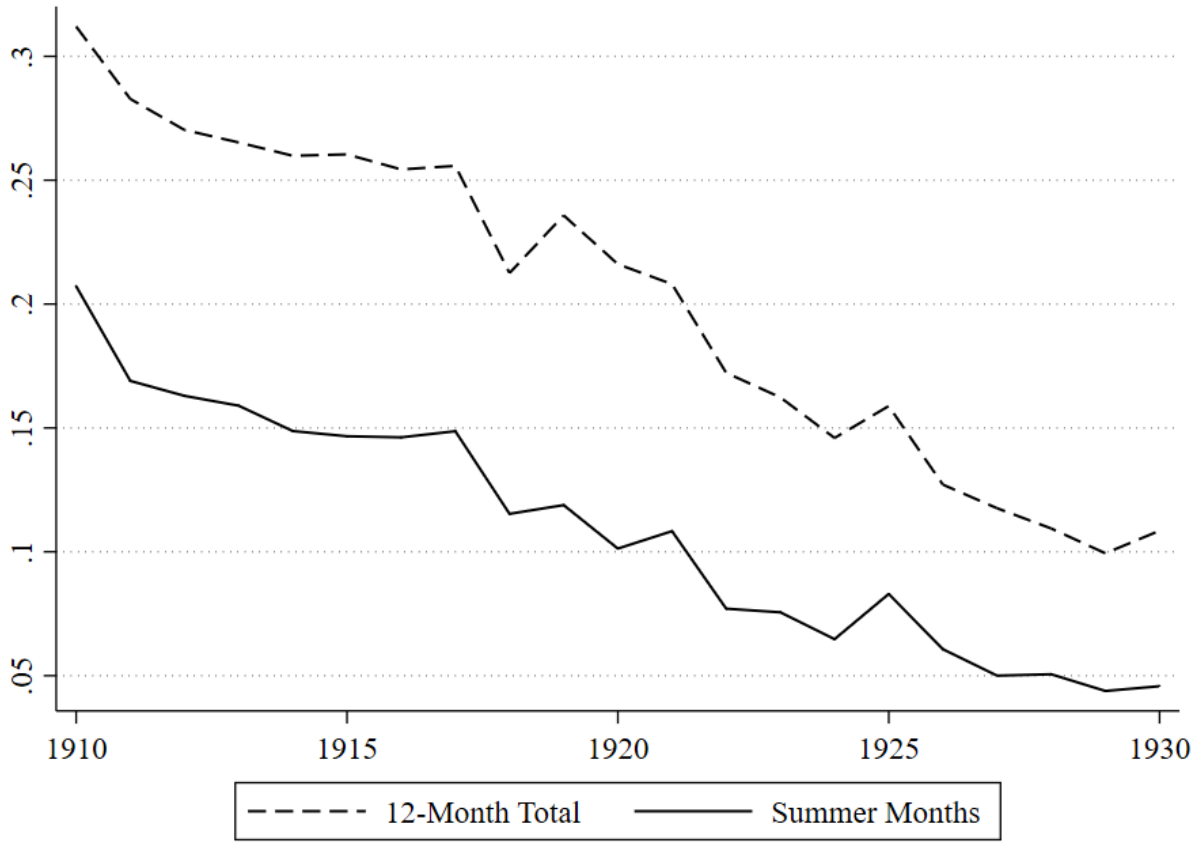
Table 5. Public Health Interventions and Summer Diarrhea by Race

	(1)	(2)
	ln(*Diarrhea - Whites*)	ln(*Diarrhea - Blacks*)
Filtration	-.099*	.108
	(.056)	(.124)
Filtration × Summer	.208*	.165
	(.111)	(.153)
Chlorination	-.088	-.086
	(.081)	(.068)
Chlorination × Summer	.196**	-.022
	(.082)	(.160)
Clean Water Project	.085	1.74***
	(.116)	(.220)
Clean Water Project × Summer	.081	-.151
	(.108)	(.183)
Sewage Treated	.059	-.184
	(.075)	(.223)
Sewage Treated × Summer	-.091	-.006
	(.126)	(.160)
Bacteriological Standard	-.003	-.136
	(.047)	(.111)
Bacteriological Standard × Summer	.002	-.068
	(.085)	(.183)
N	3,456	3,456
R^2	.887	.529

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

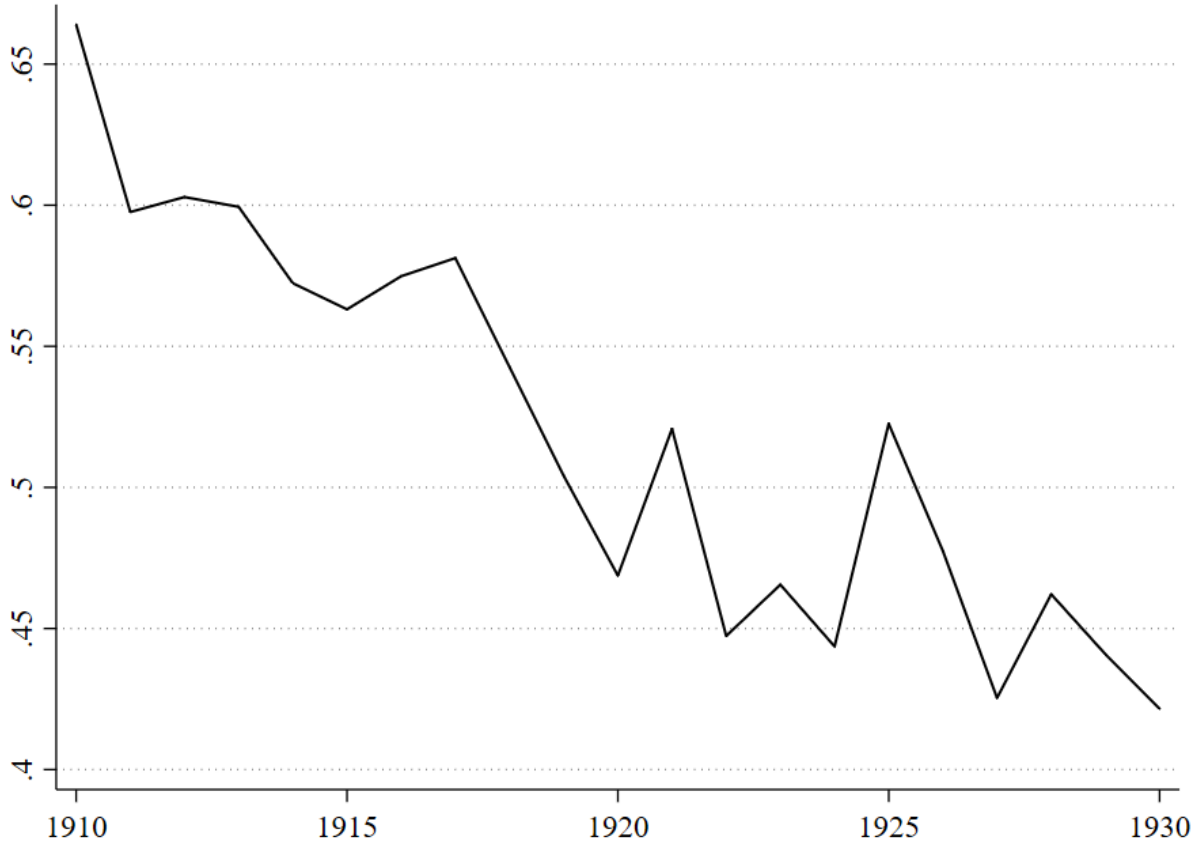
Notes: Based on annual data from *Mortality Statistics* for the period 1910-1930, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the number of diarrheal deaths among children under the age of two per 100,000 of the relevant population in city *c* and month *t*. Controls include the city characteristics listed in Table 1, city fixed effects, month-by-year fixed effects, and city-specific linear trends. Regressions are weighted by the relevant city population. Standard errors, corrected for clustering at the city level, are in parentheses.

