NBER WORKING PAPER SERIES

SAFEGUARDING CONSUMERS THROUGH MINIMUM QUALITY STANDARDS: MILK INSPECTIONS AND URBAN MORTALITY, 1880-1910

D. Mark Anderson
Kerwin Kofi Charles
Michael McKelligott
Daniel I. Rees

Working Paper 30063
http://www.nber.org/papers/w30063

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
May 2022, Revised July 2022

We thank Lauren Hoehn-Velasco, Sam Preston, Paul Rhode, Randy Rucker, Tianyi Wang and seminar participants at Montana State University and the 2022 American Economic Association Annual Meeting for comments and suggestions. We also thank Mary Guthmiller at the Montana State University library for her help with obtaining municipal and state public health records via interlibrary loan. Partial support for this research came from a Eunice Kennedy Shriver National Institute of Child Health and Human Development research infrastructure grant, R24 HD042828, to the Center for Studies in Demography and Ecology at the University of Washington. Support also came from the Comunidad de Madrid, grant EPUC3M11 (V PRICIT) and grant H2019/HUM-5891. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Safeguarding Consumers Through Minimum Quality Standards: Milk Inspections and Urban Mortality, 1880-1910
D. Mark Anderson, Kerwin Kofi Charles, Michael McKelligott, and Daniel I. Rees
NBER Working Paper No. 30063
May 2022, Revised July 2022
JEL No. H75,I18,J18,L51,N31

ABSTRACT

We examine the effect of enforcing minimum quality standards (MQSs) on consumer health. In the late 1800s, the urban milk supply was regularly skimmed and diluted with water, but consumers could not easily determine its quality because dyes, caramel, and salt were added. To protect consumers, milk inspectors were tasked with enforcing a well-defined MQS. Using city-level data for the period 1880-1910, we find that milk inspections reduced mortality from waterborne and foodborne diseases by 12-19 percent. Ours is the first study to provide evidence that MQSs can improve consumer health when directly applied to an experience or credence good.

D. Mark Anderson
Department of Agricultural Economics
& Economics
Montana State University
P.O. Box 172920
Bozeman, MT 59717
and NBER
dwight.anderson@montana.edu

Kerwin Kofi Charles
School of Management
Yale University
165 Whitney Avenue
New Haven, CT. 06511
and NBER
kerwin.charles@yale.edu

Michael McKelligott
Harris School of Public Policy
University of Chicago
1307 E 60th St
Chicago, IL 60637
mckelligott.michael@gmail.com

Daniel I. Rees
Department of Economics
Universidad Carlos III de Madrid
Calle Madrid 126
28903 Getafe
Spain
Daniel.Rees@uc3m.es

This commodity is such an essential food in the dietary of every household, and at the same time is so…dangerous a medium for carrying disease that the duty to safeguard its purity and wholesomeness has been recognized in most large centers.

--C.S. Duncan writing in the *Journal of Political Economy*, 1918

1. INTRODUCTION

Economists have a longstanding interest in government-mandated quality inspections (Mill 1859, 1909; Jevons 1882). Viewed as remedying market failure caused by asymmetric information between buyers and sellers, government inspections incentivize adherence to minimum quality standards (MQSs) but, in theory, can restrict output and "price out" economically vulnerable consumers (Wetherill and Chiu 1975; Leland 1979; Garella and Petrakis 2008; Hotz and Xiao 2011).

Many goods and services are subject to MQSs and government inspections. For instance, restaurants in the United States are periodically inspected by local, county, or state health departments, while meat and poultry shipped across state lines must be inspected by the Food Safety and Inspection Service. Although quality inspections are, in the words of Jevons (1882, p. 44), supposed to offer protection against the unwitting purchase of "putrid sausages, poisonous pickles, [and] dangerous guns," previous research has often focused on code violations or inspection scores (Feinstein 1989; Campbell et al. 1998; Aldrich 2007; Kovács et al. 2013; Jin and Lee 2014, 2018; Ibanez and Toffel 2020), neither of which is necessarily related to consumer health or safety.[1]

In this study, we examine the effects of milk inspections, which were undertaken by most major American cities in the 1880s and 1890s, on two health-related outcomes of obvious importance to consumers: infant mortality and mortality from waterborne and foodborne diseases

[1] For instance, Jones et al. (2004) examined scores from 167,574 routine restaurant inspections conducted in Tennessee during the period 1993 to 2000. None of the 12 most cited violations were related to critical food safety hazards, defined as those "more likely to contribute to food contamination, illness, or environmental degradation…" Several studies provide evidence that the association between restaurant inspection scores and foodborne illness outbreaks is, at best, weak (Cruz et al. 2001; Jones et al. 2004; Lee and Hedberg 2016). Other research has examined how consumers react to the posting of hygiene grade cards in restaurant windows (Jin and Leslie 2003). An important distinction between MQSs and the mandatory posting of grades is that any product falling below a MQS is withheld from the market entirely, while buyers are at liberty to choose among different product grades (Gardner 2003).

(hereinafter referred to as "waterborne diseases"). Before the advent of milk inspections, the milk supply of American cities was regularly diluted with (potentially contaminated) water and skimmed; boric acid was often added as a preservative (Hart 1952; Meckel 1990). Although consumers occasionally complained about the use of boric acid, public health experts were particularly concerned about dilution and skimming (Newton 1877; Morris 1885), both of which reduced the nutritional value of milk.[2] In an effort to curb these practices, municipal inspectors were tasked with collecting and analyzing milk samples. Dairymen, dealers, and retailers who were caught peddling substandard milk were fined and their product was spilled onto the ground.

Milk in the last decades of the 19th century can be thought of as an "experience" or "credence" good. Buyers cannot determine the quality of an experience good before its purchase (Nelson 1970), while the quality of credence goods is difficult to evaluate even after purchase and consumption (Darby and Karni 1973).[3] Milk inspectors, with the help of a lactometer, measured the percentage of solids in milk to determine whether it was watered or skimmed. Consumers, on the other hand, could not easily ascertain the quality of milk because caramel, dyes, salt, and sugar were added to restore its color, body, and taste (Newton 1877; Hart 1952). If an infant or child ingested milk to which contaminated water had been added, linking an infection back to its original source would have been impractical, if not impossible.

---

[2] Derived from borax, boric acid is toxic and, if ingested by humans, can cause diarrhea and vomiting (Litovitz et al. 1988). The practice of adding borax to milk was still widespread at the turn of the 20th century despite consumer complaints ("Pure and Impure Milk" 1876; "Dangerous Milk Adulteration" 1879; "How Milk is Adulterated" 1887; "A Chemical Examination Shows Borax Acid in Milk" 1889). Today, boric acid is commonly used as an insecticide and fungicide (See et al. 2010). Other preservatives frequently added to milk in the last decades of the 19th century include formaldehyde, sodium carbonate, and sodium bicarbonate (Newton 1877; Martin 1884; Drescher 1887; Hart 1952).

[3] Darby and Karni (1973) were the first to describe goods with so-called credence qualities. According to Darby and Karni (1973, pp. 68-69), credence goods "cannot be evaluated in normal use" and additional costly information is required for assessment. The line between experience goods and credence goods is not always sharp, especially if quality can only be determined with sustained use (Darby and Karni 1973).

Today, health and safety regulations are typically complex and multi-layered, making it challenging to credibly estimate the effect of any one facet of the regulatory environment. By contrast, urban milk markets were wholly unregulated before the hiring of municipal inspectors. Requirements that milk meet bacteriological standards, which encouraged pasteurization, and requirements that dairy cows be tested for tuberculosis were post-1900 phenomena (Meckel 1990, pp. 62-91; Anderson et al. 2022a). Moreover, the supply chain was, by modern standards, exceedingly short and simple. The milk was transported from nearby farms on wagons or trains in the morning, and then sold—and typically consumed—within a day or two.

Contemporary public health experts credited milk inspections with saving the lives of thousands of infants and children every year (Meckel 1990, p. 68). According to a Dr. H.A. Pooler, milk inspections in New York City "had a very happy effect by reducing the death rate of children…3,673 less in 1883 than in 1882, other conditions of the city being about the same" (Morris 1885, p. 250). Dr. Pooler did not adjust his estimate for the fact that mortality had begun to trend downwards in New York City (and other major American cities) well before the hiring of milk inspectors (Higgs 1979), but his claim of *ceteris paribus* was not otherwise farfetched. Milk inspections were the first—and, for almost two decades, the only—concerted, widespread effort aimed at improving the quality of the milk supply and reducing the alarmingly high rates of mortality among infants and children living in the crowded tenements of major U.S. cities (Meckel 1990).

Our analysis uses mortality data from 35 U.S. cities for the period 1880-1910 (Appendix Table A1). Newly transcribed mortality counts for the period 1880-1899 come from municipal and state public health reports, obtained from a variety of sources including the archives at the National Library of Medicine in Bethesda, Maryland. Mortality counts for the period 1900-1910 come from *Mortality Statistics*, published annually by the U.S. Census Bureau.

Event-study estimates provide little support for the hypothesis that enforcing a well-defined MQS through pre-market inspections reduced infant mortality. This result updates, and is consistent with, estimates reported by Anderson et al. (2022b). When we shift our focus to waterborne diseases such as diarrhea and typhoid, there is strong evidence that enforcing a MQS through conducting inspections led, on net, to better health outcomes. Five years after their start, inspections are associated with a 12 percent reduction in mortality from waterborne diseases; after 10+ years, inspections are associated with a 19 percent reduction in mortality from waterborne diseases. It is likely that milk inspections reduced waterborne mortality by discouraging dairymen, dealers, and retailors from diluting their milk with water, which was all too often demonstrably contaminated with typhoid or other potentially harmful bacteria such as *E. coli* (Kober 1902; Trask 1908). However, because many typhoid outbreaks at the turn of the 20th century were credibly linked to the handling of milk by infected dairy workers (Kober 1902; Trask 1908; Frost 1916), we cannot dismiss the possibility that inspections reduced waterborne mortality through curbing the sale of skimmed milk.

By the 1880s, physicians were recommending that milk be heated at home to destroy microscopic pathogens (Neville 1880; Levenstein 1983), and it is possible that the public discourse surrounding the hiring of milk inspectors encouraged this practice. To explore whether household efforts to sterilize milk can explain the negative association between milk inspections and waterborne mortality, we turn to diphtheria mortality. Diphtheria can be transmitted through the consumption of raw dairy products but not through water; the bacteria that cause diphtheria are easily destroyed by heating (Schereschewsky and Dyer 1922; Wagner et al. 2011). We find no evidence that milk inspections reduced diphtheria mortality, suggesting that the strong, negative association between milk inspections and mortality from waterborne diseases is not driven by household efforts to sterilize milk through heating.

Our results are directly relevant to ongoing policy debates regarding MQSs and their effects on consumer welfare (Gardner 2003; Swinnen et al. 2015). If quality can be accurately assessed before purchase, MQSs clearly benefit producers at the expense of consumers (Bockstael 1984). There is, however, a stronger theoretical case to be made for MQSs if quality cannot be easily assessed before, or even after, purchase (Leland 1979; Garella and Petrakis 2008). Previous studies provide evidence that, when applied to production inputs, MQSs restrict supply and put upward pressure on prices (Chipty and Witte 1997; Hotz and Xiao 2011; Kawaguchi et al. 2014). Our study is the first to provide evidence that MQSs can improve consumer health when they are applied directly to an experience or credence good.

The remainder of the paper is organized as follows. We begin by providing background information, including an introduction to milk inspections in the late 19th century and a brief description of the previous empirical work on MQSs. In Section 3, we focus on descriptive first-stage evidence from Boston, where there was an unexpected ten-fold increase in the intensity of milk inspections. We describe our data and empirical framework in Section 4, and report our results in Section 5. Section 6 concludes.

2. Background

2.1. Milk inspections

Exclusive breastfeeding was not the norm at the turn of the 20th century among American mothers (Woodbury 1925, 1926; Wolf 2001, 2003).[4] Instead of breast milk, mothers typically fed their infants a gruel that contained water and cows' milk (Alsan and Goldin 2019). Because infants

[4] In 1912, the *Journal of the American Medical Association* lamented that the "nursing period has gradually been diminished to one year, then to six months, then to three months, and now it is largely a question as to whether the mother will nurse her baby at all" ("The Care of Infants Historical Data" 1912, p. 542). A 1915 study of children born in Montclair, New Jersey found that 20 percent of 3-month-olds and half of 9-month-olds had been completely weaned (Williamson 1915).

were weaned at such an early age, the dilution of cows' milk represented a direct threat to their health. Although it was widely recognized that the water added to milk could carry deadly pathogens (Steere-Williams 2020), public health officials in the 1870s and 1880s were focused on ensuring that infants and children received adequate nutrition (Meckel 1990, pp. 68-70).[5] Several cities had already prohibited the selling of adulterated food and milk, but these ordinances appear to have been of little practical value either because "adulteration" was vaguely defined or inadequate provision was made for enforcement (Meckel 1990, pp. 68-70).[6]

The hiring of milk inspectors was viewed as a crucial first step towards purifying the milk supply.[7] Their principal task was to enforce a minimum threshold for milk solids, typically set at 12 percent.[8] Absent this well-defined threshold, milk could be watered or skimmed with impunity

---

[5] For instance, Newton (1877, p. 222), the New Jersey milk inspector, wrote:

> If we try to nourish a child on skimmed or water milk, fat in insufficient quantities is supplied, wasting results, death may follow; or, in other words, the child is starved…Milk, being the principal article of diet in infancy, we naturally turn to that period of life to find the effects of impure milk; and it is just at that period of life that we note the highest mortality. Thousands of children perish annually from starvation due to feeding on skimmed and watered milk.

The classic study conducted by Ballard (1871) led to the widespread recognition that typhoid could be transmitted through the practice of diluting milk with contaminated water (Steere-Williams 2020).

[6] For instance, the milk inspector for the state of New Jersey argued that an 1875 law prohibiting the adulteration of milk was "practically a dead-letter" because:

> …no standard of purity is fixed by law, on which to base degrees of sophistication…A standard of purity should be fixed by law and officers, competent to determine the degree and character of adulteration, should be appointed to make analyses for the health officers in our towns and cities (Newton 1877, p. 231).

[7] Public health officials recognized the importance of milk inspections relative to the inspection of meat products because "milk is so largely used as the food of infants" ("Microbes in Milk" 1898, p. 6). Preston and Haines (1991) argued that purifying the milk supply was more important to the health of infants and children than purifying the water supply. Rashid (1988, p. 248) argued that American cities were not supplied with clean milk until after the 1920s when "large-scale production and distribution" became the norm.

[8] With only a handful of exceptions, American cities required that milk have at least 12 percent solids and 3 percent fat (Alvord and Pearson 1903; Doane 1905). Milk sold in Atlanta, Boston, Minneapolis, and Saint Paul had to have at least 13 percent total solids ("The New Milk Law" 1880; "Milk Adulteration in St. Paul and Minneapolis" 1887; Alvord and Pearson 1903).

because it was nearly impossible to obtain a conviction. For instance, upon being appointed in January of 1889, the first Philadelphia milk inspector complained that, under existing legislation, "the act of adulteration must be witnessed by an officer of the law" ("Can be Read at a Glance" 1889; "Long Live the Pump" 1890, p. 8). Soon after, an ordinance defining what constituted impure milk was passed by the Philadelphia City Council ("Work of the City Council" 1890).[9]

Using a lactometer, inspectors could do on-the-spot testing at retailers, train depots, and as milk wagons came into the city.[10] If the lactometer reading was too low, or if the milk had a suspicious bluish hue, then health departments employed chemists to perform more sophisticated analyses.[11] Fines for selling substandard milk varied from city to city but could be quite steep. First-time offenders in Philadelphia were fined $50 and this amount doubled for the second offense ("Providing for Milk Inspection" 1889; "Brief Comment" 1892). In St. Louis, offenders were

---

[9] According to the new Philadelphia ordinance, milk was considered to be adulterated if it contained less than 12 percent solids or less than 9 percent "mixed solids, exclusive of butter fat" ("Sale of Impure Milk" 1890, p. 3). In 1880, the Boston milk inspector complained that it was "almost impossible to convict the sellers of watered or doctored milk" and that the penalties were "not severe enough to break down the practice" ("The Adulteration of Milk" 1880, p. 2), whereupon Boston adopted a well-defined pure milk standard (i.e., a minimum threshold of 13 percent solids) as well as new penalties for selling adulterated or skimmed milk ("The New Milk Law" 1880).