Appendix Figure 1. Ratio of Diarrheal Mortality to Total Mortality Among Children Under the Age of Two



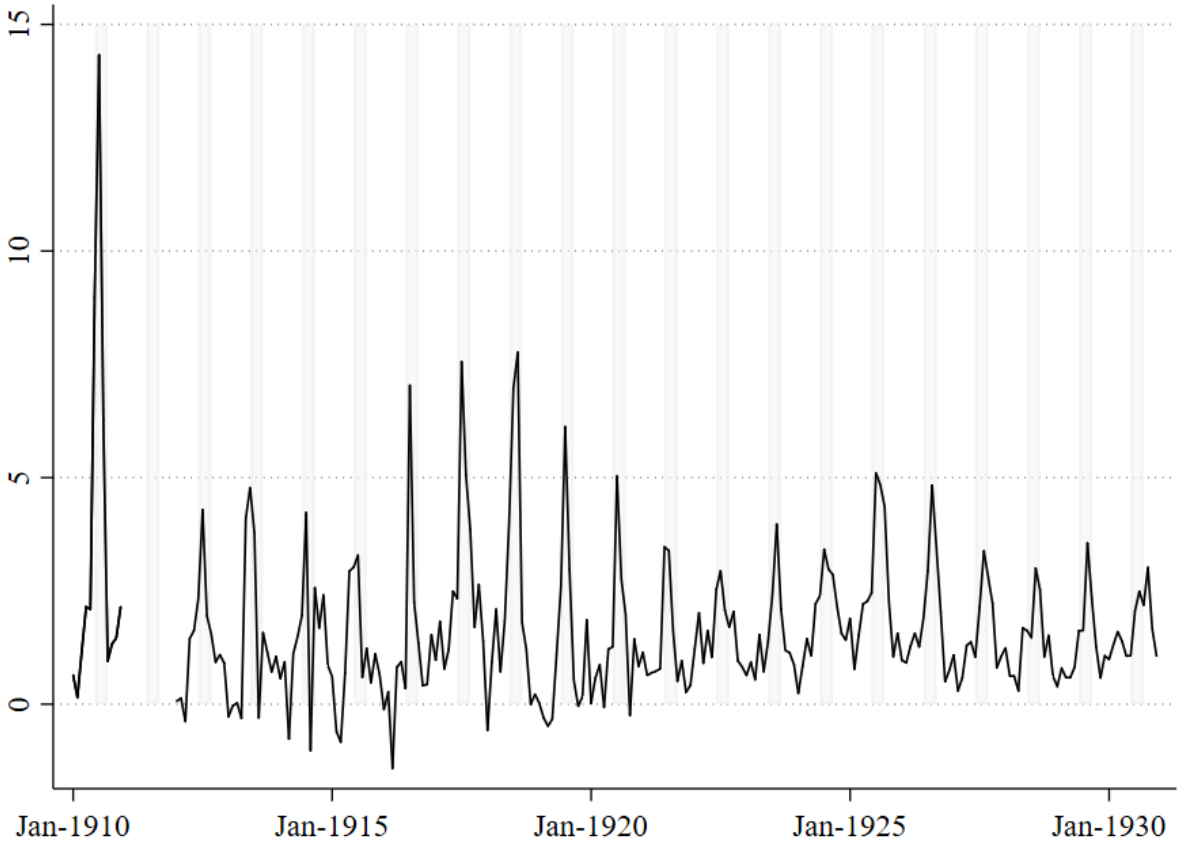
Notes: Based on data from *Mortality Statistics* for the 26 cities under study, published by the U.S. Census Bureau. The summer months are defined as June through September.

Appendix Figure 2. Ratio of Summer Diarrheal Mortality to Total Diarrheal Mortality Among Children Under the Age of Two



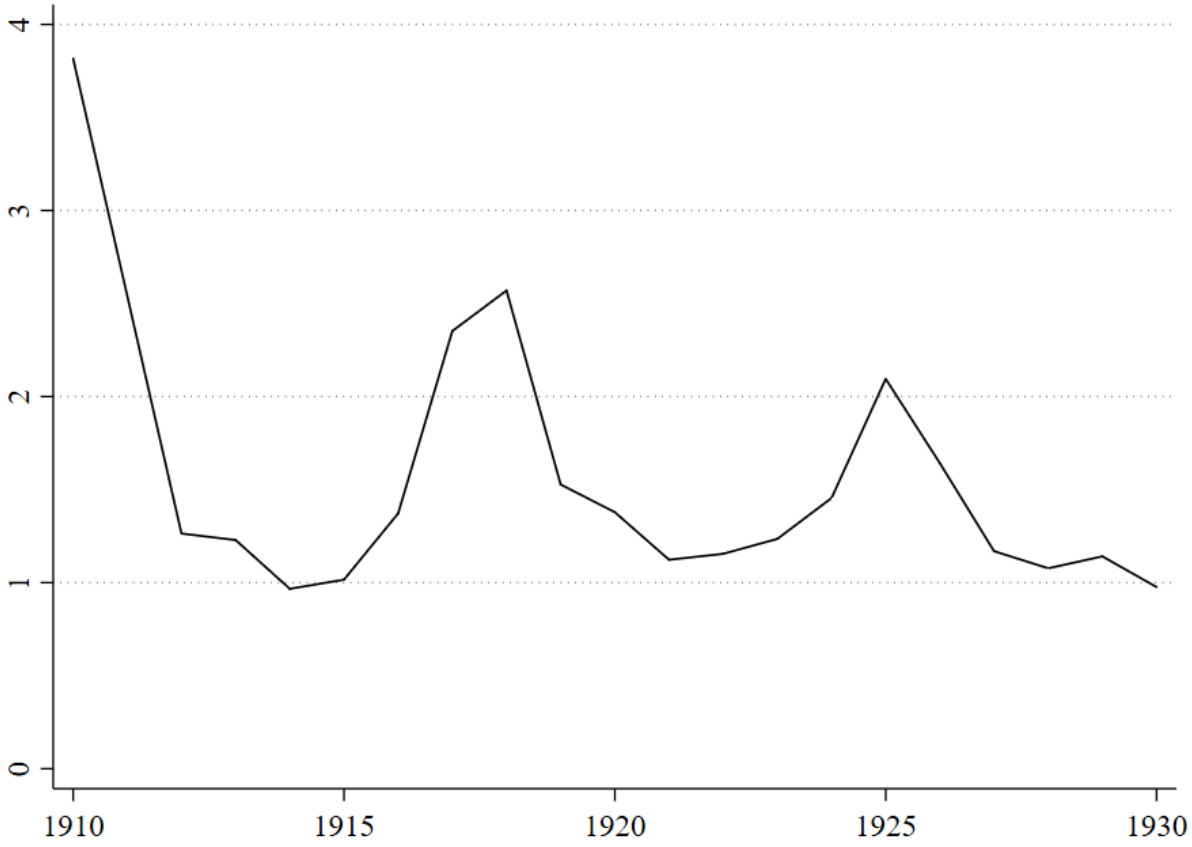
Notes: Based on data from *Mortality Statistics* for the 26 cities under study, published by the U.S. Census Bureau. The summer months are defined as June through September.

Appendix Figure 3. Monthly Black-White Diarrheal Mortality Gap Among Children Under the Age of Two per 100,000 Population



Notes: Based on data from *Mortality Statistics* for the 19 cities under study, published by the U.S. Census Bureau. The shaded vertical bars indicate the summer months (June-September). Diarrheal mortality counts by race are unavailable for 1911.

Appendix Figure 4. Black-White Diarrheal Mortality Gap Among Children Under the Age of Two per 100,000 Population During Non-Summer Months



Notes: Based on data from *Mortality Statistics* for the 19 cities under study, published by the U.S. Census Bureau. Diarrheal mortality counts by race are unavailable for 1911.

Appendix Table 1. Municipal Water Purification, 1900-1930

City and State	Water Filtration Plant[a]	Water Treated with Chlorine[b]
Baltimore, Maryland	1915	1911
Boston, Massachusetts	…	1928
Buffalo, New York	1926	1914
Chicago, Illinois	…	1912
Cincinnati, Ohio	1907	1918
Cleveland, Ohio	1918	1911
Detroit, Michigan	1923	1913
Indianapolis, Indiana	1904	1909
Jersey City, New Jersey	…	1908
Kansas City, Missouri	1928	1911
Los Angeles, California	…	1925
Louisville, Kentucky	1909	1913
Milwaukee, Wisconsin	…	1910
Minneapolis, Minnesota	1913	1910
Newark, New Jersey	…	1921
New Orleans, Louisiana	1909	1915
New York, New York	…	1911
Philadelphia, Pennsylvania	1906	1910
Pittsburgh, Pennsylvania	1908	1910
Providence, Rhode Island	1904	1917
Rochester, New York	…	1925
San Francisco, California	…	1922
Seattle, Washington	…	1911
St. Louis, Missouri	1915	1913
St. Paul, Minnesota	1923	1920
Washington, D.C.	1905	1923

[a] **Philadelphia, PA**: Filtration began before 1906, but not all parts of the city received filtered water until February, 1909. **Pittsburgh, PA**: By October 1908, the water supply of peninsular Pittsburgh was being filtered. In 1909 and 1914, the Southside and the Northside, respectively, began receiving filtered water.

[b] **Chicago, IL**: Chlorination began in 1912, but full chlorination was not achieved until 1917. **Milwaukee, WI**: Water was chlorinated from June, 1910-December, 1910; February, 1912-March 1912; April, 1912 onwards. **Newark, NJ**: Chlorine was used in rare, emergency-only cases beginning in 1913; continuous use started in 1921. **Philadelphia, PA**: Water was chlorinated from December, 1910-April, 1911; December, 1911-February, 1913; November, 1913 onwards. **Pittsburgh, PA**: Water was chlorinated from January, 1910-March, 1910; November, 1910-April, 1911; August, 1911 onwards.

Notes: Identification of the *Filtration* indicator comes from the cities that began filtering their water supply during the period 1910-1930. Identification of the *Chlorination* indicator comes from the cities that began chlorinating their water supply during the period 1910-1930.

Appendix Table 2. Clean Water Projects, 1900-1930

City and State	Clean Water Project	Description
Boston, Massachusetts	1904	Water was conveyed by the Wachusett/Weston Aqueduct to the Weston Reservoir. Water was first delivered to metropolitan Boston on December 29, 1904.
Buffalo, New York	1913	Water intake, located on Lake Erie's Emerald Channel, was completed on May 12, 1913.
Cleveland, Ohio	1904	Cleveland built the first tunnel (the "Five Mile Crib") to draw water from Lake Erie. It went into operation on April 6, 1904.
Jersey City, New Jersey	1904	The Boonton Reservoir began delivering water to Jersey City on May 23, 1904.
Los Angeles, California	1913	Los Angeles began receiving water from Owens Valley on November 5, 1913.
Newark, New Jersey	1930	The Wanaque Reservoir began delivering water to Newark on March 20, 1930.
New York, New York	1907	The New Croton Dam was completed on January 1, 1907 and began delivering water to New York City on November 6, 1907. The Catskills Aqueduct began delivering water to the Bronx on December 27, 1915. By January 22, 1917, all other boroughs were receiving water.
Providence, Rhode Island	1926	The Scituate Reservoir began delivering water to Providence on September 30, 1926.

Notes: Identification of the *Clean Water Project* indicator comes from the cities that undertook clean water project during the period 1910-1930.

Appendix Table 3. Sewage Treatment/Diversion, 1900-1930

City and State	Sewage Treatment Plant/Sewage Diversion	Description
Baltimore, Maryland	1911	Operation of the sewage treatment plant was begun "in the latter part of 1911" (Wagenhals et al. 1925).
Chicago, Illinois	1907	In 1907, the last sewer outfalls emptying into Lake Michigan were shut off.
Cleveland, Ohio	1922	The first sewage treatment plant was opened in 1922. By 1928, two additional plants were in operation.
Detroit, Michigan	1912	The Detroit River Interceptor was built in 1912. It intercepted sewage and discharged it below the intake for drinking water. Detroit began treating its sewage in February, 1940.
Indianapolis, Indiana	1925	The sewage treatment plant began operations in May, 1925.
Jersey City, New Jersey	1924	The sewage treatment plant was built in 1924 and upgraded in 1937.
Milwaukee, Wisconsin	1925	The sewage treatment plant began operations in June, 1925.
Newark, New Jersey	1924	The sewage treatment plant began operations in 1924.
Providence, Rhode Island	1901	The Providence sewage treatment plant, built in 1901, used chemical precipitation. It converted to using an activated sludge process in the mid-1930s.
Rochester, New York	1917	The sewage treatment plant began operations in March, 1917

Notes: Identification of the *Sewage Treated* indicator comes from the cities that began treating their sewage during the period 1910-1930.

Sources for Appendix Tables 1-3

Baltimore, Maryland

Hendrickson, Martha A. 2012. "The Montebello Water Filtration Plant I: Clean Water for City & Suburb Alike." *History Trails*, 43(3-4): 1-20.

Jennings, C.A. 1918. "Some Results Secured by Chlorine Compounds in Water Purification and Sewage Treatment." *City Engineering*, LV(1): 249-251.

Wagenhals, H.H., E.J. Theriault and H.B. Hommon. 1925. Report on the Study of Fifteen Representative Sewage Treatment Plants. Washington, D.C.: Government Printing Office.

Boston, Massachusetts

Castellon, Cynthia M. 2008. "Disinfection Byproduct (DBP) Precursors in Central MA." Environmental & Water Resources Engineering Masters Projects, University of Massachusetts-Amherst.

Mohlman, F. W. 1940. "Sewage Treatment in Large American Cities." *Sewage Works Journal*, 12(1): 168-171.

Ropes, Horace. 1904. "Westin Aqueduct Department". In the *Third Annual Report of the Metropolitan Water and Sewage Board* (Public Document 57). Boston, MA: Wright and Potter Printing Company, pp. 113-136.

Buffalo, New York

Andrews, George C. 1927. "The Buffalo Water Works." *Journal of the American Water Works Association*, 17(3): 279-290.

Fronczak, Francis E. 1915. "Reduction in Typhoid." *Buffalo Sanitary Bulletin*, 8(8): 85-86.

Mohlman, F. W. 1940. "Sewage Treatment in Large American Cities." *Sewage Works Journal*, 12(1): 168-171.

Rossi, Mary C. 1995. "The History of Sewage Treatment in the City of Buffalo, New York." *Middle States Geographer*, 28: 9-19.

Chicago, Illinois

Baylis, John R. 1949. "Chicago South District Filtration Plant." *Journal of the American Water Works Association*, 41(7): 599-615.

Cain, Louis P. 1978. *Sanitation Strategy for a Lakefront Metropolis: The Case of Chicago.* DeKalb, IL: Northern Illinois University Press.

Gustaitis, Joseph. 2013. *Chicago's Greatest Year, 1893: The White City and the Birth of a Modern Metropolis*. Carbondale, IL: Southern Illinois University Press.

Hering, Rudolph and George W. Fuller. 1907. “Sewage Disposal at Chicago and Vicinity.” *Engineering Record*, 55(5): 130-134.