[10] Inspections of milk wagons coming into the city and at train depots were often conducted before sunrise ("Events in the Metropolis" 1883). The proprietor of the Harlem milk depot in 1878 cursed milk inspectors as "a pack of sneaks" operating under the cover of darkness ("A 'Skim' Milk Crusade" 1878, p. 8).

[11] Geisler (1891 p. 93) provided instructions for using a lactometer:

> The milk to be tested should be warmed or cooled, as the case may be, to the temperature of 60° Fahr. The lactometer is placed in it, care being taken not to wet that part of the stem above the milk. Now take the lactometer out of the milk and observe whether the thin film adhering to it runs rapidly off, and whether the milk appears thin and blueish and the taste of the milk is flat and watery: if such is the case and the lactometer floats at some point less than 100—as, for instance, 90—then we are reasonably certain that water has been added.

Using a lactometer did not guarantee that milk was above the minimum 12 percent threshold for solids. Unscrupulous dealers and retailers added salt and sugar to raise the density of skimmed or watered milk. Because cream and water are both lighter than whole milk, the practice of simultaneously skimming and watering was difficult to detect using a lactometer (Doremus 1885; Meckel 1990, p. 261).

punished by "a fine of not less than $50 nor more than $500" ("Human Foods" 1888, p. 3), and in Chicago fines ranged from $25 to $100 ("Strike for Reform" 1892).[12]

There is anecdotal evidence that consumers were unaware of, or indifferent to, the adulteration and skimming of milk.[13] Skimmed milk, which cost a penny or two less per quart, was often sold in poorer neighborhoods (Merrick 1879; State Charities Aid Association 1883; Welply 1894). Reformers and government officials worried that the children of mothers living in tenements were particularly susceptible to becoming malnourished (State Charities Aid Association 1883; "Work Among the Babies" 1883; Ives 1889), but at least one observer noted that stores openly selling skimmed milk were "always thronged with customers" and that their patrons received considerably more milk for their money (Merrick 1879, p. 5).[14]

2.2. Other efforts to provide pure milk

By the end of the 19th century, other efforts to ensure the wholesomeness and safety of the urban milk supply were coming to the fore (Meckel 1990; Preston and Haines 1991). The first milk station was opened in 1893 by Nathan Straus, a New York City philanthropist. It provided

---

[12] One year after Chicago began inspecting its milk supply, Dr. Adolph Gehrmann, who was in charge of the milk and food section of the city health department, remarked on their efforts:

> Eleven dealers were prosecuted in February for violation of the milk ordinance, eleven in March, seventeen in April, and twenty in May. In nearly every case a conviction was secured, though in some cases the parties had sufficient political influence to send around to the Law Department and have the fines suspended. Still the work has been beneficial to the public in the improvement of the quality of the milk sold. Until June 1 the use of coloring water was quite general. Now we discover only two or three cases of it a day. The milk dealers do not like being prosecuted. We have had to prosecute only five or six of them twice ("To Secure Pure Milk" 1894, p. 14).

[13] See, for instance, "Dairy Farming" (1877), Merrick (1879), "'Prepared,' not 'Adulterated Milk'" (1883); Bellevue (1888), "Items of Interest" (1891), and Chapin (1901).

[14] Instead of prohibiting the sale of skimmed milk, cities such as Boston and Philadelphia required that it be accurately labeled. Newton (1881, p. 119) noted that these labels were difficult for customers to read and urged New Jersey to follow the example of New York City by imposing an outright ban on the sale of skimmed milk. See "How to Get Pure Milk" (1892. p. 4) for evidence that Philadelphia milk dealers purposely concealed labels on milk cans.

subsidized, pasteurized milk to low-income mothers living on the Lower East Side. Within a decade, milk stations had also opened in Chicago and Rochester (McCleary 1904; Kerr 1910). Operated by public health departments as well as private philanthropies, milk stations became widespread after 1908 (Kerr 1910; Condran and Lentzner 2004).

Boston was the first city in the United States to set a so-called bacteriological standard for milk. As of June 5, 1905, milk sold in Boston could have, at most, 500,000 bacteria per cubic centimeter (Rosenau 1909).[15] Initially "the subject of scoffing" (Rosenau 1909, p. 434), similarly strict limits on bacteria were eventually adopted by almost every major American city (Anderson et al. 2022a). Bacteriological standards encouraged pasteurization, but there is no evidence that they reduced infant, typhoid, diarrheal, or non-pulmonary tuberculosis mortality rates (Anderson et al. 2022a), all of which had been rapidly declining for at least two decades (Anderson et al. 2022b).

Between 1900 and 1910, most American cities began inspecting the dairy farms that supplied their milk (Parker 1917).[16] These inspections focused on inputs to the production of milk as opposed to the quality of the milk itself. Dairy workers and cows were supposed to be free of transmittable diseases, barns had to have adequate ventilation and lighting, and utensils (e.g., coolers, pails, and strainers) were supposed to be regularly sterilized (Alvord and Pearson 1903; Magruder 1910; Price 1912; Parker 1917). Using data from 40 U.S. cities for the period 1900-1920, Komisarow (2017) found that dairy farm inspections were associated with a 14-20 percent reduction in mortality from diarrhea and enteritis among one-year-olds but had no effect on infant mortality.

---

[15] Ordinances requiring milk to meet bacteriological standards are often referred as "pasteurization ordinances" (Troesken 2015, pp. 33-34; Komisarow 2017, p. 131) because these standards were difficult to meet without resorting to pasteurization (Meckel 1990, pp. 88-89).

[16] A handful of cites in our sample, including Baltimore (1896), Indianapolis (1897), Newark (1882), Rochester (1898), St. Paul (1899), and Washington D.C. (1895), began inspecting dairy farms prior to 1900 (Parker 1917, Table 114). By 1913, 167 U.S. cities with a population greater than 25,000 were inspecting their dairy farms (Jordan 1913, Table 1). In 1912, New York City became the first city to introduce a grading system for market milk (Lee 2007).

Finally, bovine tuberculosis (TB), which can be transmitted through unpasteurized milk, represented an important threat to the health of consumers at the turn of the 20th century (Olmstead and Rhode 2004). In 1907, St. Paul and Cincinnati became the first cities in our sample to require that milk sold within their limits come from TB-tested cows, and other major cities soon followed suit. However, municipal-level efforts to protect consumers from bovine TB appear to have had little, if any, effect on mortality (Anderson et al. 2022a). The disease was ultimately brought under control through a federal eradication campaign that began in 1917 (Olmstead and Rhode 2004).

2.3. Minimum quality standards and their effects

Previous empirical studies provide evidence, albeit limited, on the effects of imposing and enforcing quality standards. In 2007, the Japanese government adopted a stricter planning and approval process for buildings with a height of 13 or more meters.[17] Kawaguchi et al. (2014) found that the adoption of this stricter planning process restricted the supply of new condominiums in Tokyo, increasing the price of existing condominiums by 15 percent.

Hotz and Xiao (2011) examined the effects of imposing more stringent quality standards in the childcare market. The quality of childcare centers is, *ex-ante* (and even *ex-post*), often difficult for parents to assess (Mocan 2007). Hotz and Xiao (2011) found that caps placed on the number of children per staff and educational/training requirements for staff reduced the supply of childcare centers (especially in low-income markets), shifting children from childcare centers into family daycare homes. Hotz and Xiao (2011) were not, however, able to examine whether this crowding-out phenomenon hampered the cognitive or emotional development of children.[18]

[17] Under this stricter planning and approval process, architects were required to use government-approved "structural calculation software" when designing buildings with a height of 13 or more meters (Kawaguchi et al. 2014, p. 199). In addition, architects were required to submit their original data so that inspectors could check their structural calculations.

[18] Chipty and Witte (1997), Blau (2007), and Currie and Hotz (2004) also examined the effects of MQSs for childcare. Chipty and Witte (1997) found that more stringent quality standards can induce childcare centers to exit the market.

The quality standards examined by Hotz and Xiao (2011) and Kawaguchi et al. (2014) were imposed on inputs to production. The theoretical literature has, by contrast, focused on MQSs applied directly to a good or service (Leland 1979; Bockstael 1984; Ronnen 1991; Lapan and Moschini 2007; Garella and Petrakis 2008). MQSs applied directly to a good or service can, in theory, restrict output and put upward pressure on prices, but consumers are provided some assurance against the unwitting purchase of a low-quality product.[19] Which of these two effects dominates is an open question. It depends upon—among other things—market structure, the availability of suitable substitutes, and the share of consumers who cannot easily ascertain quality before purchase (Ronnen 1991; Crampes and Hollander 1995; Garella and Petrakis 2008).

3. Did Milk Inspections Matter? First-stage Evidence from Boston

As a prelude to our principal analysis, we examine an overhaul of the Boston milk inspections system that occurred in the spring of 1885. The advantage of focusing on this overhaul and its aftermath is that we have monthly data on a first-stage outcome not available elsewhere: the percent of milk samples adulterated with water. Although the results of this case study are purely descriptive, they provide evidence that milk inspections could, if pursued with vigor, have a dramatic impact on the quality of milk sold in a large urban market.[20]

Blau (2007) found that more stringent quality standards did not affect price or quality, but instead led to childcare centers cutting the pay of their workers. Estimates produced by Currie and Hotz (2004) suggest that requiring daycare center directors to have more education reduces the incidence of unintentional child injuries. A related literature has studied minimum staffing requirements for nursing homes (see, e.g., Bowblis 2011; Tong 2011; Matsudaira 2014; Chen and Grabowski 2015).

[19] To our knowledge, the only evidence that consumers can benefit from a well-defined MQS directly applied to a good or service comes from Kotschedoff and Pachali (2020). These authors studied a German prohibition on the production and sale of the lowest-quality eggs (i.e., "battery-cage" eggs), which was implemented to promote animal welfare. Using survey data on household purchases and estimating a structural demand model, they found that higher-income households were willing to pay more for eggs that came from hens raised in better living conditions (e.g., open range).

[20] This case study is based on annual reports of the Inspector of Milk and Vinegar published by the City of Boston and contemporary newspaper accounts. See Appendix B for a full list of sources. Boston is not included in our principal mortality analysis because pre-treatment mortality data are not available.

The first Boston milk inspector, Henry Faxon, was hired in 1859. He remained in office for 20 years, but eschewed the use of a lactometer and, by all accounts, failed to curb the widespread practice of adulteration (Parker 1917; "Report of the Inspector of Milk" 1878; "The Inspection of Milk" 1879; "'Prepared, not 'Adulterated Milk'" 1883). His immediate successors were apparently no more effective. An 1884 study conducted by the Massachusetts Board of Health found that fully 40 percent of the milk being sold in Boston was watered (City of Boston 1889).

The Boston milk market was unexpectedly and radically upended when James F. Babcock became the Inspector of Milk and Vinegar on April 6, 1885 in the wake of a scandal involving his predecessor.[21] Upon taking office, Babcock reorganized his department, increasing the intensity of milk inspections almost tenfold.[22] In the pre-Babcock era, between 90 and 100 milk samples were collected and analyzed per month. Only one month into office, Babcock stepped up the pace of milk inspections, collecting "samples from all parts of the city" ("Watching Milkmen" 1885, p. 4). In May of 1885 alone, his department collected and analyzed more than 600 samples of milk; in June of 1885, his department collected and analyzed 1,070 milk samples ("Watching Milkmen" 1885; "Work Performed by Milk Inspector Babcock" 1885).[23]

Figure 1 shows the percent of the Boston milk supply adulterated with water during the period 1884-1888. This information comes from the 1888 annual report of the Boston Milk and Vinegar Inspector, which highlighted Babcock's accomplishments (City of Boston 1889). Forty

---

[21] His predecessor, B.F. Davenport, held the office for less than a year. The mayor declined to reappoint him when it was discovered that he had spent $1,311 without the authority of the City Council ("The Assumption of Milk Inspector Davenport Condemned" 1884; "Boston's Milk Inspector" 1885).

[22] The explicit goal of the department reorganization was that "inspection should be so extensive that every dealer should be made to feel that he is liable to have his milk tested on any day (including Sundays), and at any hour" (City of Boston 1889, p. 12).

[23] According to the annual reports of the Boston Milk and Vinegar Inspector, 1,072 milk samples were collected and analyzed in 1884 ("Annual Report of the Milk Inspector" 1885). By contrast, 9,853 milk samples were collected and analyzed in 1885 ("Good and Bad Milk" 1886).

percent of milk samples were found to have been adulterated in 1884, the year before Babcock reorganized the department. Similarly, 39 percent of milk samples were found to have been adulterated in May, June, and July of 1885, when Babcock's inspectors gave first offenders warnings and only a handful of prosecutions were pursued.[24] Starting in August of 1885, adulteration rates began to trend downwards. Although rebounding in the summer of 1886, the adulteration rate never approached 40 percent again. In 1888, Babcock's last full year in office, only 8.5 percent of milk samples were found to have been adulterated (City of Boston 1889).

Babcock's successful curbing of milk adulteration did not go unnoticed. Across the country, the "Boston system" of milk inspections was lauded and emulated.[25] For example, upon taking office, the first Chicago milk inspector visited Boston to meet with Babcock's immediate successor, observe how milk inspections were conducted, and establish "Chicago's milk inspection service on a good foundation" ("Praises Boston's Milk Inspections" 1893, p. 14).[26]

---

[24] According to an anonymous *Boston Globe Reporter* who interviewed Babcock in May of 1885 about the overhaul of the inspections system:

> When a sample of milk procured at a store is found by analysis to be of a quality inferior to that which the law requires, a warning notice is sent to the dealer informing him of this fact and notifying him that further sale of such milk…will render him liable to the penalties provided by the law…This usually brings around the delinquent dealer…and the delinquency is usually remedied without resort to the courts. The penalty for the first offence is $50 … ("Watching Milkmen" 1885, p. 4).

Milk inspectors issued over 500 warnings during the months of May, June, and July of 1885, but filed only 59 complaints ("Watching Milkmen" 1885; "Work Performed by Milk Inspector Babcock" 1885; "Notes and Gleanings" 1885).

[25] See also "Milk Inspection: The System in Boston and How it Works" (1885), "Praises Boston's Milk Inspection" (1893), and "Where Milk's Always Good: Regulation and Inspection of Supply in Three Large Cities" (1906).

[26] See also "Milk Inspection: The System in Boston and How it Works" (1885), "Praises Boston's Milk Inspection" (1893), and "Where Milk's Always Good: Regulation and Inspection of Supply in Three Large Cities" (1906). The Chicago Inspector, E.B. Stuart, explained that "the [Boston] system has been copied so widely by other large cities seems to prove conclusively—in view of the fact that it has been thoroughly investigated before being copied—that it is one of unexampled merit" ("Praises Boston's Milk Inspection" 1893, p. 14). Inspection efforts did not wane after Babcock's departure. For instance, 13,853 milk samples were collected and analyzed by Boston inspectors in 1890, but only 220 cases were taken to court (Whitaker 1898).