Jennings, C. A. 1923. “The Disinfection of Public Water Supplies and its Relation to Public Health.” *Journal of the American Water Works Association*, 10(1): 127-138.

Melosi, Martin. 2008. *The Sanitary City: Environmental Services in Urban America from Colonial Times to the Present*. Pittsburgh, PA: University of Pittsburgh Press.

Cincinnati, Ohio

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

Eddy, Harrison P. 1913. “Report upon Necessity and Feasibility of Treating the Sewage of Cincinnati before its Discharge into the Ohio River.” *Progress Report on a Plan of Sewerage for the City of Cincinnati.* Department of Public Works, Cincinnati, OH, pp. 295-610.

Mohlman, F. W. 1940. “Sewage Treatment in Large American Cities.” *Sewage Works Journal*, 12(1): 168-171.

Cleveland, Ohio

Ellms, J. W. and John J. Wirts. 1943. “Sewage Treatment Problems in Cleveland, Ohio.” *Sewage Works Journal*, 15(1): 40-47.

Hyde, Charles Gilman, George H. Wilhelm and Frank C. Miller. 1916. *A Report Upon Possible Sources of Water Supply for the City of Sacramento.* Sacramento, CA: Rincon Publishing Company, Printers.

Ohio (state). 1913. *Twenty Seventh Annual Report of the State Board of Health.* Columbus, Ohio: F.J. Heer Printing Company, pp. 623-633.

Orth, Samuel Peter. 1910. *A History of Cleveland, Ohio, Volume 1*. Chicago-Cleveland: S.J. Clarke Publishing Company.

Perkins, Roger G. 1921. “Typhoid Fever in Cleveland Ohio for the Years 1918, 1919, and 1920” *Public Health Reports*, 36(20): 1095-1132.

Stradling, David and Richard Stradling. 2015. *Where the River Burned: Carl Stokes and the Struggle to Save Cleveland*. Ithaca, NY: Cornell University Press.

Detroit, Michigan

Detroit Water and Sewerage Department. 2002. *Detroit Water and Sewerage Department: The First 300 Years* (Daisy, Michael, editor). Detroit, MI: Detroit Water and Sewerage Department.

Jennings, C.A. 1918. “Some Results Secured by Chlorine Compounds in Water Purification and Sewage Treatment.” *Municipal Engineering*, LV(1): 249-251.

Indianapolis, Indiana
Calvert, C.K. 1934. "The Sanitary Works of Indianapolis." *American Journal of Public Health*, 24(7): 739-742.

Jordan, H.E. 1909. "Preliminary Chemical Treatment as an Aid to Slow Sand Filtration; Indianapolis Water Company." *Engineering News*, 66(6): 144-148.

Mabee, W.C. 1909. "Concrete in Waterworks Construction." *Fire and Water Engineering*, 46: 242-244.

Unknown Author. 1919. "Disinfection of Water Supplies." *Municipal Journal and Public Works*, 46(24): 437-439 and 444.

Jersey City, New Jersey
Jennings, C.A. 1918. "Some Results Secured by Chlorine Compounds in Water Purification and Sewage Treatment." *Municipal Engineering*, LV(1): 249-251.

Leith, Rodney B. 1972. "Jersey City Gives Up its Sewage Treatment Plant." *New York Times*, April 30. Available at: https://www.nytimes.com/1972/04/30/archives/jersey-city-gives-up-its-sewagetreatment-plant.html.

McGuire, Michael J. 2013. *The Chlorine Revolution: Water Disinfection and the Fight to Save Lives*. Denver, CO: American Water Works Association.

Stoddard, Andrew, Jon B. Harcum, Jonathan T. Simpson, James R. Pagenkopf and Robert K. Bastian. 2002. *Municipal Wastewater Treatment: Evaluating Improvements in National Water Quality*. New York, NY: John Wiley and Sons.

Kansas City, Missouri
Bullard, Loring. 2010. *Source to Tap: A History of Missouri's Public Water Supplies.* Available at: http://www.watershedcommittee.org/wp-content/uploads/2010/08/copy-of-copy-of-source-to-tapfinal.pdf.

Hyde, Charles Gilman, George H. Wilhelm and Frank C. Miller. 1916. *A Report Upon Possible Sources of Water Supply for the City of Sacramento.* Sacramento, CA: Rincon Publishing Company, Printers.

Mohlman, F. W. 1940. "Sewage Treatment in Large American Cities." *Sewage Works Journal*, 12(1): 168-171.

Samuel, T.D. 1930. "The Water Supply System of Kansas City Missouri." *Journal of the American Water Works Association*, 22(9): 1236-1246.

Los Angeles, California
Feldman, David Lewis. 2017. *The Water-Sustainable City: Science, Policy and Practice*. Northampton, MA: Edward Elgar Publishing.

Goudey, R.F. 1935. "Chlorination of Los Angeles Water Supply." *American Journal of Public Health*, 25(6): 730–734.

Hanak, Ellen, Jay Lund, Ariel Dinar, Brian Gray, Richard Howitt, Jeffry Mount, Peter Moyle, and Barton Thompson. 2011. *Managing California's Water: From Conflict to Reconciliation*. San Francisco: Public policy Institute of California.

Prud'homme, Alex. 2012. *The Ripple Effect: The Fate of Freshwater in the Twenty-First Century*. New York, NY: Scribner Publishing.

Wilson, Carl. "To C.G. Gillespie." 24 Dec. 1951. Available at: https://thisdayinwaterhistory.files.wordpress.com/2013/10/ladwp-letter-to-calif-health-dept-121224.pdf.

Louisville, Kentucky
Bruggers, James. 2016. "Yuk! Louisville Still has a $943m Sewer Problem." *The Courier Journal*, October 22. Available at: https://www.courier-journal.com/story/tech/science/environment/2016/10/22/yuck-louisville-still-has-943m-sewer-problem/87721810/.

Gazlay, Webster. 1912. "The Louisville Water Purification Plant." *Engineering Record*, 65(26): 728.

Recktenwold, Roger. 2017. "Water and Wastewater Service for the Commonwealth of Kentucky." In *Water in Kentucky: Natural History, Communities, and Conservation* (editors Brian D. Lee, Daniel I. Carey, Alice L. Jones), Lexington, KY: University Press of Kentucky.

Unknown Author. 1911. "Louisville Waterworks Report." *Fire and Water Engineering*, 49(22): 209.

Milwaukee, Wisconsin
Foss-Mollan, Kate. 2001. *Hard Water: Politics and Water Supply in Milwaukee, 1870-1995.* West Lafayaette, IN: Purdue University Press.

Jennings, C. A. 1918. "Some Results Secured by Chlorine Compounds in Water Purification and Sewage Treatment." *Municipal Engineering*, LV(1): 249-251.

Minneapolis, Minnesota
Cappelen, F.W. 1918. *Annual Report of the City Engineer of the City of Minneapolis for the Year Ending December 31, 1914*. Minneapolis, MN: Syndicate Printing Company.

Mohlman, F. W. 1940. “Sewage Treatment in Large American Cities.” *Sewage Works Journal*, 12(1): 168-171.

National Research Council of the National Academies. 2008. *Mississippi River Water Quality and the Clean Water Act*. Washington, D.C.: National Academies Press.

Saint Paul (MN). 1938. *Annual Report of the Commissioner of Public Works*. Saint Paul, MN: Department of Public Works.

Stokes, William Royal. 1911. “A Report Concerning the Treatment of Baltimore Drinking Water with Hypochlorite of Calcium.” *Maryland Medical Journal*, LIV(7): 204-214.

Unknown Author. 1917. “Chlorine Disinfection in Water-Works Plants.” *Water and Gas Review*, 27(10): 17-22.