4. Data and Empirical Framework

The city-level mortality data used in our principal analysis come from a wide range of sources. For the pre-1900 period, mortality counts are from annual municipal and state public health records. These records were obtained either through interlibrary loan, the HathiTrust Digital Library, Google Books, or the archives at the National Library of Medicine in Bethesda, Maryland. For instance, mortality data for Cleveland, OH were obtained from the HathiTrust Digital Library (1880-1883), the Cleveland Public Library via interlibrary loan (1884-1885), and the National Library of Medicine Archives (1886-1899).[27] For the period 1900-1910, mortality counts come from *Mortality Statistics*, which, beginning in 1900, was published annually by the U.S. Census Bureau.[28] Appendix Table A1 lists the cities and years used in our principal analysis and Appendix Table A2 lists the sources from which the pre-1900 mortality data were obtained.[29]

Figure 2 shows infant deaths (i.e., deaths among children under the age of one) per 100,000 population for the 35 cities in our sample. Population data come from the decennial censuses and are linearly imputed for intercensal years. In 1880, there were 564.2 infant deaths per 100,000 population. By 1910, the infant mortality rate had fallen to 320.5, or 43 percent.

Figure 2 also shows the waterborne mortality rate, defined as deaths due to diarrheal diseases and typhoid per 100,000 population.[30] Typhoid deaths are often used by researchers as a proxy for

---

[27] To take another example, mortality data for Philadelphia, PA were obtained from the HathiTrust Digital Library (1880-1887, 1890, 1892), the National Library of Medicine Archives (1888-1889, 1894-1896, 1899), and Google Books (1891, 1893, 1897-1898).

[28] Mortality data from *Mortality Statistics* have been used by other researchers interested in the effectiveness of public health interventions. For instance, see Cutler and Miller (2005), Hoehn-Velasco (2018), Anderson et al. (2019), and Hoehn-Velasco and Wrigley-Field (2022).

[29] We collected mortality data for a number of major U.S. cities that were ultimately excluded from our sample. These cities were excluded because we could either not determine when milk inspections began or because they would have entered the sample as "already-treated" units (Goodman-Bacon 2021). Already-treated cities include Boston and New York City.

[30] For the pre-1900 period, the diarrheal disease category is defined differently across the cities in our sample and is based on consistently available information from the annual municipal and state public health reports. For instance, the

water quality (Ferrie and Troesken 2008; Clay et al. 2014; Anderson et al. 2020), and the connection between watered milk and typhoid fever was well established by the turn of the 20th century (Steere-Williams 2020). During the period 1880-1910, waterborne and infant mortality followed similar trends. In 1880, there were 239.5 waterborne deaths per 100,000 population. By 1910, the waterborne mortality rate had fallen to 165.7, or 31 percent. To our knowledge, Figure 2 is the first attempt to document pre-1900 trends in waterborne mortality for such a broad sample of U.S. cities.

Purifying municipal water supplies through filtration and chlorination was primarily a post-1900 phenomenon (Anderson et al. 2022a). It is, however, clear from Figure 2 that infant and waterborne mortality rates had begun trending downwards well before the turn of the 20th century. To explore whether the trends shown in Figure 2 can be explained by milk inspections, we estimate the following regression model:

$$(1) \qquad MR_{ct} = a_0 + v_c + \lambda_t + \sum_{y=-5}^{-2} \pi_y 1(t - T_c^* = y) + \sum_{y=0}^{10} \pi_y 1(t - T_c^* = y) + \boldsymbol{X}_{ct}\boldsymbol{\beta} + \varepsilon_{ct},$$

where MR_{ct} is the infant (or waterborne) mortality rate in city c and year t = 1880…1910.[31] City fixed effects, v_c, control for time-invariant determinants of mortality or reporting differences across municipalities; year fixed effects, λ_t, account for common shocks.

diarrheal mortality count for Mobile, AL; San Francisco, CA; and Richmond, VA is the sum of deaths due to diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, gastroenteritis, and enterocolitis. On the other hand, the diarrheal mortality count for Cleveland, OH is only the sum of deaths due to diarrhea and cholera infantum. For other cities, such as Atlanta, GA and those in New Jersey, deaths were reported as an aggregate category simply called "diarrheal diseases." Importantly, however, the definition of diarrheal mortality never changes within a given city during the pre-1900 period. The inclusion of city fixed effects accounts for cross-city differences in reporting. Appendix Table A3 lists the diseases used to define diarrheal mortality for each city for the years 1880-1899. For the period 1900-1910, *Mortality Statistics* reports city-level deaths due to "diarrhea and enteritis" as a combined category. The inclusion of year fixed effects accounts for any changes in reporting that is common across all cities. In a robustness check shown below, we report estimates based solely on the pre-1900 period. Information from Whipple (1908) was used to supplement the city-level data on typhoid mortality.

[31] The results shown below are qualitatively similar if we transform the dependent variable by taking its natural log, quartic root, or inverse hyperbolic sine.

The event-year dummies, y, are equal to 1 when the year of observation is y = -5,…,0,…,10 years from T_c^*, the year in which city c's milk supply was first sampled and inspected with the goal of preventing adulteration and skimming. We omit y = -1 from equation (1), which normalizes the estimates of π_y to 0 in that year. The y = -5 event-year dummy is equal to 1 if t is 5 or more years before T_c^*. Likewise, the y = 10 event-year dummy is equal to 1 if t is 10 or more years after T_c^*.

Inspection dates are listed in Appendix Table A1. They are based on newspaper accounts and other sources such as municipal public health reports.[32] The vector $\boldsymbol{X}_{ct}$ includes controls for whether city c filtered its water, treated it with chlorine, or had undertaken a major clean water project.[33] Appendix Table A4 provides descriptive statistics and Appendix C lists the wide variety of sources used to determine the milk inspection and water-related intervention dates.

5. RESULTS

Panel A of Figure 3 reports ordinary least squares (OLS) estimates of equation (1) for infant mortality. With or without controlling for other public health interventions, the estimates of π_y follow a similar pattern: there is little evidence of systematic pre-treatment trends, but the post-treatment estimates are generally small and statistically insignificant. These estimates update, and are consistent with, those reported by Anderson et al. (2022b).

---

[32] Several of these dates are different than those reported by Anderson et al. (2022b). For instance, Anderson et al. (2022b) reported that San Francisco began milk inspections in 1898, while Appendix Table A1 lists 1895 as the starting date. This confusion was caused by San Francisco milk inspections being suspended in 1897 and then resuming in 1898 ("Liquid Death Once Again to be Sold to Mothers and Babes" 1897; "After the Milkmen" 1898).

[33] We observe 4 cities undertaking a major clean water project, which were generally designed to deliver clean water from further afield. In 1897, Camden, NJ began receiving water from artesian wells that did not require filtering (Cooper 1909). In 1904, the "Five Mile Crib" began delivering water to Cleveland, OH from Lake Erie and the Boonton Reservoir began delivering water to Jersey City, NJ ("Jersey Has a New Reservoir" 1904; Dubelko 2022). Lastly, our clean water indicator goes from zero to one for Chicago in 1900 when the flow of the Chicago River was reversed (Janega 2013). See Anderson et al. (2021, 2022) for more information on the water-related interventions included in $\boldsymbol{X}_{ct}$.

Gastro-intestinal diseases were a leading cause of death among infants and children at the turn of the 20th century (Preston and Haines, Table 1.1). In panel B of Figure 3, we focus on deaths due to waterborne illnesses, the majority of which were diarrheal. While we do not observe waterborne mortality by age, U.S. Vital Statistics records indicate that 53 percent of all waterborne deaths in 1900 occurred among infants and 69 percent occurred among children under the age 5 (United States Bureau of the Census 1906).[34]

The pre-treatment estimates of π_y shown in panel B of Figure 3 are small and statistically insignificant, while the post-treatment estimates of π_y provide strong evidence that milk inspections reduced mortality from waterborne diseases.[35] Ten of the 11 post-treatment estimates are negative and 7 are statistically significant at conventional levels. We can reject the null hypothesis that the post-treatment estimates of π_y are jointly equal to zero at the 5 percent level (p-value = 0.046).

Controlling for other public health efforts, milk inspections are associated with 30 fewer waterborne deaths per 100,000 population after five years, which represents a 12 percent reduction relative to the pre-treatment mean of 246.6; after 10+ years, inspections are associated with 46 fewer deaths (≈ 19 percent reduction). This pattern of results is consistent with contemporary accounts of milk inspections becoming more rigorous as additional inspectors were hired and previously hired inspectors gained experience. For instance, New York City hired its first milk inspector in the 1870s, but he struggled to curb adulteration and skimming ("The State Capital" 1870; "Local Miscellany" 1875; "The Board of Health" 1879). The city did not begin "fighting the skim milk in

[34] In 1900, 67 percent of all deaths due to diarrhea/enteritis occurred among infants, and 86 percent of diarrhea/enteritis deaths occurred among children under the age of 5 (United States Bureau of the Census 1906). Appendix Figure A1 plots the ratio of diarrheal to typhoid deaths from 1880 to 1910 in our sample of 35 cities. The average ratio was 3.7 but it reached as high as 6.4 in 1910.

[35] See Appendix Table A5 for the estimates plotted in Figure 3. In Appendix Figure A2, we report the results of experimenting with alternative lead structures. The pre-treatment estimates of π_y are small and statistically insignificant regardless of which lead structure is chosen.

earnest" until the early 1880s when three additional milk inspectors were hired and the frequency of inspections increased ("Events in the Metropolis" 1883, p. 12).[36]

5.1. Sensitivity analysis

We begin the sensitivity analysis by controlling for timing group-specific linear trends (Goodman-Bacon 2021).[37] The post-treatment estimates of π_y based on this specification are slightly larger than those discussed above: after five years, milk inspections are associated with a 17 percent reduction in waterborne mortality relative to the pre-treatment mean; after 10 years, they are associated with a 29 percent reduction in waterborne mortality (Figure 4, panel A).[38]

In panel B of Figure 4, we include an indicator for dairy farm inspections on the right-hand side of the estimating equation, which does not appreciably affect the estimates of π_y.[39] Likewise, our estimates of π_y are qualitatively similar if they are not weighted by city population (Figure 4, panel C). In panel D of Figure 4, we show estimates of π_y for the period 1880-1889. As noted above, mortality counts for the pre-1900 period come from municipal and state public health reports, while

---

[36] In 1883, Charles E. Munsell, one of 4 New York City milk inspectors, described the quality of the milk supply:

> The milk this year is remarkably good, and there is a great deal of it, so that honest dealers are heartily in sympathy with the Board of Health in its efforts to drive the adulterated article out of the City… During the entire year so far, we have ordered but 30 cans of milk destroyed for failing to reach the standard, while two years ago we dumped from 80 to 100 cans a night ("Events in the Metropolis" 1883, p. 12).

[37] A timing group is based on the timing of treatment and is defined as a group of cities that implemented milk inspections during the same year. For instance, St. Paul, MN; St. Louis, MO; and Dayton, OH comprise one timing group because they all began inspecting their milk supply in 1887.

[38] These estimates do not change substantially if we replace the timing group-specific linear trends with city-specific linear trends.

[39] Information on dairy farm inspections comes from Parker (1917, Table 114), the same source used by Komisarow (2017). This information is, however, frequently contradicted by other contemporary sources (e.g., newspaper accounts and public health reports). Moreover, it is not clear whether the dates provided by Parker (1917) correspond to when dairy farms within city limits were first inspected or whether the inspections extended to farms located outside city limits. The coefficient estimate of the dairy farm inspection indicator is negative but statistically indistinguishable from zero (coefficient estimate = -18.4; standard error = 14.9).

counts for the years 1900-1910 come from the U.S. Census Bureau's *Mortality Statistics*. Estimates of π_y based on this earlier period are similar to those discussed above.[40]

If the effects of milk inspections on waterborne mortality were dynamic and heterogeneous, then our estimates of π_y are potentially biased. Sun and Abraham (2021) demonstrated that estimates from models such as (1) can be biased even when parallel-trends and no-anticipation assumptions hold. A key implication of their analysis is that estimates of π_y can be contaminated by treatment effects from other periods. In panels E and F of Figure 4, we report results from the interaction-weighted estimator developed by Sun and Abraham (2021), which allows for treatment effect heterogeneity.[41] Using never-treated cities as the comparison group, the post-treatment estimates of π_y are similar to—and occasionally larger than—those discussed above (panel E). After five years, milk inspections are associated with an 11 percent reduction in waterborne mortality relative to the pre-treatment mean; after 10+ years, inspections are associated with a 31 percent reduction. Expanding the comparison group to include cities treated after 1904 produces similar estimates (panel F).[42]

5.2. Heterogeneity analysis

There is descriptive evidence that wealthier households were more likely to take preventative measures against the spread of waterborne illnesses (Troesken 2004), but there is also evidence that

---

[40] Estimates are also similar if we drop cities in New Jersey from the sample, all of which began inspecting milk in 1883 (panel A of Appendix Figure A3) or drop the largest cities from the population-weighted regression analysis (panels B-F of Appendix Figure A3).

[41] The estimator proposed by Sun and Abraham (2021) is a special case of the one proposed by Callaway and Sant'Anna (2021). See Baker et al. (2022) for a survey on methods designed to address the bias in difference-in-differences estimators based on staggered treatment timing.

[42] Including cities treated after 1904 in the comparison group effectively limits the sample period to 1880-1904. Estimates are qualitatively similar, but less precisely measured, if we further expand the set of control cities by considering an even shorter sample period (e.g., 1880-1899).

breastfeeding duration varied inversely with father's earnings at the turn of the 20th century (Preston and Haines 1991). Estimates produced by interacting the event-year dummies with an indicator of whether the mean manufacturing wage in city *c* in 1899 was above the median are shown in panel A of Figure 5.[43] These estimates are generally negative but often imprecise. We view them as providing tentative evidence that milk inspections were more effective in wealthier cities.

According to the U.S. Bureau of Labor (1906), households in the North Atlantic, North Central, and Western states consumed roughly 50 percent more milk than those in the South, where the climate made it challenging to preserve milk (and other foods). In panel B of Figure 5, we show estimates produced by interacting an indicator *South* with the event-year dummies. Consistent with the hypothesis that milk inspections were more effective outside of the South, 9 of the 11 post-treatment estimates of π_y are positive, but only two are statistically indistinguishable from zero.

German households had a penchant for heating their milk and helped introduce this custom in the United States in the 1880s (Ewbank and Preston 1989). Italian and Polish mothers practiced exclusive breastfeeding at markedly higher rates than U.S. natives and other immigrant populations (Woodbury 1925; Preston and Haines 1991).[44] In panel C of Figure 5, we show estimates produced by interacting the event-year dummies with an indicator for whether city *c*'s German, Italian, and Polish immigrant population was above the median (based on data from the 1880 census). There is little evidence to suggest that the effectiveness of milk inspections depended upon the share of German, Italian, and Polish immigrants. The results are qualitatively similar if we consider a continuous, rather than binary, measure of immigrant population.

---

[43] Data on the manufacturing wage come from the *Biennial Census of Manufactures*, and can be thought of as measuring the purchasing power of urban workers (Rees and Jacobs 1961).

[44] Sixty-nine and 66 percent of Italian and Polish mothers exclusively breastfed during the first 9 months, respectively. By comparison, 56 percent of white U.S. natives breastfed exclusively, while Portuguese and French-Canadian mothers breastfed exclusively at rates below 50 percent (Preston and Haines 1991, Table 1.2).

5.3. Diarrheal versus typhoid mortality

In this section, we provide estimates of the effects of milk inspections on the two components of waterborne mortality: diarrheal diseases and typhoid.[45] Event-study estimates for diarrheal mortality, which are reported in panel A of Figure 6, look similar to those discussed above. Controlling for other public health efforts, milk inspections are associated with nearly 16 fewer diarrheal deaths per 100,000 population after five years, which represents an 8 percent reduction relative to the pre-treatment mean; after 10+ years, milk inspections are associated with a 14 percent reduction relative to the pre-treatment mean.

Event-study estimates for typhoid mortality are reported in panel B of Figure 6. The pre-treatment estimates of π_y exhibit an upward trend, which is consistent with the hypothesis that milk inspections were undertaken as a response to rising typhoid infections. At $y = 0$, there is a sharp reversal in this upward trend, providing convincing evidence that milk inspections were effective. After three years, milk inspections are associated with 21 fewer typhoid deaths per 100,000 population, or a 37 percent reduction relative to the pre-treatment mean; after four years, milk inspections are associated with 27 fewer typhoid deaths (≈ 46 percent reduction). Milk inspections likely reduced typhoid mortality by discouraging the dilution of milk with contaminated water, but we cannot rule out the possibility that they reduced typhoid mortality, at least in part, by curbing the sale of skimmed milk. Hundreds of typhoid outbreaks at the turn of the 20th century were traced to

[45] Typhoid mortality was primarily recorded among adults, but it is likely that a substantial number of typhoid deaths among infants and children were misclassified as diarrheal. The presentation of typhoid fever in children over the age of 5 generally resembles that in adults but it is, in general, more difficult to clinically diagnose among younger populations (Lal Gurubacharya and Karki 2006; Arora et al. 2019). Infants and younger children often present non-specific symptoms, including diarrhea, vomiting, and dehydration (Mulligan 1971). During a discussion at the 1912 annual meeting of the American Pediatric Society, physicians remarked that typhoid is "extremely difficult" to diagnose among infants, "is not recognized as frequently as it should be," and "occurs among children more frequently than is supposed" (Society Proceedings 1912, p. 61). Dr. J.P. Crozer Griffith, who analyzed 73 cases of typhoid in children under 2 and a half years of age, noted that "[t]he fully developed attack of typhoid in infancy shows many digestive symptoms" and that "diarrhea is more common than in childhood" (Society Proceedings 1912, p. 61).

the handling of milk by infected dairy workers and several were traced to creameries (Welply 1894; Kober 1902; Trask 1908; Frost 1916).

The estimates shown in Figure 6 suggest that milk inspections had a more immediate impact on typhoid as compared to diarrheal mortality.[46] We speculate that this could have been due to milk inspectors focusing initially on skimming and the dilution of milk with water. After these practices were brought under control, they then turned their attention to curbing the use of dyes and adulterants such as boric acid, which can cause diarrhea if ingested (Litovitz et al. 1988).[47]

5.4. Milk inspections and diphtheria mortality: a falsification test

Household efforts to purify milk through heating could, in theory, have intensified during the public discourse surrounding the hiring of milk inspectors, potentially biasing the estimated effects of milk inspections.[48] In an attempt to rule out this possibility, we explore the association between milk inspections and diphtheria mortality. Caused by the bacteria *Corynebacterium diphtheriae*, *C. pseudotuberculosis* and *C. ulcerans* (Bonnet and Begg 1999; Wagner et al. 2011), diphtheria was the second leading cause of death among children ages 1-4 at the turn of the 20th century (Preston and Haines 1991, Table 1.1).[49] *C. pseudotuberculosis* and *C. ulcerans* are spread by being in close contact

---

46 In Appendix Table A6, we report the estimates plotted in Figure 6. See Appendix Figure A4 for the corresponding interaction-weighted estimates (Sun and Abraham 2021).

47 The newly hired Chicago milk inspectors focused entirely on curbing the skimming of milk, while adulteration of milk with borax, carbonate of soda, and formaldehyde continued unabated for years (Wolf 2001, pp. 56-59). A similar pattern of enforcement occurred after Babcock's 1885 reorganization of milk inspections in Boston. Initially, the focus of the department was on curbing the practice of watering, but there was a crackdown on adding dyes to milk two years later ("Work Performed by Milk Inspector Babcock" 1885; "Inspection of Milk: Interesting Report of Inspector Babcock" 1887).

48 For instance, Philadelphia hired its first milk inspector in 1889 and an ordinance defining what constituted adulterated milk was passed by its City Council in 1890. Local newspaper articles about these events often featured descriptions of the milk supply as "impure" and "unwholesome" ("Death Lurking in Milk" 1888, p. 2; "The Milk Bill Lost" 1890, p. 3; "Long Live the Pump" 1890, p. 8).

49 Referred to as "childhood's deadly scourge" or the "plague among children," it was not uncommon for families to lose several children during a single diphtheria epidemic (Hammonds 1999; Klass 2021). The disease's signature feature is the buildup of a thick, gray membrane of dead cells in the nose and throat, which can obstruct breathing. With their

with infected animals or the consumption of raw dairy products, while *C. diphtheriae* is typically transmitted through infected respiratory droplets (Bonnet and Begg 1999; Wagner et al. 2011). Unlike the bacteria that cause typhoid, diphtheria bacteria are not transmitted through water (Wagner et al. 2011). Relative to other bacteria that cause milk-borne diseases (e.g., *Mycobacterium tuberculosis* and *Salmonella typhimurium*), the bacteria that cause diphtheria are killed at the lowest temperature, 136°F (Dhanashekar et al. 2012).

Panel A of Figure 7 shows event-study estimates of the relationship between milk inspections and diphtheria mortality. We limit the sample period to 1880-1899 because, after the turn of the century, milk inspectors shifted their attention from preventing adulteration and skimming to preventing contamination with microscopic pathogens (Meckel 1990).[50] Limiting the sample in this fashion also allows us to avoid potential confounding effects from distribution of the diphtheria antitoxin, which became widely available in the early 1900s.[51]

Post-treatment estimates of π_y shown in panel A of Figure 7 suggest that milk inspections had no appreciable effect on diphtheria mortality: they are consistently positive and statistically indistinguishable from zero. We view these estimates as providing evidence that the negative relationship between milk inspections and waterborne mortality is indeed causal. Because the bacteria that causes diphtheria can be easily killed through heating, the results shown in panel A of Figure 7 effectively rule out the possibility that household-level efforts to sterilize milk were

relatively small airways, children are particularly vulnerable. While cases of diphtheria are exceedingly rare in the United States today, recent outbreaks have occurred in places such as Yemen, Bangladesh, and India (Das et al. 2016; Badell et al. 2021; Polonsky et al. 2021). Historical outbreaks of diphtheria in the United States have been linked to the milk supply (Chase 1900; Dean and Todd 1902; Porter 1922).

[50] The first bacteriological standard for milk was imposed in 1905, when Boston required that milk sold within its limits have no more than 500,000 bacteria per cubic centimeter (Rosenau 1909).

[51] The diphtheria antitoxin was first used in the United States in the mid-1890s, but access was limited. In 1899, W.E.B. Du Bois' two-year-old son died from diphtheria in Atlanta, GA, where treatment was unavailable. The family lamented their recent decision to move from Philadelphia, where they believed they would have had access to the antitoxin (Klass 2021).

systematically correlated with the hiring of milk inspectors. Event-study estimates are similar if we instead focus on the full sample period, 1880-1910 (Figure 7, panel B).

6. Conclusion

Is there an economic rationale for regulating quality? When quality is observed at zero cost before purchase, enforcing a minimum standard will unambiguously reduce consumer welfare (Bockstael 1984). If, however, buyers cannot determine the quality of a good or service prior to (or even after) purchase, then MQSs can improve upon the unregulated competitive market equilibrium (Leland 1979).

Empirical studies have focused on MQSs applied to the inputs of production. For instance, Chipty and Witte (1997) and Hotz and Xiao (2011) found that tightening educational requirements for staff at childcare centers can reduce supply and lead to higher prices. The theoretical literature has, by contrast, focused on MQSs applied directly to a good or service (Leland 1979; Bockstael 1984; Ronnen 1991; Lapan and Moschini 2007; Garella and Petrakis 2008).

In this study, we examine the effects of a well-defined MQS applied directly to an essential food at the turn of the 20th century: milk. Prior to the introduction of milk inspections in the late 1800s, consumers had difficulty determining the quality of milk. Dairymen and dealers regularly skimmed the urban milk supply and diluted it with water. Boric acid, which can be toxic if ingested, was used as a preservative, and caramel, dyes, salt, and sugar were added to restore color, body, and taste (Newton 1877; Hart 1952; Litovitz et al. 1988; Meckel 1990).

In an effort to deter these practices, milk inspectors were hired and tasked with ensuring that milk sold within city limits contained at least 12 percent solids. Milk that did not meet this MQS was prohibited from the market, and anyone caught selling substandard milk was subject to hefty fines or even prison time. Our case study of the Boston milk market during the period 1884-

1888 provides descriptive evidence that increasing the intensity of inspections could dramatically improve the quality of milk being sold. The percent of milk samples adulterated with water in Boston fell from 40 to 8.5 percent after a tenfold increase in the intensity of milk inspections.

Using data from 35 major U.S. cities for the period 1880-1910, our principal analysis estimates the effects of milk inspections on infant mortality and mortality from waterborne diseases such as diarrhea and typhoid. Although we find little evidence that enforcing the 12 percent solids requirement through pre-market inspections reduced infant mortality, deaths from waterborne diseases fell, on average, by 12 percent five years after the start of inspections. After 10 years, milk inspections are associated with a 19 percent reduction in waterborne diseases. To our knowledge, these estimates represent the first evidence that MQSs can improve the health of consumers when they are applied directly to a good or service the quality of which is difficult to ascertain prior to purchase.

Until the early 1900s, milk inspections were the only concerted, widespread effort aimed at improving the quality of the milk supply. It is, however, possible that household efforts to sterilize milk through heating could have intensified with the hiring of milk inspectors. To address this possibility, we use diphtheria mortality as a falsification test. Diphtheria is not transmitted through water but can be spread through consuming raw dairy products; the bacteria that cause diphtheria are killed at relatively low heating points (Schereschewsky and Dyer 1922; Wagner et al. 2011; Dhanashekar et al. 2012). We find no evidence of an association between milk inspections and diphtheria mortality, suggesting that the observed negative relationship between inspections and waterborne mortality is indeed causal.

Finally, our results are relevant to the developing world, where food adulteration is still common due to a lack of monitoring and enforcement (Azad and Ahmed 2016; Handford et al. 2016). Academic studies and the popular press provide evidence that milk sold in developing countries (including Brazil, China, India, Kenya, and Pakistan) is frequently adulterated with water and can contain boric acid, detergents, salt, sugar, and starches (Handford et al. 2016; Wanjala et al. 2018; Frontier Post Report 2019; Musa and Yang 2021; Tribune News Service 2021). In the coming decades, the demand for milk in the developing world is projected to skyrocket and, as a consequence, the need to inspect milk supplies has taken on a new urgency (Gülzari et al. 2020). Although milk inspection technologies have improved over time, methods such as infrared analysis are complex and expensive (Newton 2014). The tools employed by U.S. milk inspectors at the turn of the 20th century remain favored in poorer countries because they are cheap and simple (Gichohi et al. 2004; Newton 2014; Alonso et al. 2018). Our estimates provide evidence that milk inspectors, armed with basic tools such as the lactometer, can help prevent waterborne diseases such as diarrhea and typhoid, both of which are still deadly and common in the developing world.

REFERENCES

"A Chemical Examination Shows Borax Acid in Milk." 1889. *Wichita Star*, July 27, p. 1.

"A 'Skim' Milk Crusade." 1878. *New York Times*, Aug. 28, p. 8.

Aldrich, Mark. 2007. "Running out of Steam: Federal Inspection and Locomotive Safety, 1912-1940." *Journal of Economic History*, 67(4): 884-916.

Alonso, Silvia, Emmanuel Muunda, Sara Ahlberg, Emma Blackmore, and Delia Grace. 2018. "Beyond Food Safety: Socio-Economic Effects of Training Informal Dairy Vendors in Kenya." *Global Food Security*, 18(September): 86-92.

Alsan, Marcella and Claudia Goldin. 2019. "Watersheds in Child Mortality: The Role of Effective Water and Sewerage Infrastructure, 1880 to 1920." *Journal of Political Economy*, 127(2): 586-638.

Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

Anderson, D. Mark, Kerwin Kofi Charles, Michael McKelligott, and Daniel I. Rees. 2022b. "Estimating the Effects of Milk Inspections on Infant and Child Mortality, 1880-1910." *American Economic Association Papers and Proceedings*, 112: 1-6.

Anderson, D. Mark, Kerwin Kofi Charles, and Daniel I. Rees. 2020. "Occupational Licensing and Maternal Health: Evidence from Early Midwifery Laws." *Journal of Political Economy*, 128(11): 4337-4383.

Anderson, D. Mark, Kerwin Kofi Charles, and Daniel I. Rees. 2022a. "Re-Examining the Contribution of Public Health Efforts to the Decline in Urban Mortality." *American Economic Journal: Applied Economics*, In Press.

Anderson, D. Mark, Kerwin Kofi Charles, Daniel I. Rees, and Tianyi Wang. 2021. "Water Purification Efforts and the Black-White Infant Mortality Gap, 1906-1938." *Journal of Urban Economics*, 122(March): 103329.

Anderson, D. Mark, Kerwin Kofi Charles, Claudio Las Heras Olivares, and Daniel I. Rees. 2019. "Was the First Public Health Campaign Successful?" *American Economic Journal: Applied Economics*, 11(2): 143-175.

Anderson, D. Mark, Daniel I Rees, and Tianyi Wang. 2020. "The Phenomenon of Summer Diarrhea and its Waning, 1910-1930." *Explorations in Economic History*, 78(October): 101341.

"Annual Report of the Milk Inspector." 1885. *The Boston Globe*, June 3, p. 5.

Arora, Paul, Kristian Thorlund, Darren R. Brenner, and Jason R. Andrews. 2019. "Comparative Accuracy of Typhoid Diagnostic Tools: A Bayesian Latent-Class Network Analysis." *PLoS Neglected Tropical Diseases*, 13(5): e0007303.

Azad, Tanzina and Shoeb Ahmed. 2016. "Common Milk Adulteration and their Detection Techniques." *International Journal of Food Contamination*, 3(22): 1-9.

Badell, Edgar, Abdulilah Alharazi, Alexis Criscuolo, Khaled Abdullah Ali Almoayed, Noémie Lefrancq, Valerie Bouchez, Julien Guglielmini, Melanie Hennart, Annick Carmi-Leroy, Nora Zidane, Marine Pascal-Perrigault, Manon Lebreton, Helena Martini, Henrik Salje, Julie Toubiana, Fekri Dureab, Ghulam Dhabaan, Sylvain Brisse, NCPHL diphtheria outbreak working group. 2021. "Ongoing Diphtheria Outbreak in Yemen: A Cross-Sectional and Genomic Epidemiology Study." *Lancet Microbe*, 2(8): E386-E396.

Baker, Andrew, David Larcker, and Charles Wang. 2022. "How Much Should We Trust Staggered Difference-in-Differences Estimates?" *Journal of Financial Economics*, 144(2): 370-395.

Ballard, Edward. 1871. *On a Localised Outbreak of Typhoid Fever in Islington, During the Months of July and August, 1870, Traced to the Use of Impure Milk*. London: J. & A. Churchill

Bellevue, B.R. Stouffer. 1888. "City Milk Supply." *Proceedings: Annual Meeting of the Nebraska State Board of Agriculture*, pp. 313-323. Lincoln, NE: State Journal Company.

Blau, David M. 2007. "Unintended Consequences of Child Care Regulations." *Labour Economics*, 14(3): 513–538.

Bockstael, Nancy E. 1984. "The Welfare Implications of Minimum Quality Standards." *American Journal of Agricultural Economics*, 66(4): 466-471.

Bonnet, J.M. and N.T. Begg. 1999. "Control of Diphtheria: Guidance for Consultants in Communicable Disease Control." *Communicable Diseases and Public Health*, 2(4): 242-249.

"Boston's Milk Inspector." *New England Farmer*, Feb. 14, p. 2.

Bowblis, John R. 2011. "Staffing Ratios and Quality: An Analysis of Minimum Direct Care Staffing Requirements for Nursing Homes." *Health Services Research*, 46(5): 1495-1516.

"Brief Comment." 1892. *The Tribune* (Scranton, PA), Nov. 18, p. 4.

Callaway, Brantly and Pedro H.C. Sant'Anna. 2021. "Difference-in-Differences with Multiple Time Periods." *Journal of Econometrics*, 225(2): 200-230.

Campbell, Monica, Charles Gardner, John Dwyer, Sandy Isaacs, Paul Krueger, and Jane Ying. 1998. "Effectiveness of Public Health Interventions in Food Safety: A Systematic Review." *Canadian Journal of Public Health*, 89(3): 197-202.