Newark, New Jersey
Hendricks David. 2011. *Fundamentals of Water Treatment Unit Processes: Physical, Chemical, and Biological.* New York, NY: CRC Press.

Modica, Glenn R. 2001. *The History of the Newark Sewer System*. Cranbury, NJ: Richard Grubb & Associates.

Newark (NJ), Dept. of Streets and Public Improvements. 1922. *Annual Report*, Newark, NJ.

North Jersey District Water Supply Commission. 1950. *Wanaque and Ramapo Projects*. Wanaque, NJ.

Unknown Author. 1917. “Chlorine Disinfection in Water-Works Plants.” *Water and Gas Review*, 27(10): 17-22.

Unknown Author. 1919. “Disinfection of Water Supplies.” *Municipal Journal and Public Works*, 46(24): 437-439 and 444.

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

Porter, John L. 1909. “Operation and Maintenance Purification Stations.” In the *Semi-annual Report of the Sewerage and Water Board of the City of New Orleans, La*, pp. 57-63.

Reeves, William D. 2003. *Historic Louisiana: An Illustrated History.* San Antonio, TX: Historical Publishing Network.

New York, New York
Coffin, T.D.L. 1913. “Chlorinating Plants, Croton Water Supply.” *Engineering News*, 69(9): 419-422.

Donaldson, Wellington. 1939. “First Year’s Operation of Wards Island Sewage Treatment Works.” *Sewage Works Journal*, 11(1): 100-116.

Mohlman, F. W. 1940. “Sewage Treatment in Large American Cities.” *Sewage Works Journal*, 12(1): 168-171.

New York City Department of Environmental Protection. “New York City’s Wastewater Treatment System.” Available at: http://www.nyc.gov/html/dep/pdf/wwsystem.pdf.

Unknown Author. 1908. “The Filling of the New Croton Reservoir.” *The Engineering Review*, 18(1): 53.

Pittsburgh, Pennsylvania

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

Mohlman, F. W. 1940. “Sewage Treatment in Large American Cities.” *Sewage Works Journal*, 12(1): 168-171.

Pittsburgh (PA), Dept. of Public Works. 1916. *The City of Pittsburgh and Its Public Works.* Pittsburgh, PA: Pittsburgh Printing Company.

Philadelphia, Pennsylvania

Hendricks, David W. 2006. *Water Treatment Unit Processes: Physical and Chemical*. Boca Raton, FL: CRC Press.

McCarthy, Michael P. 1987. *Typhoid and the Politics of Public Health in Nineteenth-century Philadelphia*. Philadelphia, PA: American Philosophical Society.

Mohlman, F. W. 1940. “Sewage Treatment in Large American Cities.” *Sewage Works Journal*, 12(1): 168-171.

Philadelphia (PA), 1909. *Description of the Filtration Works and Pumping Stations: Also Brief History of the Water Supply.* Philadelphia, PA: Bureau of Water.

West, Francis D. 1909. “Sanitary Control of Filter Plants.” *Proceedings of the Engineers’ Club of Philadelphia*, 26(2): 135-144.

West, Francis D. 1914. “Disinfecting 200,000,000 Million Gallons of Water a Day—Experience with Chloride of Lime and Liquid Chlorine at the Torresdale Filtration Plant.” *Journal of the American Water Works Association*, 1(3): 403-446.

Providence, Rhode Island

Bronsdon, M.H. 1919. “Operating Results of Slow-Sand Filtration Plant at Providence R.I.” *Chemical Abstracts*, 13(7): 760.

Cady, John Hutchins. 1957. *The Civic and Architectural Development of Providence, 1636-1950.* Providence, RI: The Book Shop.

Nixon, Scott W. 1995. *Metal Inputs to Narragansett Bay: A History and Assessment of Recent Conditions*. Narragansett, RI: Rhode Island Sea Grant Communications Office.

Unknown Author. 1909. "Water Filters of Providence, R.I." *Municipal Journal and Engineer*, 27(3): 85-89.

Rochester, New York
Baker, Frank Collins. 1920. "Animal Life and Sewage in the Genesee River, New York." *The American Naturalist*, 54(631): 152-161.

McKelvey, Blake. 1972. "Water for Rochester." *Rochester History*, 34(3): 1-24.

Rochester (City of), Department of Environmental Services, Bureau of Water. 2013. *A Pocket History of the Rochester Water Works*, Rochester New York.

San Francisco, California
Environmental Protection Agency, Office of Enforcement. 1975. *Evaluation of Sewage Treatment Facilities San Francisco, California September 1975*. EPA-330/2-75-008, San Francisco, CA.

Hanson, Warren D. 2005. *A History of the Municipal Water Department and Hetch Hetchy System.* San Francisco, CA: San Francisco Public Utilities Commission.

Hassler, William C. 1930. "Typhoid Fever Epidemic Occurring During the Summer of 1928." *American Journal of Public Health*, 20(2): 137–146.

Schussler, Hermann. 1906. *The Water Supply of San Francisco, California, Before, During and After the Earthquake of April 18th, 1906, and the Subsequent Conflagration*. New York, NY: Martin B. Brown Press.

Unknown Author. 1919. "Disinfection of Water Supplies." *Municipal Journal and Public Works*, 46(24): 437-439, 444.

Seattle, Washington
Dominguez, Sarai. 2011. "Why Seattle's Tap Water Is So Good." *Seattle Magazine*. Available at: https://www.seattlemag.com/article/why-seattle-s-tap-water-so-good.

Lamb, John. 1914. The Seattle Municipal Water Plant. Seattle: Moulton Printing Company.
Laws, Edward A. 2000. *Aquatic Pollution: An Introductory Text* (3rd edition). New York: John Wiley and Sons.

Wilma, David. 2000. “Metro (Seattle) Dedicates West Point Treatment Plant on July 20, 1966.” *HistoryLink.org*, Essay 2732. Available at: http://www.historylink.org/File/2732.

St. Louis, Missouri

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

Mohlman, F. W. 1940. “Sewage Treatment in Large American Cities.” *Sewage Works Journal*, 12(1): 168-171.

National Research Council of the National Academies. 2008. *Mississippi River Water Quality and the Clean Water Act*. Washington, D.C.: National Academies Press.

Wall, Edward E. 1920. “Water Treatment at St. Louis Mo.” *American Journal of Public Health*, 10(5): 437-443.

St. Paul, Minnesota

Jensen, Bob. 2016. “A Drink of Water.” *LillieNews.com*, August 3. Available at: http://www.lillienews.com/articles/2016/08/03/drink-water.

Mohlman, F. W. 1940. “Sewage Treatment in Large American Cities.” *Sewage Works Journal*, 12(1): 168-171.

Saint Paul (MN). 1938. *Annual Report of the Commissioner of Public Works*. Saint Paul, MN: Department of Public Works

Unknown Author. 1914. “St. Paul, Minn., Water Report for 1913.” *Fire and Water Engineering*, 56(2): 20.

Washington, D.C.

Cosby, Spencer. 1909. “The Water Supply of Washington” In (editor, John H. Walker) the *Purification of the Washington Water Supply* (3rd edition), Washington, D.C.: Government Printing Office, Chapter 8, pp. 260-265.

Mohlman, F. W. 1940. “Sewage Treatment in Large American Cities.” *Sewage Works Journal*, 12(1): 168-171.

Parker, Horatio N. 1907. “Stream Pollution, Occurrence of Typhoid Fever, and the Character of Surface Waters in the Potomac Basin.” *Water-Supply and Irrigation Papers of the United States*, Paper No. 192: 191-290.

Penn, James R. 2001. *Rivers of the World: A Social, Geographical, and Environmental Sourcebook.* Santa Barbar, CA: ABC-CLIO, Inc.

United States Engineer Office, War Department. 1939. The Washington Aqueduct Water Supply, District of Columbia. Available at: http://www.waterworkshistory.us/DC/Washington/

1939Aqueduct.pdf.