Chapin, C.V. 1901. *Municipal Sanitation in the United States*. Providence, RI: Snow and Furnhum.

Chase, H. Lincoln. 1900. "A Diphtheria Outbreak Believed to be Due to Infected Milk." *Journal of the Massachusetts Association of Boards of Health*, 10(1): 5-20.

Chen, Min M. and David C. Grabowski. 2015. "Intended and Unintended Consequences of Minimum Staffing Standards for Nursing Homes." *Health Economics*, 24(7): 822-839.

Chipty, Tasneem, and Ann Dryden Witte. 1997. "An Empirical Investigation of Firms' Responses to Minimum Standards Regulations." NBER WP 6104.

City of Boston. 1889. *City of Boston, Thirtieth Annual Report of the Inspector of Milk and Vinegar*. Boston, MA: Office of the Inspector of Milk and Vinegar.

Clay, Karen, Werner Troesken, and Michael Haines. 2014. "Lead and Mortality." *Review of Economics and Statistics*, 96(3): 458-470.

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.

Cooper, Howard Mickle. 1909. *Historical Sketch of Camden, N. J.* Camden, NJ: H. B. Ketler.

Crampes, Claude and Abraham Hollander. 1995. "Duopoly and Quality Standards." *European Economic Review*, 39(1): 71-82.

Cruz, Miguel A., Dolores J. Katz, and Juan A. Suarez. 2001. "Restaurant Inspections to Predict Food-Borne Outbreaks in Miami–Dade County, Florida." *American Journal of Public Health*, 91(5): 821–823.

Currie, Janet and V. Joseph Hotz. 2004. "Accidents Will Happen? Unintentional Childhood Injuries and the Effects of Child Care Regulations." *Journal of Health Economics*, 23(1): 25-59.

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

"Dairy Farming." 1877. *New England Farmer*, June 23, page 1.

"Dangerous Milk Adulteration." 1879. *The Brooklyn Daily Eagle*, July 7, p. 2.

Darby, Michael R. and Edi Karni. 1973. "Free Competition and the Optimal Amount of Fraud." *Journal of Law and Economics*, 16(1): 67-88.

Das, Partha Pratim, Saurav Jyoti Patgiri, Lahari Saikia, and Debosmita Paul. 2016. "Recent Outbreaks of Diphtheria in Dibrugarh District, Assam, India." *Journal of Clinical and Diagnostic Research*, 10(7): DR01-DR03.

Dean, George and Charles Todd. 1902. "Experiments on the Relation of the Cow to Milk-Diphtheria." *Journal of Hygiene*, 2(2): 194-205.

"Death Lurking in Milk" 1888. *The Philadelphia Inquirer*, Dec. 5, p. 2.

Dhanashekar, Revathi, Sindhura Akkinepalli, and Arvind Neullutla. 2012. "Milk-borne Infections. An Analysis of their Potential Effect on the Milk Industry." *Germs*, 2(3): 101-109.

Doane, C. F. 1905. "The Milk Supply of Twenty-Nine Southern Cities." Washington, D.C.: United States Government Printing Office.

Doremus, R. Ogden. 1895. "Milk and its Adulterations." *The Cincinnati Lancet-Clinic*, 74(September 28), pp. 345-348.

Drescher, August. 1887. "What is the Field for the Pharmacist in Adding to His Profession, that of Analyst of Articles of Food, Drink, etc." *The Pharmaceutical Era*, 1(July): 250-252.

Dubelko, Jim. 2022. "The 1916 Waterworks Tunnel Disaster." *Cleveland Historical*, accessed March 10. Available at: https://clevelandhistorical.org/items/show/736.

Duncan, C.S. 1918. "The Chicago Milk Inquiry." *Journal of Political Economy*, 26(4): 321-346.

"Events in the Metropolis." *New York Times*, July 8, p. 12.

Ewbank, Douglas and Samuel Preston. 1990. "Personal Health Behavior and the Decline in Infant and Child Mortality: The United States, 1990-1930." In *What We Know about Health Transition: The Cultural, Social, and Behavioral Determinants of Health* (John Caldwell et al., eds.). Health Transition Center, Canberra: Australian National University.

Feinstein, Jonathan S. 1989. "The Safety Regulation of U.S. Nuclear Power Plants: Violations, Inspections, and Abnormal Occurrences." *Journal of Political Economy*, 97(1): 115–54.

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

Frontier Post Report. 2019. "PFA Discards 4,915 Liters Adulterated Milk in Punjab." *Frontier Post*. Available at: https://thefrontierpost.com/pfa-discards-4915-liters-adulterated-milk-in-punjab/.

Frost, W.H. 1916. "Relationship of Milk Supplies to Typhoid Fever." *Public Health Reports (1896-1970)*, 31(48): 3291-3302.

Gardner, Bruce. 2003. "U.S. Food Quality Standards: Fix for Market Failure or Costly Anachronism?" *American Journal of Agricultural Economics*, 85(3): 725-730.

Garella Paolo G. and Emmanuel Petrakis. 2008. "Minimum Quality Standards and Consumers' Information." *Economic Theory*, 36(2): 283-302.

Geisler, Joseph F. 1891. "Signification of Lactometer Tests." *Journal of the American Chemical Society*, 13 (2): 93–98.

Gichohi, Paul, Angela Wokabi, and Brian Dugdill. 2004. "Improve the Quality of Your Milk and Please Your Customers: Training Guide for Small-Scale Informal Milk Traders in Kenya." Smallholder Dairy Project. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/1758/SDPMilkHygieneGuide-Trader.pdf?sequence=1.

"Good and Bad Milk." 1886. *The Boston Globe*, Feb. 16, p. 3.

Goodman-Bacon, Andrew. 2021. "Differences-in-Differences with Variation in Treatment Timing." *Journal of Econometrics*, 225(2): 254-277.

Gülzari, Şeyda Özkan, Joshua Ombaka Owade, and Oghaiki Asaah Ndambi. 2020. "A Review of Interventions and Parameters Used to Address Milk Quality in Eastern and Southern Africa." *Food Control*, 116(October): 107300.

Hammonds, Evelynn Maxine. 1999. *Childhood's Deadly Scourge: The Campaign to Control Diphtheria in New York City, 1880-1930*. Baltimore, MD: The Johns Hopkins University Press.

Handford, Caroline E., Katrina Campbell, and Christopher T. Elliott. 2016. "Impacts of Milk Fraud on Food Safety and Nutrition with Special Emphasis on Developing Countries." *Comprehensive Reviews in Food Science and Food Safety*, 15(1): 130-142.

Hart, Leslie. 1952. "A History of the Adulteration of Food Before 1906." *Food, Drug, Cosmetic Law Journal*, 7(1): 5-22.

Higgs, Robert. 1979. "Cycles and Trends of Mortality in 18 large American Cities, 1871-1900." *Explorations in Economic History*, 16(4): 381-408.

Hoehn-Velasco, Lauren. 2018. "Explaining Declines in US Rural Mortality, 1910-1933: The Role of County Health Departments." *Explorations in Economic History*, 70(October): 42-72.

Hoehn-Velasco, Lauren and Elizabeth Wrigley-Field. 2022. "City Health Departments, Public Health Expenditures, and Urban Mortality Over 1910-1940." *Economic Inquiry*, 60(2): 929-953.

Hotz, V. Joseph and Mo Xiao. 2011. "The Impact of Regulations on the Supply and Quality of Care in Child Care Markets." *American Economic Review*, 101(5): 1775-1805.

"How Milk is Adulterated". 1887. *The Philadelphia Inquirer*, Nov. 12, p. 10.

"How to Get Pure Milk." 1892. *The Philadelphia Times*, Aug. 21, p. 4.

"Human Foods." 1888. *St. Louis Post-Dispatch*, Jan. 16, p. 3.

Ibanez, Maria R. and Michael W. Toffel. 2020. "How Scheduling Can Bias Quality Assessment: Evidence from Food-Safety Inspections." *Management Science*, 66 (6): 2396–2416

"Inspection of Milk: Interesting Report of Inspector Babcock." 1887. *The Boston Globe*, Feb 8, p. 6.

"Items of Interest." 1891. *The San Francisco Call*, April 19, p. 14.

Ives, Warren. 1889. *Biennial Report of the Minnesota State Dairy Commissioner, Volume 2*. St. Paul, MN: The Pioneer Press Company, 1889

Janega, James. 2013. “Reversing the Chicago River (1900).” *Chicago Tribune*, October 29. Available at: https://www.chicagotribune.com/business/blue-sky/chi-reversing-chicago-river-1900-innovations-bsi-series-story.html.

“Jersey Has a New Reservoir.” 1904. *The Sun*, Jan. 24, p. 15.

Jevons, William Stanley. 1882. *The State in Relation to Labour*. New York, NY: Macmillan and Company.

Jin, Ginger Zhe and Jungmin Lee. 2014. Inspection Technology, Detection, and Compliance: Evidence from Florida Restaurant Inspections. *RAND Journal of Economics*, 45: 885–917.

Jin, Ginger Zhe and Jungmin Lee. 2018. “A Tale of Repetition: Lessons from Florida Restaurant Inspections.” *Journal of Law and Economics*, 61(1): 159-188.

Jin, Ginger Zhe and Phillip Leslie. 2003. “The Effect of Information on Product Quality: Evidence from Restaurant Hygiene Grade Cards.” *Quarterly Journal of Economics*, 118(2): 409-451.

Jones, Timothy F., Boris I. Pavlin, Bonnie J. LaFleur, L. Amanda Ingram, and William Schaffner. 2004. “Restaurant Inspection Scores and Foodborne Disease.” *Emerging Infectious Diseases*, 10(4): 688–692.

Jordan, Edwin O. 1913. “The Municipal Regulation of Milk-Supply.” *Journal of the American Medical Association*, 61(26): 2286-2291.

Kawaguchi, Daiji, Tetsushi Murao, and Ryo Kambayashi. 2014. “Incidence of Strict Quality Standards: Protection of Consumers or Windfall for Professionals?” *Journal of Law & Economics*, 57(1): 195-224.

Kerr, J. W. 1910. “The History, Development, and Statistics of Milk Charities in the United States.” *Public Health Reports*, 25(39): 1351-1367.

Klass, Perri. 2021. “How Science Conquered Diphtheria, the Plague Among Children.” *Smithsonian Magazine*, October. Available at: https://www.smithsonianmag.com/science-nature/science-diphtheria-plague-among-children-180978572/.

Kober, George M. 1902. “Abnormal Milk and Milk- Borne Diseases.” Statement before the Committee on Agriculture, House of Representatives, U. S., Tuesday, Jan. 14, 1902, p. 37-135.

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

Kotschedoff, Marco J. W. and Max J. Pachali. 2020. “Higher Minimum Quality Standards and Redistributive Effects on Consumer Welfare.” *Marketing Science*, 39(1): 253–280.

Kovács, Balázs, David W. Lehman, and Glenn R. Carroll. 2020. “Grade Inflation in Restaurant Hygiene Inspections: Repeated Interactions between Inspectors and Restaurateurs.” *Food Policy*, 97, Article 101960.

Lal Gurubacharya, Rajesh and Poojayshree Karki. 2006. "Typhoid Fever in an 8-Month-Old Infant." *Nepal Medical College Journal*, 8(2): 147-148.

Lapan, Harvey and GianCarlo Moschini. 2007. "Grading, Minimum Quality Standards, and the Labeling of Genetically Modified Products." *American Journal of Agricultural Economics*, 89(3): 769-783.

Lee, Kwang-Sun. 2007. "Infant Mortality Decline in the Late 19th and Early 20th Centuries: The Role of Market Milk." *Perspectives in Biology and Medicine*, 50(4): 585-602.

Lee, Petrona and Craig W. Hedberg. 2016. "Understanding the Relationships between Inspection Results and Risk of Foodborne Illness in Restaurants." *Foodborne Pathogens and Disease*, 13(10): 582-586.

Leland, Hayne E. 1979. "Quacks, Lemons, and Licensing: A Theory of Minimum Quality Standards." *Journal of Political Economy*, 87(6): 1328-1346.

Levenstein, Harvey. 1983. "'Best for Babies' or 'Preventable Infanticide'? The Controversy over Artificial Feeding of Infants in America, 1880-1920." *Journal of American History*, 70(1): 75-94.

"Liquid Death Once Again to be Sold to Mothers and Babes." 1897. *San Francisco Call*, Sept. 30, p. 9.

Litovitz, Toby L. Wendy Klein-Schwartz, Gary M. Oderda, Barbara F. Schmitz. 1988. "Clinical Manifestations of Toxicity in a Series of 784 Boric acid Ingestions." *American Journal of Emergency Medicine*, 6(3): 209-213.

"Local Miscellany." *New York Times*, April 28, p. 2.

"Long Live the Pump." 1890. *The Philadelphia Inquirer*, June 25, p. 8.

Magruder, G.L. 1910. "Milk as a Carrier of Contagious Disease, and the Desirability of Pasteurization." *New England Medical Monthly*, 29(5): 159-170.

Martin, Edward W. 1884. "Report on Milk and its Adulterations." *Documents of the Assembly of the State of New York*, Volume 7: 429-442.

Matsudaira, Jordan. 2014. "Government Regulation and the Quality of Healthcare: Evidence from Minimum Staffing Legislation for Nursing Homes." *Journal of Human Resources*, 49(1): 32-72.

McCleary, G.F. 1904. "The Infants Milk Depot: Its History and Function." *Journal of Hygiene*, 4(3): 329-368.

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

"Microbes in Milk." *San Francisco Call*, Dec. 8, p. 6.

"Milk Adulteration in St. Paul and Minneapolis." 1887. *Star Tribune*, April 7, p. 4.

"Milk Inspection: The System in Boston and How it Works." 1885. *The Baltimore Sun*, Dec. 10, p. 5.

Mill, John Stuart. 1859. *On Liberty*. Mineola, NY: Dover Publications.

Mill, John Stuart. 1909. *Principles of Political Economy*. Carmel, IN: Liberty Fund.

Mocan, Naci. 2007. "Can Consumers Detect Lemons? An Empirical Analysis of Information Asymmetry in the Market for Child Care." *Journal of Population Economics*, 20(4): 743-80.

Morris, J. Cheston. 1885. "The Milk-Supply of Our Large Cities: The Extent of Adulteration and Its Consequences: Methods of Prevention" *Public Health, Papers and Reports*, 10: 246-252.

Mulligan, T.O. 1971. "Typhoid Fever in Young Children." *British Medical Journal*, 4(5788): 665-667.

Musa, Mohammed Abdallah and Shuming Yang. 2021. "Detection and Quantification of Cow Milk Adulteration using Portable Mear-Infrared Spectroscopy Combined with Chemometrics." *African Journal of Agricultural Research*, 17(2): 198-207.

Nelson, Phillip. 1970. "Information and Consumer Behavior." *Journal of Political Economy*, 78(2): 311-329.

Neville, W.H.H. 1880. "Animal Feed as a Marketable Product." *Transactions of the Homeopathic Medical Society of the State of Pennsylvania. Sixteenth Annual Session*, pp. 117-123. Pittsburgh, PA: W.W. Lewis and Company.

Newton, Jennifer. 2014. "Quick, Inexpensive Milk Quality Test Could Help Developing Countries." *Scientific American*, Sept. 1. Available at: https://www.scientificamerican.com/article/quick-inexpensive-milk-quality-test-could-help-developing-countries/.

Newton, William K. 1877. "Our Milk Supply." *Annual Report of the Department of Health of the State of New Jersey, 1877*. Trenton, NJ: Nabb, Day & Naab, Printers, pp. 209-235.

"Notes and Gleanings" 1885. *The Boston Globe*, Aug. 18, p. 5.

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.

Parker, Horatio N. 1917. *City Milk Supply*. New York, NY: McGraw-Hill Book Company, Inc.

Polonsky, Jonathan A., Melissa Ivey, Md. Khadimul Anam Mazhar, Ziaur Rahman, Olivier le Polain de Waroux, Basel Karo, Katri Jalava, Sirenda Vong, Amrish Baidjoe, Janet Diaz, Flavio Finger, Zakir H. Habib, Charls Erik Halder, Christopher Haskew, Laurent Kaiser, Ali S. Khan, Lucky Sangal, Tahmina Shirin, Quazi Ahmed Zaki, Md. Abdus Salam, and Kate White. 2021. "Epidemiological, Clinical, and Public Health Response Characteristics of a Large Outbreak of Diphtheria among the Rohingya Population in Cox's Barzar, Bangladesh, 2017 to 2019: A Retrospective Study." *PLoS Medicine*, 18(4): e1003587.

Porter, A.E. 1922. "An Outbreak of Diphtheria Due to Infected Milk." *British Medical Journal*, 2(3228): 906-907.

"Praises Boston's Milk Inspection." 1893. *Chicago Tribune*, Jan. 11, p. 14.

"'Prepared,' not 'Adulterated Milk.'" 1883. *Everett Press*, Dec. 19, p. 5.

Preston, Samuel and Michael Haines. 1991. *Fatal Years: Child Mortality in Late Nineteenth-Century America*. Princeton, NJ: Princeton University Press.

Price, W. 1912. "Methods Employed and Resulted Obtained in Improving the Milk Supply of Detroit." In: *First Annual Report of the International Association of Dairy and Milk Inspectors*, pp. 59-68.

"Providing for Milk Inspection." 1889. *The Philadelphia Times*, May 14, p. 1.

"Pure and Impure Milk". 1876. *New York Daily Herald*, Feb. 21, p. 9.

Rashid, Salim. 1988. "Quality in Contestable Markets: A Historical Problem?" *Quarterly Journal of Economics*, 103(1): 245-249.

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

"Report of the Inspector of Milk." 1878. *Boston Post*, April 2, p. 3.

Ronnen, Uri. 1991. "Minimum Quality Standards, Fixed Costs, and Competition." *The RAND Journal of Economics*, 22(4): 490-504.

Rosenau, Milton J. 1909. "The Number of Bacteria in Milk and the Value of Bacterial Counts." In *Milk and Its Relation to the Public Health*, 429–53. Washington D.C.: Government Printing Office.

"Sale of Impure Milk" 1890. *The Times*, June 13, p. 3.

Schereschewsky, J.W. and R. E. Dyer. 1922. "Diphtheria. Its Prevention and Control." *Public Health Reports*, 37(33): 1994-2013.

See, Ang Swi, Abu Bakar Salleh, Fatimah Abu Bakar, Nor Azah Yusof, Ahmed Sahib Abdulamir, and Lee Yook Heng. 2010. "Risk and Health Effect of Boric Acid." *American Journal of Applied Sciences*, 7(5): 620-627.

Society Proceedings. 1912. "Typhoid in Infancy." *Journal of the American Medical Association*, 59(1): 57-63.

State Charities Aid Association (NY). 1883. "Pure Milk and Infants' Food in Tenement Houses." Bulletin No. 34.

Steere-Williams, Jacob. 2020. *The Filth Disease: Typhoid Fever and the Practices of Epidemiology in Victorian England.* Rochester, NY: University of Rochester Press.

"Strike for Reform." 1892. *Chicago Tribune*, Nov. 22, p. 1.

Sun, Liyang and Sarah Abraham. 2021. "Estimating Dynamic Treatment Effects in Event Studies with Heterogeneous Treatment Effects." *Journal of Econometrics*, 225(2): 175-199.

Swinnen, Johan, Koen Deconinck, Thijs Vandemoortele, and Anneleen Vandeplas. 2015. *Quality Standards, Value Chains, and International Development: Economic and Political Theory*. New York, NY: Cambridge University Press.

"The Adulteration of Milk." 1880. *The New England Farmer*, Feb. 21, p. 2.

"The Assumption of Milk Inspector Davenport Condemned" 1884. *The Boston Globe*, December 19, p. 2.

"The Board of Health: More Inspectors and Physicians Urgently Needed." 1879. *New York Daily Herald*, Dec. 23, p. 9.

"The Care of Infants Historical Data." 1912. *Journal of the American Medical Association*, 59(7): 542-543.

"The Inspection of Milk" 1879. *The Boston Globe*, Jan. 7, p. 2.

"The Milk Bill Lost." 1890. *The Philadelphia Times*, June 24, p. 3.

"The New Milk Law." 1880. *The New England Farmer*, Sept. 25, p. 1.

"The State Capital." *New York Herald*, April 19, p. 7.

"To Secure Pure Milk." 1894. *Chicago Tribune*, July 21, p. 14.

Tong, Patricia K. 2011. "The Effects of California Minimum Nurse Staffing Laws on Nurse Labor and Patient Mortality in Skilled Nursing Facilities." *Health Economics*, 20(7): 802-816.

Trask, John W. 1908. "Milk as a Cause of Epidemics of Typhoid Fever, Scarlet Fever, and Diphtheria." Hygienic Laboratory Bull. No. 41, U. S. Public Health and Marine-Hospital Service of the United States, pp. 21-147. Washington D.C.: Government Printing Office.

Tribune News Service. 2021. "20% Milk Samples Found Adulterated in Karnal." *The Tribune*, Nov. 21. Available at: https://www.tribuneindia.com/news/haryana/20-milk-samples-found-adulterated-in-karnal-343282.

Troesken, Werner. 2004. *Water, Race, and Disease*. Cambridge, MA: MIT Press.

Troesken, Werner. 2015. *The Pox of Liberty: How the Constitution Left Americans Rich, Free, and Prone to Infection.* Chicago, IL: University of Chicago Press.

United States Bureau of the Census. 1906. *Mortality Statistics*. Washington, D.C.: United States Government Printing Office.

Wagner, K. S., J.M. White, N.S. Crowcroft, S. D.E. Martin, G. Mann, and A. Efstratiou. 2010. "Diphtheria in the United Kingdom, 1986–2008: The Increasing Role of Corynebacterium Ulcerans." *Epidemiology and Infection*, 138(11): 1519–1530.

Wanjala, George, Philip Kutima, and Julius Maina Marthara. 2018. "Prevalence of Adulteration and Inhibitory Substances in Raw and Pasteurized Milk Marketed in Nairobi Region." *Asian Food Science Journal*, 3(2): 1-8.

"Watching Milkmen." 1885. *The Boston Globe*, May 20, p. 4.

Welply, J.J. 1894. "Creameries and Infectious Diseases." *Lancet*, 143(3686): 992-996.

Wetherill, G. B. and W. K. Chiu. 1975. "A Review of Acceptance Sampling Schemes with Emphasis on the Economic Aspect." *International Statistical Review*, 43(2): 191-210.

"Where Milk's Always Good: Regulation and Inspection of Supply in Three Large Cities." 1906. *The Kansas City Star*, January 23, p. 3.

Whipple, George. *Typhoid Fever – Its Causation, Transmission and Prevention*. New York, NY: John Wiley and Sons.

Whitaker, George M. 1898. "The Milk Supply of Boston and Other New England Cities." Washington, D.C.: United States Government Printing Office.

Williamson, Margaretta A. 1915. *Infant Mortality: Montclair, N.J.*, U.S. Children's Bureau Publication No. 11. Washington, D.C.: Government Printing Office.

Wolf, Jacqueline H. 2001. *Don't Kill Your Baby: Public Health and the Decline of Breastfeeding in the 19th and 20th Centuries*. Columbus, OH: Ohio State University Press.

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

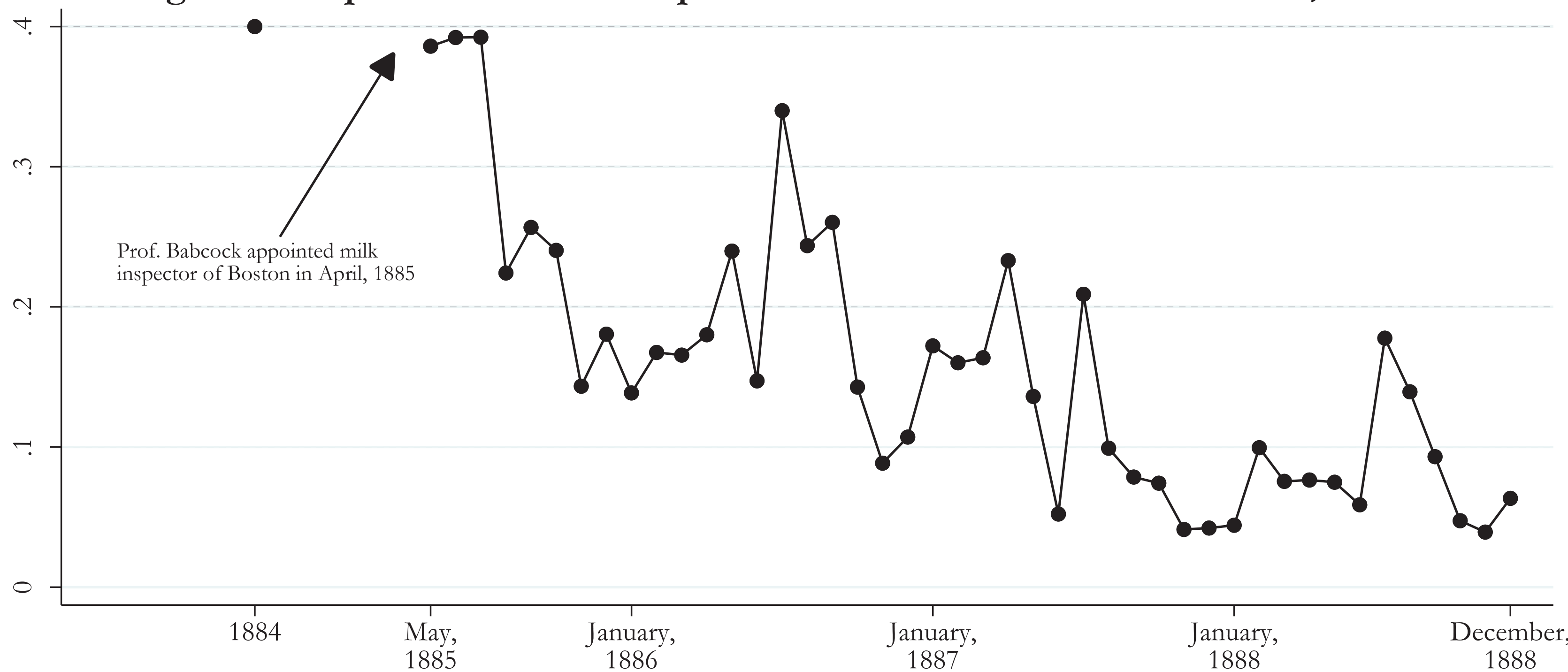
Woodbury, R.M. 1925. *Causal Factors in Infant Mortality: A Statistical Study Based on Investigations in Eight Cities*. Washington, D.C.: Government Printing Office.

Woodbury, R.M. 1926. *Infant Mortality and Its Causes*. Baltimore, MD: The Williams and Wilkins Company.

"Work Among the Babies." 1883. *The Sun*, Oct. 17, p. 3.

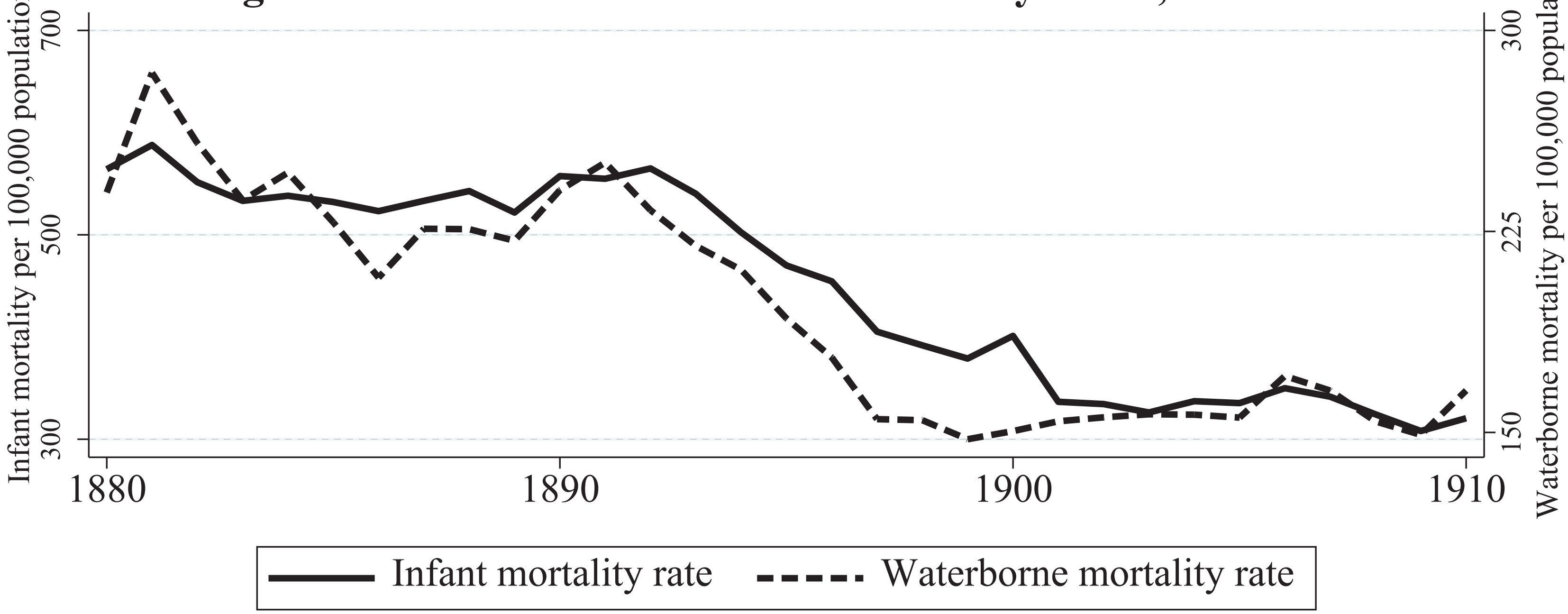
"Work Performed by Milk Inspector Babcock." 1885. *The Boston Globe*, July 7, p. 5.

Figure 1. Proportion of Milk Samples Adulterated with Water in Boston, 1884-1888



Notes: Based on data from the 1888 report of the Boston Milk and Vinegar Inspector.