Unknown Author. 1978. “Blue Plains Treatment Plant, Washington D.C.” *Journal Water Pollution Control Federation*, 50(5): 997-998, 315a, 317a.

Appendix Table 4. Bacteriological Standards for Milk, 1900-1930

City and State	Bacteriological Standard[a]
Baltimore, Maryland	1913
Boston, Massachusetts	1905
Buffalo, New York	1918
Chicago, Illinois	1909
Cincinnati, Ohio	1914
Cleveland, Ohio	1906
Detroit, Michigan	1915
Indianapolis, Indiana	1916
Jersey City, New Jersey	1915
Kansas City, Missouri	1910
Los Angeles, California	1905
Milwaukee, Wisconsin	1908
Minneapolis, Minnesota	1907
Newark, New Jersey	1913
New Orleans, Louisiana	1923
New York, New York	1912
Philadelphia, Pennsylvania	1915
Pittsburgh, Pennsylvania	1910
Providence, Rhode Island	1915
Rochester, New York	1907
San Francisco, California	1909
Seattle, Washington	1910
St. Louis, Missouri	1923
St. Paul, Minnesota	1907

[a] **Baltimore, MD**: On October 15, 1912, Baltimore passed an ordinance setting a bacteriological standard, but the first milk inspectors did not start working until January 1, 1913. **Boston, MA**: On March 1, 1905, the Boston Board of Health (in conjunction with the State Board of Health) set a bacteriological standard for health inspectors to follow. On January 8, 1913, Boston passed an ordinance that required licensing of milk producers and set a bacteriological standard. **Buffalo, NY**: The Buffalo Health Commissioner conducted bacteriological tests of milk as early as 1907, but standards were not set by law until October 9, 1918. **Chicago, IL:** The Chicago milk ordinance that came into effect on January 1, 1909 was nullified by the Illinois legislature on June 12, 1911. A new ordinance, passed on August 14, 1912, required that non-pasteurized milk come from tuberculin-tested cows and meet a bacteriological standard. On July 22, 1916, the Chicago Commissioner of Health required that all milk be pasteurized. **Detroit, MI:** An ordinance required that all milk sold in Detroit be pasteurized as of May 1, 1915. **Philadelphia, PA**: As of October 15, 1909, dairy farmers were required to have a license. Although inspections were conducted under rules set by the Board of Health, a bacteriological standard was not enforced until July 1, 1915.

Notes: Identification of the *Bacteriological Standard* indicator comes from the cities that began requiring that milk sold within their limits meet a bacteriological standard during the period 1910-1930.

Sources for Appendix Table 4

Baltimore, Maryland

Blanck, Fred. 1913. "Report of the Chemical Laboratory." *Annual Report Department of Public Safety*, Sub-Department of Health to the Mayor and City Council of Baltimore for the Fiscal Year Ended December 31, 1912. Baltimore, MD: Meyer and Thalheimer, p. 511-558.

City of Baltimore. 1943. *One Hundred and Twenty-Ninth Annual Report of the Department of Health*. Baltimore, MD: Department of Health.

Early, Floyd R. 1925. "Restrictions of Milk Production in Different Large Cities in the East." *Milk Products Review*, 6(3): 8.

Steffens, D.H. 1913. "Some Weaknesses of the City Inspection Theory." *The Creamery and Milk Plant Monthly*, 1(10): 1-6.

Wessel, Joyce E. 1984. "Baltimore's Dairy Industry and the Fight for Pure Milk, 1900-1920." Business and Economic History, 13 (Papers presented at the thirtieth annual meeting of the Business History Conference), pp. 150-157.

Boston, Massachusetts

Jordan, James O. 1907. "Boston's Campaign for Clean Milk." *Journal of American Medical Association*, 49: 1082-1087.

Massachusetts (State Board of Health). 1912. *The State Board of Health of Massachusetts: A Brief History of its Organization and its Work, 1869-1912*. Boston, MA: Wright and Potter Printing Company, State Printers.

Prescott, Samuel C. 1906. "The Production of Clean Milk as a Practical Proposition" *Maryland Medical Journal*, 49(6): 208-281.

Rosenau, Milton J. 1908. "The Number of Bacteria in Milk and the Value of Bacterial Counts." In *Milk and its Relation to the Public Health*, Washington, D.C.: Government Printing Office, pp. 429-453.

United States Public Health Service. 1946. *List of American Municipalities with Compulsory Pasteurization*. Washington D.C.: U.S. Public Health Service, Sanitary Engineering Division, Milk and Food Section.

Unknown Author. 1943. "Curtains for Raw Milk." *New England Journal of Medicine*, 229(20): 765.

Buffalo, New York

Baker, Moses M. 1910. "The Economic and Sanitary Supervision of City Milk Supplies." *Statistics of Cities Having a Population of Over 25,000: 1907*. Washington, D.C.: Government Printing Office, pp. 36-45, 450.

Mangold, George B. 1908. “Infant Mortality in the American Cities.” *Annals of the American Academy of Political and Social Science*, 31(2): 484-494.

Wende, Ernest. 1908. “The Bulletin’s Mission.” *The Buffalo Sanitary Bulletin*, 1(1): 1-4.

Chicago, Illinois

Czaplicki, Alan. 2007. "Pure Milk Is Better Than Purified Milk": Pasteurization and Milk Purity in Chicago, 1908-1916.” *Social Science History*, 31(3): 411-433

Eastman, Francis. 1912. *Chicago City Manual 1912*. Chicago, IL: Bureau of Statistics and Municipal Library.

Fuchs, A. W. and L.C. Frank. 1938. “Milk Supplies and Their Control in American Urban Communities of Over 1,000 Population in 1936.” *Public Health Bulletin, No. 245*. Washington D.C.: U.S. Public Health Service.

Olmstead, Alan and Paul Rhode. 2004. “An Impossible Undertaking: The Eradication of Bovine Tuberculosis in the United States.” *Journal of Economic History*, 64(3): 734–772.

Rose, James A. 1914. “Dairy Animals – Tuberculin Test.” *Bulletin of the Chicago Tuberculosis Institute,* Series 2, No. 8.

Ward, Archibald Robinson and Myer Edward Jaffa. 1909. *Pure Milk and the Public Health: A Manual of Milk and Dairy Inspection*. Ithaca, NY: Taylor and Carpenter, pp. 200-205.

Cincinnati, Ohio

Blume, R.B. 1922. “Report of the Medical Milk Commission of the Cincinnati Academy of Medicine.” Proceedings of the American Association of Medical Milk Commissions and Certified Milk Producers Association of America. Chicago, IL: American Association of Medical Milk Commissions, pp. 282-286.

Cincinnati (OH). 1913. “Milk. Production, Care, and Sale.” *Public Health Reports* (1896-1970), 28(14): 672-677.

Mangold, George B. 1908. “Infant Mortality in the American Cities.” *Annals of the American Academy of Political and Social Science*, 31(2): 484-494.

United States Public Health Service. 1915. *Municipal Ordinances, Rules, and Regulations Pertaining to Public Health*. Washington, D.C.: Washington Government Printing Office, pp. 240-241.

United States Public Health Service. 1946. *List of American Municipalities with Compulsory Pasteurization*. Washington D.C.: U.S. Public Health Service, Sanitary Engineering Division, Milk and Food Section.

Unknown Author. 1949. “City’s Main Source Closed for Certified Grade Milk at End of Month, is Word.” *Cincinnati Enquirer*, September 16, p. 12.

Cleveland, Ohio

Cleveland (OH). 1915. “Milk and Milk Products. Production, Care, and Sale. Bureau of Dairy and Food Inspection Created.” *Public Health Reports*, 30(46): 3380-3387.

Commission of Publicity and Efficiency. 1919. “Does Regulation Increase the Price of Milk?” *Toledo City Journal*, 4(7): 104.

Lane, C.B. and Ivan C. Weld. 1908. “A City Milk and Cream Contest as a Practical Method of Improving the Milk Supply.” *Bureau of Animal Industry Circular 117*. Washington D.C.: Government Printing Office.

Milk Commission of the City of Cleveland. 1906. “Report of the Milk Commission of the City of Cleveland, December 1906.” *Cleveland Medical Journal*, 6(1): 31-38.

Mowry, Don E. 1908. “Milk Regulation in the Larger Cities.” *Municipal Journal and Engineer*, 25(2): 55.

Detroit, Michigan

Clement, Clarence Elbert and Gustav Paul Warber. 1918. “The Market Milk Business of Detroit, Mich., in 1915” United States Department of Agriculture Bulletin No. 639 (February 15).

Kiefer, Guy L. 1911. “Report of the Milk Inspector.” *Thirtieth Annual Report of the Board of Health of the City of Detroit for the Fiscal Year Ending June 30, 1911*. Detroit, MI: Board of Health, pp. 94-106.

Indianapolis, Indiana

City of Indianapolis (IN) 1940. “Regular Meeting, Monday August 19.” *Journal of the Common Council of the City of Indianapolis, Indiana*, pp. 469-580.

United States Public Health Service. 1917. *Public Health Reports*, 31 (Part 2), Washington, D.C.: Washington Government Printing Office, pp. 2130-2134.

United States Public Health Service. 1946. *List of American Municipalities with Compulsory Pasteurization*. Washington D.C.: U.S. Public Health Service, Sanitary Engineering Division, Milk and Food Section.

Jersey City, New Jersey

Gray, Thomas N. 1913. “Infant Mortality.” *Journal of the Medical Society of New Jersey*, 10(1): 3-9.

United States Public Health Service. 1917. Municipal Ordinances, Rules, and Regulations Pertaining to Public Health, 1915. Washington DC: Washington Government Printing Office, pp. 291-296.

Kansas City, Missouri
Baker, Moses M. 1910. “The Economic and Sanitary Supervision of City Milk Supplies.” *Statistics of Cities Having a Population of Over 25,000: 1907*. Washington, D.C.: Government Printing Office, pp. 36-45.

Treasury Department, United States. 1912. *Municipal Ordinances, Rules, and Regulations Pertaining to Public Hygiene*. Washington, D.C.: Washington Government Printing Office, pp. 102-105

United States Public Health Service. 1916. *Public Health Reports*, 31 (Part 1), Washington, D.C.: Washington Government Printing Office, pp. 34-46.

Los Angeles, California
Koslow, Jennifer. 2004. “Putting It to a Vote: The Provision of Pure Milk in Progressive Era Los Angeles.” *The Journal of the Gilded Age and Progressive Era*, 3(2); 111-144.

Leonard, E.L. 1905. “City Bacteriologist’s Report.” *Annual Report of the City Auditor of the City of Los Angeles, California for the Year Ending November 30, 1905*.

Jackley, J.G. 1920. “Tuberculosis Eradication Work in California.” *The Pacific Dairy Review*, 26(8): 8-9.

Louisville, Kentucky
Baker, Moses M. 1910. “The Economic and Sanitary Supervision of City Milk Supplies.” *Statistics of Cities Having a Population of Over 25,000: 1907*. Washington, D.C.: Government Printing Office, pp. 36-45.

United States Department of Agriculture. 1953. The Marketing of Milk in the Louisville Area Under Federal Regulation. Marketing Research Report No. 43, Washington, D.C.: Government Printing Office.

Milwaukee, Wisconsin
Baker, Moses M. 1910. “The Economic and Sanitary Supervision of City Milk Supplies.” *Statistics of Cities Having a Population of Over 25,000: 1907*. Washington, D.C.: Government Printing Office, pp. 36-45.

Mangold, George B. 1908. “Infant Mortality in the American Cities.” *Annals of the American Academy of Political and Social Science*, 31(2): 484-494.

Minneapolis, Minneapolis
Baker, Moses M. 1910. “The Economic and Sanitary Supervision of City Milk Supplies.” S*tatistics of Cities Having a Population of Over 25,000: 1907*. Washington, D.C.: Government Printing Office, pp. 36-45.

Minneapolis (MN). 1917. Annual Report of the Health Department. Minneapolis, MN: Syndicate Printing Company, p. 83.

Minneapolis (MN), City Council. 1919. Proceedings of the City Council of the City of Minneapolis from January 1, 1919 to January 1, 1920, Volume 45, pp. 364-365.

Minneapolis (MN), City Council. 1907. Proceedings of the City Council of the City of Minneapolis from January 1, 1907 to January 1, 1908, Volume 33, pp. 553-556.

Newark, New Jersey
Gray, Thomas N. 1913. "Infant Mortality." *Journal of the Medical Society of New Jersey*, 10(1): 3-9.

Newark (NJ), Mayor. 1915. "The Mayor's Message Together with the Reports of the City Officers of the City of Newark, NJ." Newark, NJ: Daily Advertiser Office.

United States Congress, House Committee on the District of Columbia. 1921. Sale of Milk, Cream, and Certain Milk Products in the D.C.: Hearings Before the Subcommittee on the District of Columbia, Part 1, House of Representatives. Washington, D.C.: Government Printing Office, p. 39.

New Orleans, Louisiana
Maes, Urban. 1910. "Report of the Milk Commission of the New Orleans Pure Milk Society." *Proceedings of the Fourth Annual Conference of the American Association of Medical Milk Commissions*, 4: 41-43.

New Orleans (LA), Board of Health 1922. "The Following Resolution was Passed at a Regular Meeting of the Board of Health for the Parish of Orleans and the City of New Orleans, October 11." *Monthly Bulletin, Municipal Health Department*, 10(11).

Tuley, Henry Enos. 1915. "President's Address." Proceedings of the Sixth, Seventh, and Eighth Annual Conferences of the American Association of Medical Milk Commissions, Volumes 6-8, pp. 89-93.

United States Public Health Service. 1946. *List of American Municipalities with Compulsory Pasteurization*. Washington D.C.: U.S. Public Health Service, Sanitary Engineering Division, Milk and Food Section.

Unknown Author. 1925. "Hefferman Says Monroe Needing Milk Inspector." *The Monroe News-Star*, January 21, p. 3.

New York, New York
Baker, Moses M. 1910. "The Economic and Sanitary Supervision of City Milk Supplies." *Statistics of Cities Having a Population of Over 25,000: 1907*. Washington, D.C.: Government Printing Office, pp. 36-45 (and page 450).

New York (NY). 1912. "Milk. Production, Care, and Sale. With Special Reference to Pasteurization." *Public Health Reports* (1896-1970), 27(12): 434-438.

New York (NY), Department of Health. 1913. *Weekly Bulletin of the Department of Health of the City of New York*, 2(44): 1-3.

United States Public Health Service. 1946. *List of American Municipalities with Compulsory Pasteurization*. Washington D.C.: U.S. Public Health Service, Sanitary Engineering Division, Milk and Food Section.

Unknown Author. 1943. "New York City Certified Milk to be Pasteurized." *American Journal of Public Health*, 33 (October): 1305.

Philadelphia, Pennsylvania

Beard, Charles Austin. 1913. "Notes and Events." *National Civic Review*, 2(4): 675-719.

Early, Floyd R. 1925. "Restrictions of Milk Production in Different Large Cities in the East." *Milk Products Review*, 6(3): 8.

Gittings, J.C. 1922. "Report of the Milk Commission of the Philadelphia Pediatric Society" Proceedings of the American Association of Medical Milk Commissions and Certified Milk Producers Association of America. Chicago, IL: American Association of Medical Milk Commissions, pp. 463-465.