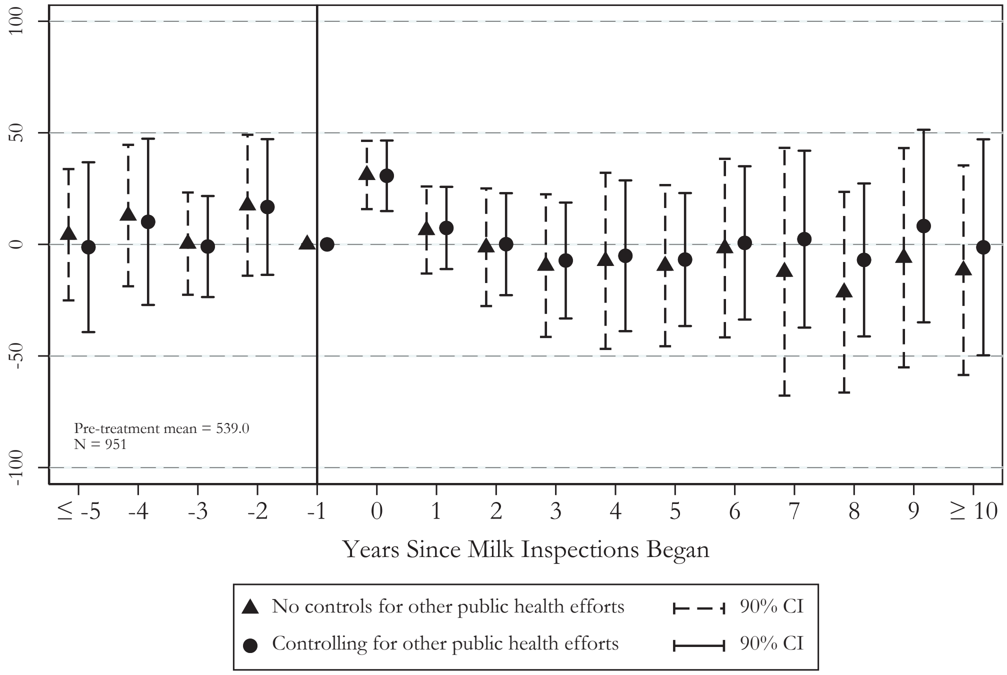
Figure 2. Infant and Waterborne Mortality Rates, 1880-1910



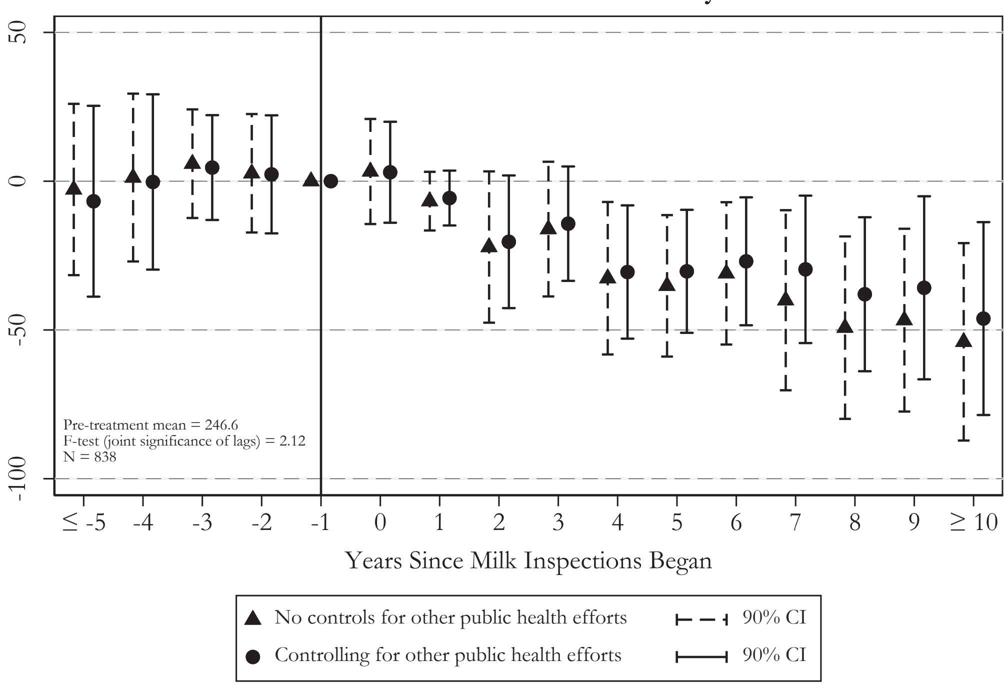
Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910).

Figure 3. The Effect of Milk Inspections on Infant and Waterborne Mortality, 1880-1910

Panel A. Infant Mortality

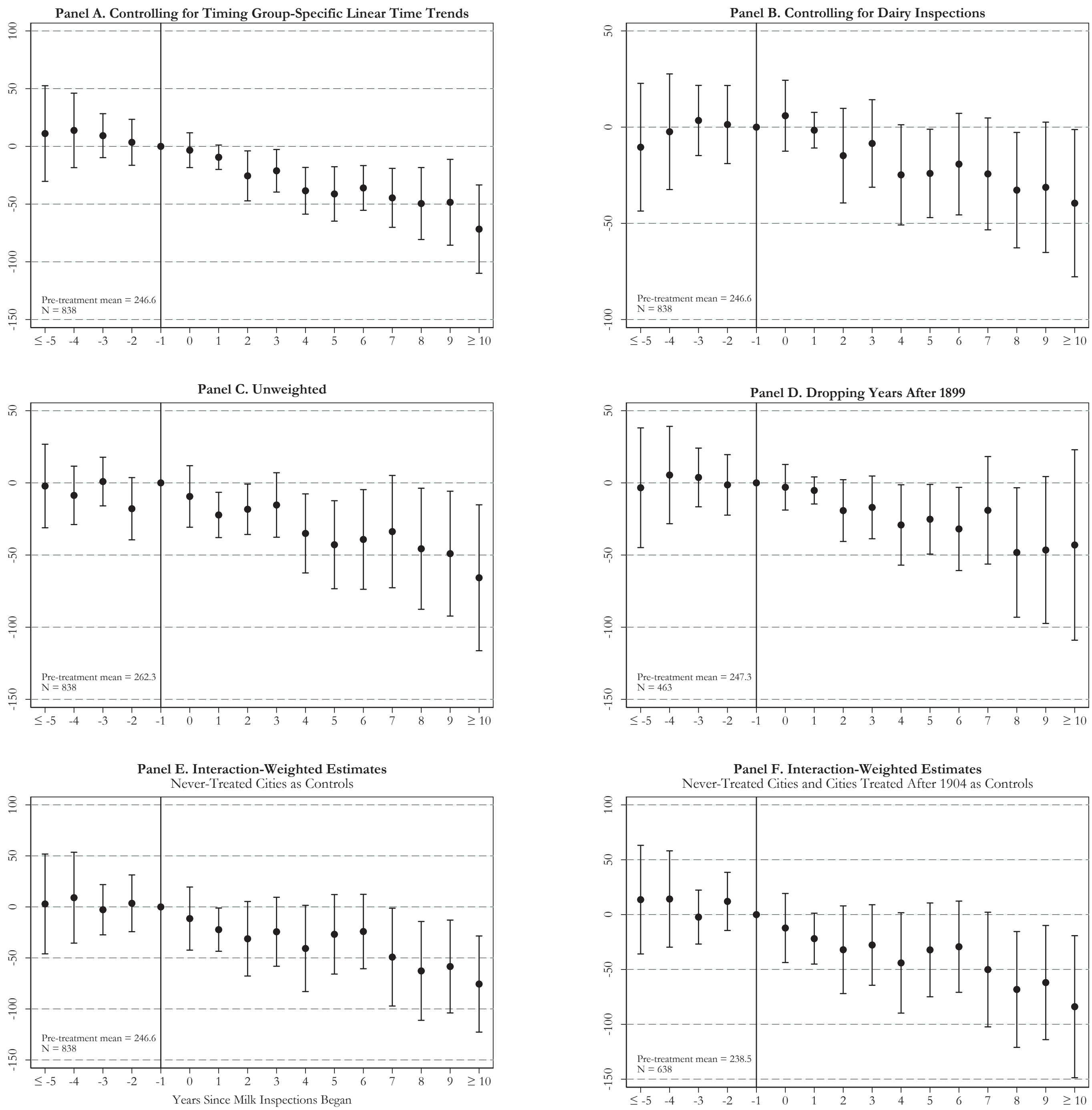


Panel B. Waterborne Mortality



Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910). Two-way fixed effects estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of specified deaths per 100,000 population in city *c* and year *t*. All models control for city and year fixed effects. Other public health efforts are listed in Appendix Table A4. Estimates are weighted by city population and standard errors are corrected for clustering at the city level.

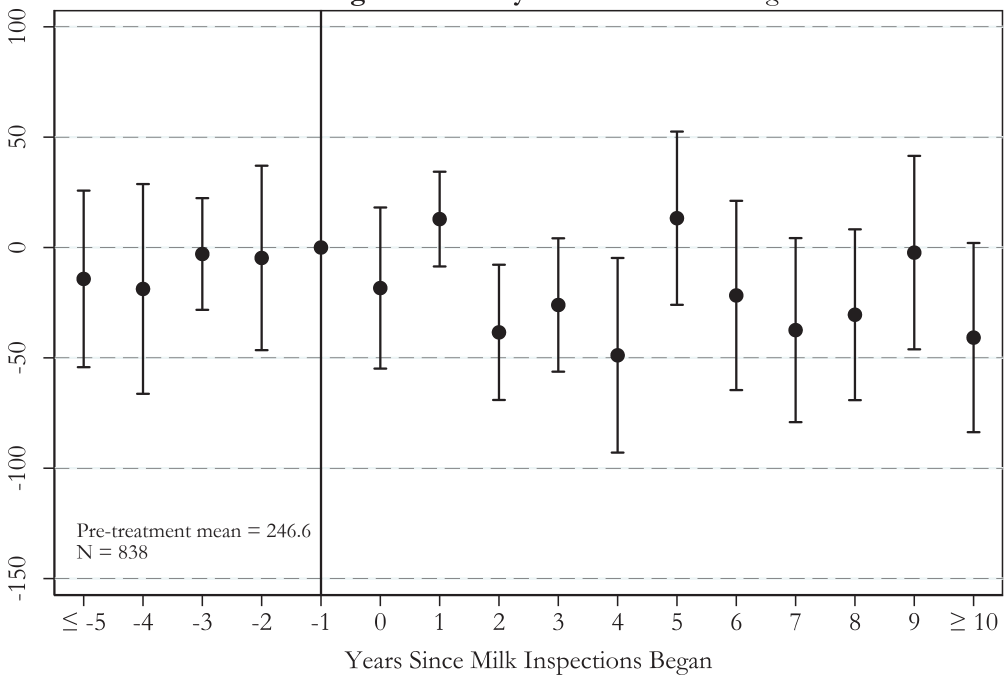
Figure 4. Milk Inspections and Waterborne Mortality: Sensitivity Analysis



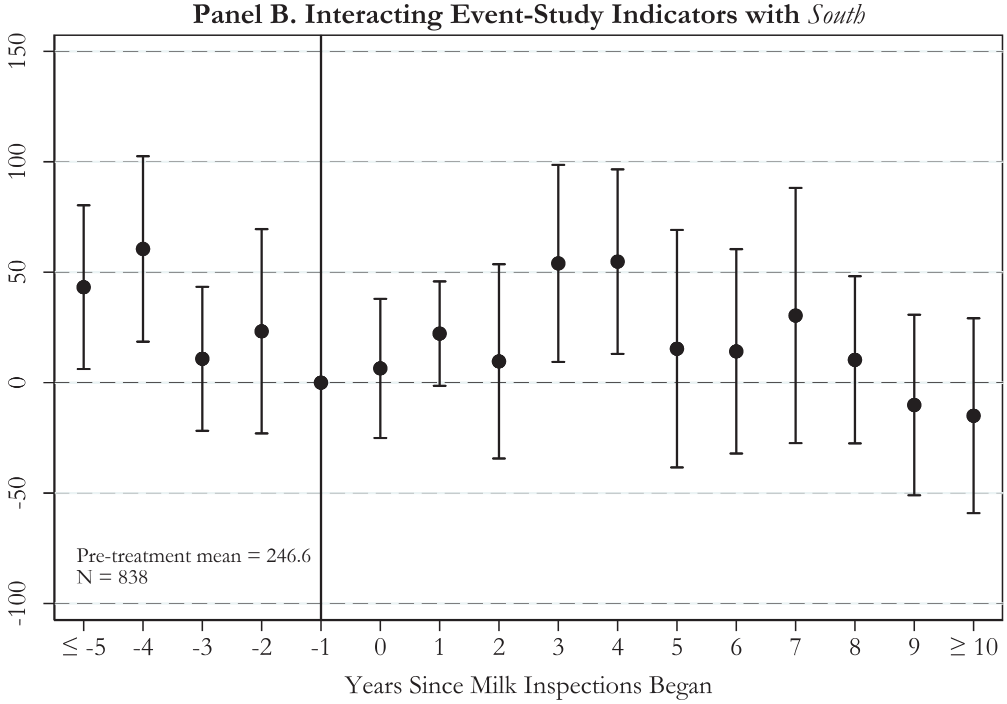
Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910). Two-way fixed effects (panels A-D) and interaction-weighted (panels E and F) estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of waterborne deaths per 100,000 population in city *c* and year *t*. All models control for city fixed effects and year fixed effects. The two-way fixed effects models also control for the other public health efforts listed in Appendix Table A4. In panels A, B, and D-F, estimates are weighted by city population. Standard errors are corrected for clustering at the city level.

Figure 5. Milk Inspections and Waterborne Mortality: Heterogeneity Analysis

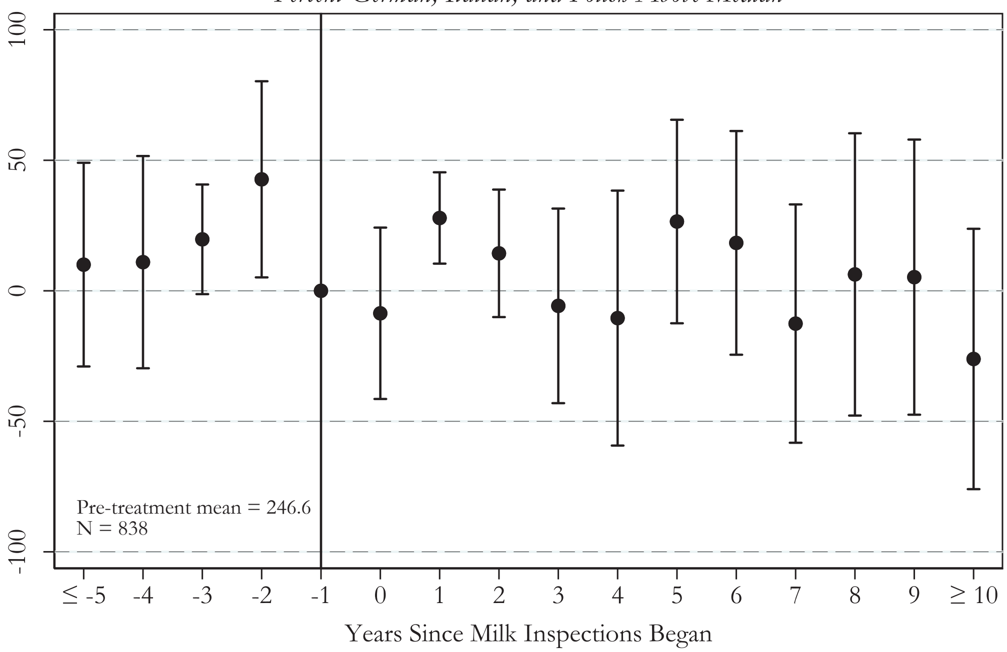
Panel A. Interacting Event-Study Indicators with *Wage Above Median*



Panel B. Interacting Event-Study Indicators with *South*



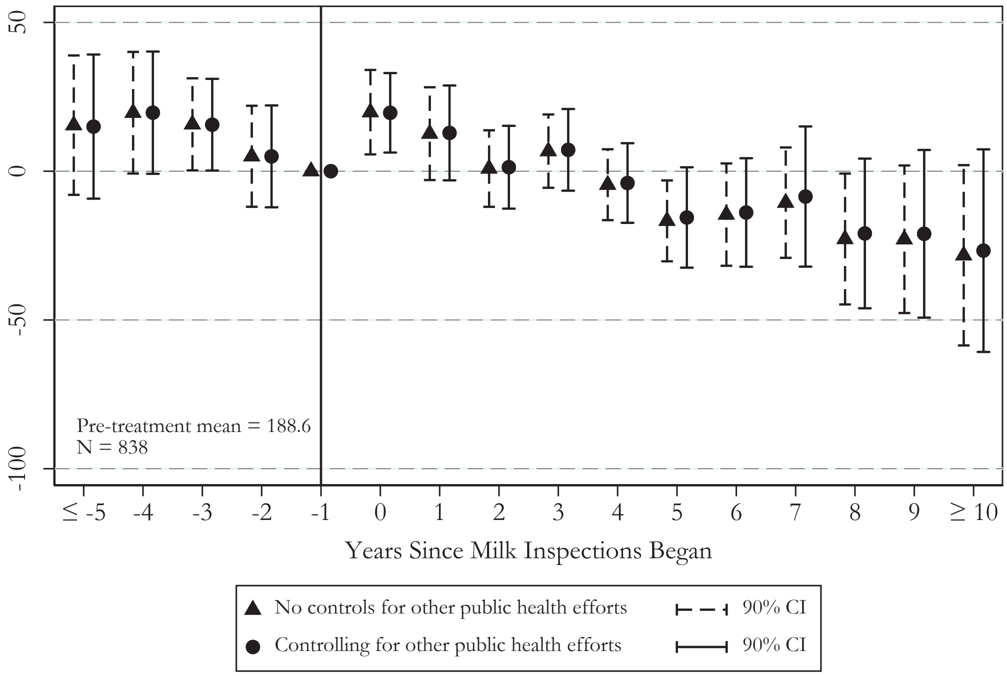
Panel C. Interacting Event-Study Indicators with
Percent German, Italian, and Polish Above Median