Henry Phipps Institute. 1915. "Food Inspection Service in Philadelphia." *Report of the Henry Phipps Institute*, 12: 57-94.

Mowry, Don E. 1908. "Milk Regulation in the Larger Cities." *Municipal Journal and Engineer*, 25(2): 55.

Philadelphia, PA, Department of Public Health. 1931. *Quarterly Bulletin of the Department of Public Health of the City of Philadelphia*. Philadelphia, PA.

Pittsburgh, Pennsylvania

Pittsburgh City Council. 1911. Municipal Record. Minutes of the Proceedings of the Select Council of the City of Pittsburgh for the Years 1910-1911, Volume 43. Pittsburgh, PA: Devine and Co., pp. 212-215.

Edwards, Ogden M. 1910. "Report of the Milk Commission of the Allegheny County Medical Society of Pittsburgh, PA." *Proceedings of the Fourth Annual Conference of the American Association of Medical Milk Commissions*, 4: 44-50.

United States Public Health Service. 1946. *List of American Municipalities with Compulsory Pasteurization*. Washington D.C.: U.S. Public Health Service, Sanitary Engineering Division, Milk and Food Section.

Unknown Author. 1942. "Ban on Raw Milk Voted by Council." *The Pittsburgh Press*, June 23, p. 21.

Providence, Rhode Island
Providence, RI. 1916. *Resolutions and Ordinances of the City Council of the City of Providence*. Providence, RI: Providence Printing Company, pp. 166-173.

Rochester, New York
Goler, G.W. 1919. "Control of the Milk Supply by the Rochester Milk Department." *Report of the Rochester Milk Survey*, pp. 160-175.

Groenewold, Ellen. 1908. "Milk Supply and Public Health." *NDQ: North Dakota Quarterly*, 8: 239-254.

Mowry, Don E. 1908. "Milk Regulation in the Larger Cities." *Municipal Journal and Engineer*, 25(2): 55.

Rochester (NY), Common Council. 1922. *Record of the Proceedings of the Common Council of the City of Rochester*. Rochester, NY: Rochester Herald Company, p. 350.

San Francisco, California
Hutshing, E.E. 1913. "The Milk Supply of San Francisco and it Bacterial Content." *California State Journal of Medicine*, 11(1): 14-17.

San Francisco (CA). 1910. *San Francisco Municipal Reports for the Fiscal Year 1908-9*. San Francisco, CA: Neal Publishing Company.

San Francisco (CA). 1915. *Ordinances Relating to the Preservation of Public Health, Regulation of Hospitals, Prevention of Disease, Preparation of Food, and Regulation of Places where Food is Offered for Sale*, pp. 25-33.

Skelly, Al. 1944. "Concerning San Francisco Ordinance Requiring Pasteurization of Milk." California and Western Medicine, 60(6): 355.

United States Public Health Service. 1917. *Municipal Ordinances, Rules, and Regulations Pertaining to Public Health.* Washington, D.C.: Washington Government Printing Office, pp. 160-173.

United States Public Health Service. 1946. *List of American Municipalities with Compulsory Pasteurization*. Washington D.C.: U.S. Public Health Service, Sanitary Engineering Division, Milk and Food Section.

Seattle, Washington
Glover, M.W. 1909. "Statement of the Sanitary Condition of Seattle, Wash." *Public Health Reports*, 24(51): 1899-1939.

Bagley, Clarence B. 2017. History of Seattle, Volume 2. Altenmünster, Germany: Jazzybee Verlag.

St. Louis, Missouri

Baker, Moses M. 1910. “The Economic and Sanitary Supervision of City Milk Supplies.” *Statistics of Cities Having a Population of Over 25,000: 1907*. Washington, D.C.: Government Printing Office, pp. 36-45.

Board of Aldermen of the City of St. Louis. 1921. “An Ordinance to Regulate the Production and Sale of Milk, Cream, and Ice Cream, and for Other Purposes.” *The City Journal*, 4(17): 16-17.

Brown, C.A. 1928. *Costs and Margins and Other Related Factors in the Distribution of Fluid Milk in Four Illinois Markets*. University of Illinois, Bulletin Number 318: Urbana, IL.

Unknown Author. 1922. “News from Far and Near.” *The Milk Dealer: The National Journal for the City Milk Trade*, 11(12): 101-104.

St. Paul, Minnesota

Baker, Moses M. 1910. “The Economic and Sanitary Supervision of City Milk Supplies.” *Statistics of Cities Having a Population of Over 25,000: 1907*. Washington, D.C.: Government Printing Office, pp. 36-45.

Mowry, Don E. 1908. “Milk Regulation in the Larger Cities.” *Municipal Journal and Engineer*, 25(2): 55.

Washington, D.C.

Dahlberg, Arthur Chester, H.S. Adams and M.E. Held. 1953. Sanitary Milk Control and Its Relation to the Sanitary, Nutritive, and Other Qualities of Milk. Washington D.C.: National Academy of Sciences.

United States Congress House Committee on the District of Columbia. 1921. Sale of Milk, Cream, and Certain Milk Products in the District of Columbia: Hearings before the Subcommittee on the District of Columbia, House of Representatives, 67th Congress. Washington, D.C.: Washington Government Printing Office, pp. 3-5.

Appendix Table 5. Public Health Interventions and Summer Diarrhea, 1910-1930

	(1)	(2)	(3)
		ln(*Diarrhea*)	
Filtration	-.137**	-.131***	-.113***
	(.058)	(.056)	(.054)
Filtration × 70°F and Above	.209**	.234**	.236**
	(.091)	(.098)	(.100)
Chlorination	-.005	-.002	-.014
	(.051)	(.046)	(.047)
Chlorination × 70°F and Above	.056	.033	.071
	(.075)	(.073)	(.073)
Clean Water Project	…	.123	.148
		(.139)	(.136)
Clean Water Project × 70°F and Above	…	.096	.117
		(.085)	(.095)
Sewage Treated	…	.044	.044
		(.066)	(.061)
Sewage Treated × 70°F and Above	…	-.007	.013
		(.140)	(.145)
Bacteriological Standard	…	…	.077
			(.049)
Bacteriological Standard × 70°F and Above	…	…	-.064
			(.088)
N	6,552	6,552	6,552
R^2	.857	.858	.858

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

Notes: Based on annual data from *Mortality Statistics* for the period 1910-1930, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the number of diarrheal deaths among children under the age of two per 100,000 population in city *c* and month *t*. Controls include the city characteristics listed in Table 1, city fixed effects, month-by-year fixed effects, and city-specific linear trends. Regressions are weighted by city population. Standard errors, corrected for clustering at the city level, are in parentheses.

Appendix Table 6. Cities and Years Covered in Summer Diarrhea Analysis by Race

City and State	Years Covered
Baltimore, Maryland	1910, 1912-1930
Boston, Massachusetts	1913-1915, 1918
Chicago, Illinois	1910, 1912-1930
Cincinnati, Ohio	1910, 1912-1930
Cleveland, Ohio	1920-1930
Detroit, Michigan	1920-1930
Indianapolis, Indiana	1910, 1912-1930
Kansas City, Missouri	1910, 1912-1930
Los Angeles, California	1914, 1915, 1918-1930
Louisville, Kentucky	1910, 1912-1930
New Orleans, Louisiana	1910, 1912-1930
New York, New York	1910, 1912-1930
Newark, New Jersey	1930
Philadelphia, Pennsylvania	1910, 1912-1930
Pittsburgh, Pennsylvania	1910, 1912-1930
San Francisco, California	1913-1915, 1918, 1930
Seattle, Washington	1919
St. Louis, Missouri	1910, 1912-1930
Washington, D.C.	1910, 1912-1930