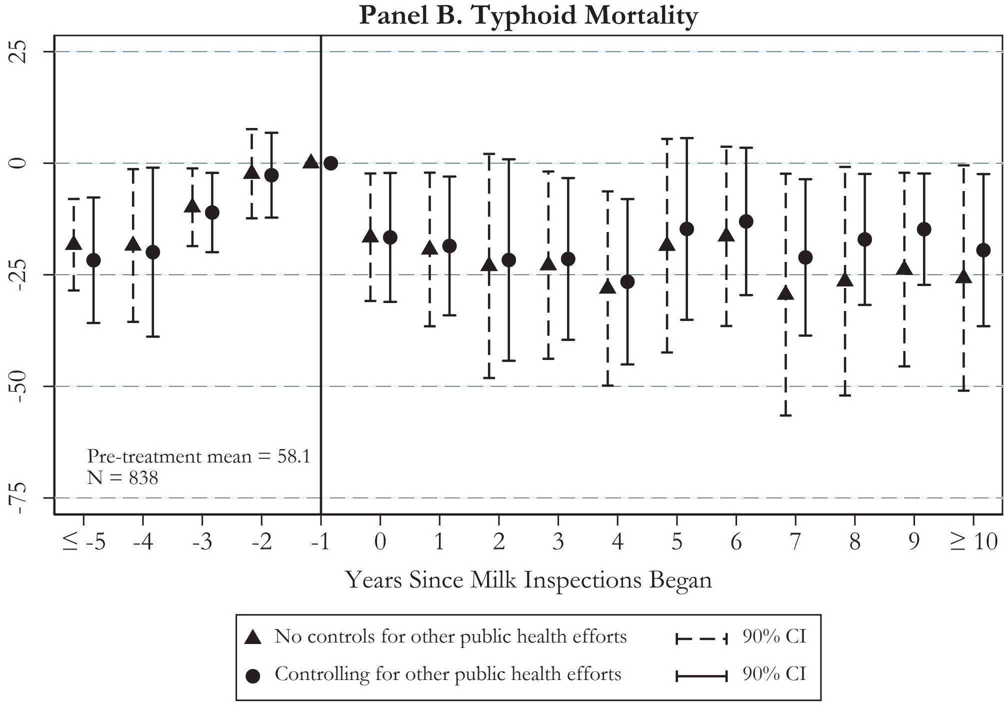
Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910). Two-way fixed effects estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of waterborne deaths per 100,000 population in city *c* and year *t*. In panel A, the event-study indicators are interacted with the variable *Wage Above Median*, which is equal to 1 if the mean manufacturing wage in city *c* during 1899 was above the median among the cities in our sample (and equal to zero otherwise). In panel B, the event-study indicators are interacted with the variable *South*, which is equal to 1 if city *c* is in the South (and equal to zero otherwise). In panel C, the event-study indicators are interacted with the variable *Percent German, Italian, and Polish Above Median*, which is equal to 1 if the percent of the foreign-born population from Germany, Italy, and Poland in city *c* during 1880 was above the median among the cities in our sample (and equal to zero otherwise). All models control for the full set of (non-interacted) event-study indicators, city fixed effects, year fixed effects, and the other public health efforts listed in Appendix Table A4. Estimates are weighted by city population and standard errors are corrected for clustering at the city level.

Figure 6. The Effect of Milk Inspections on Diarrheal and Typhoid Mortality

Panel A. Diarrheal Mortality



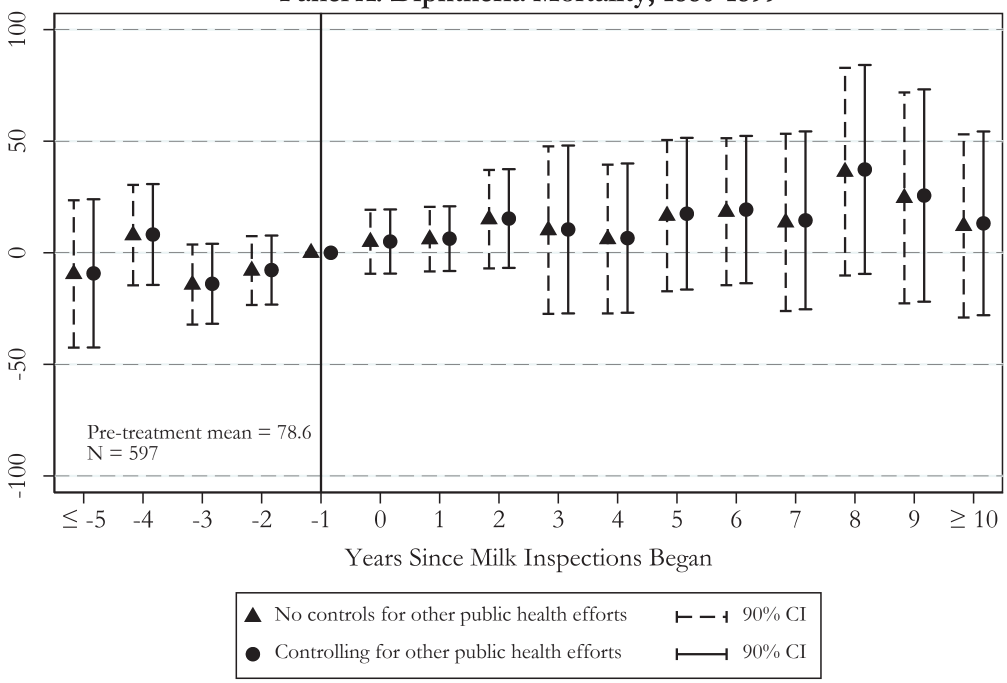
Panel B. Typhoid Mortality



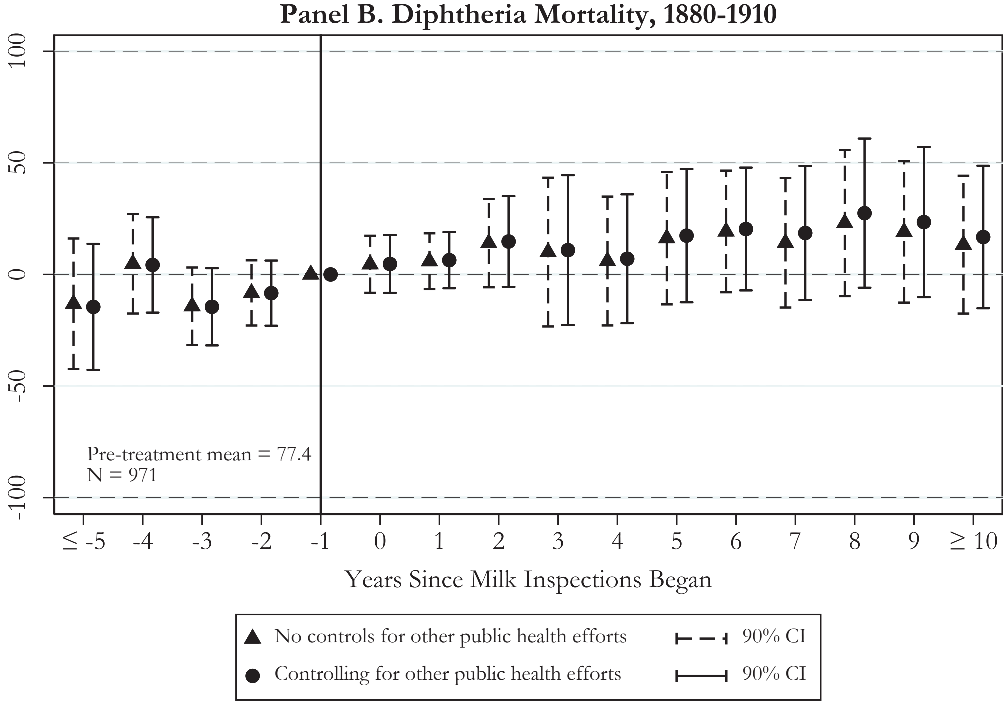
Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910). Two-way fixed effects estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of specified deaths per 100,000 population in city *c* and year *t*. All models control for city and year fixed effects. Other public health efforts are listed in Appendix Table A4. Estimates are weighted by city population and standard errors are corrected for clustering at the city level.

Figure 7. The Effect of Milk Inspections on Diphtheria Mortality

Panel A. Diphtheria Mortality, 1880-1899



Panel B. Diphtheria Mortality, 1880-1910

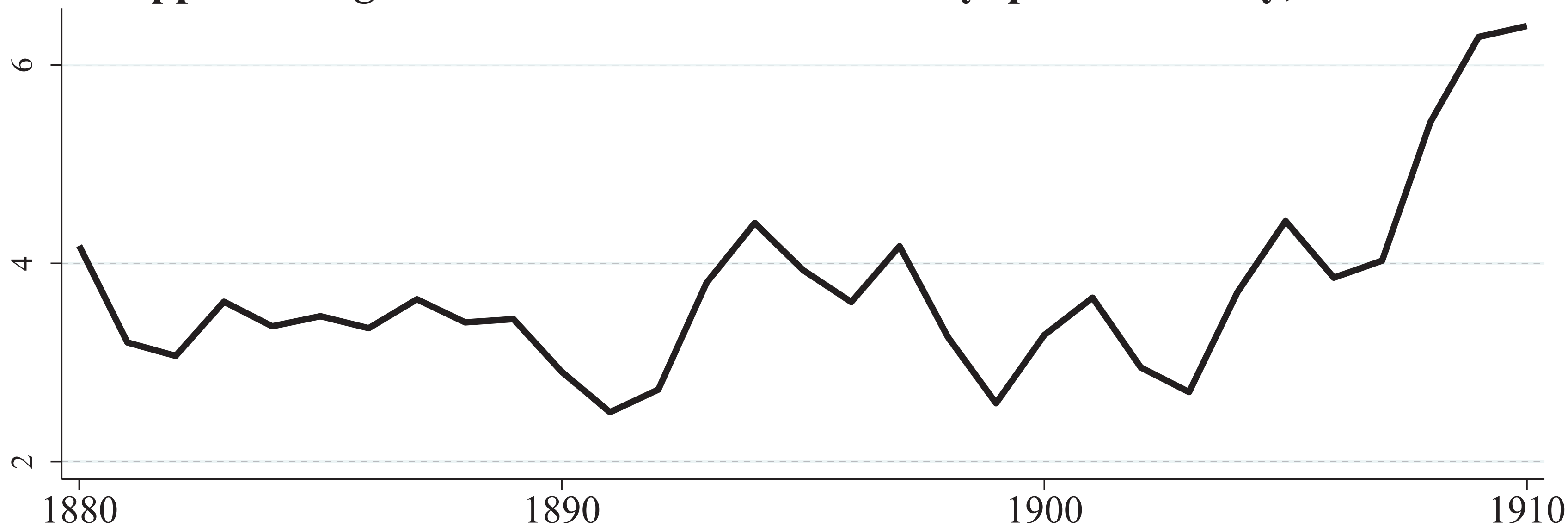


Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910). Two-way fixed effects estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of diphtheria deaths per 100,000 population in city *c* and year *t*. All models control for city and year fixed effects. Other public health efforts are listed in Appendix Table A4. Estimates are weighted by city population and standard errors are corrected for clustering at the city level.

APPENDIX A

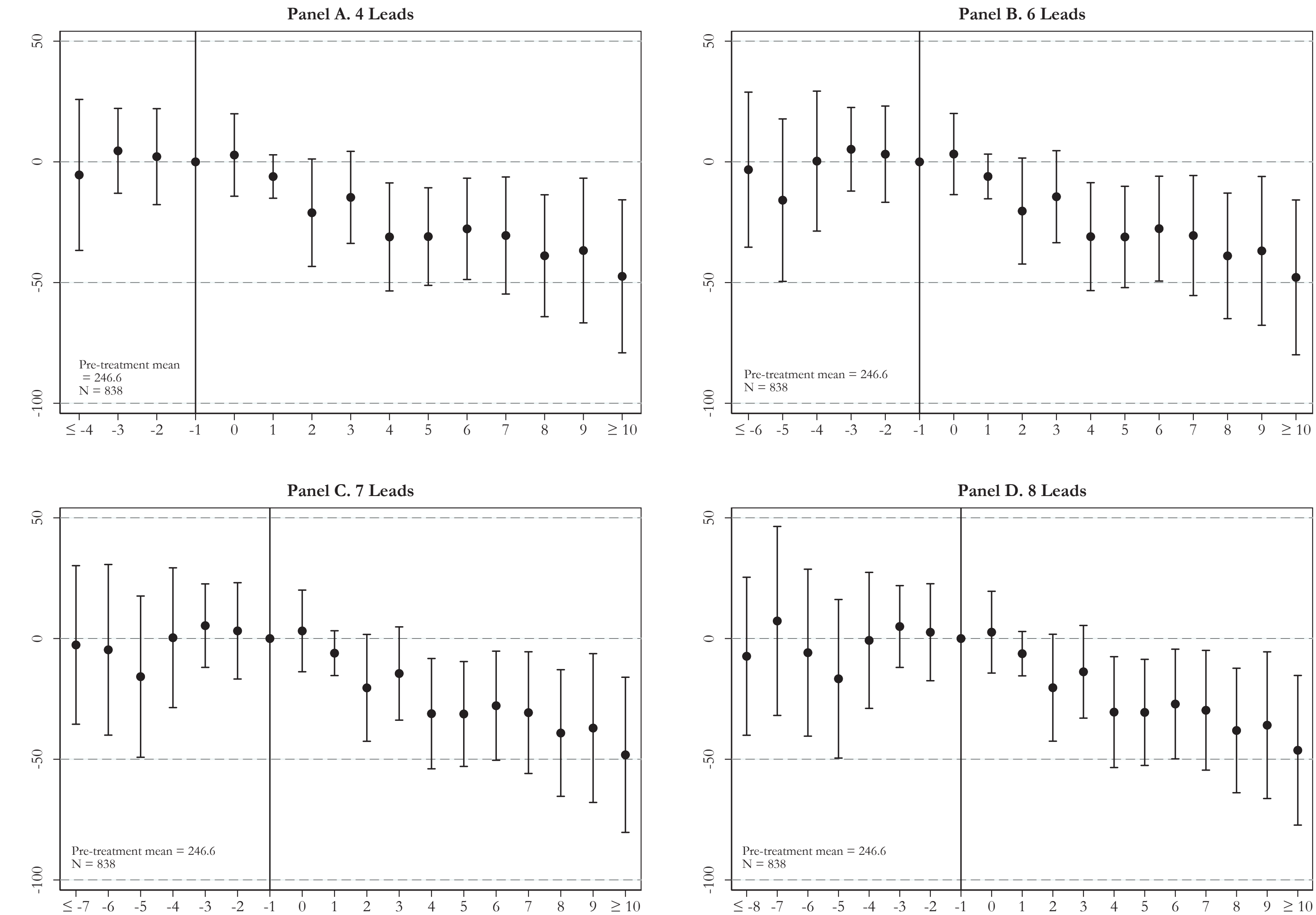
For Online Publication

Appendix Figure A1. Ratio of Diarrheal to Tyhpoid Mortality, 1880-1910



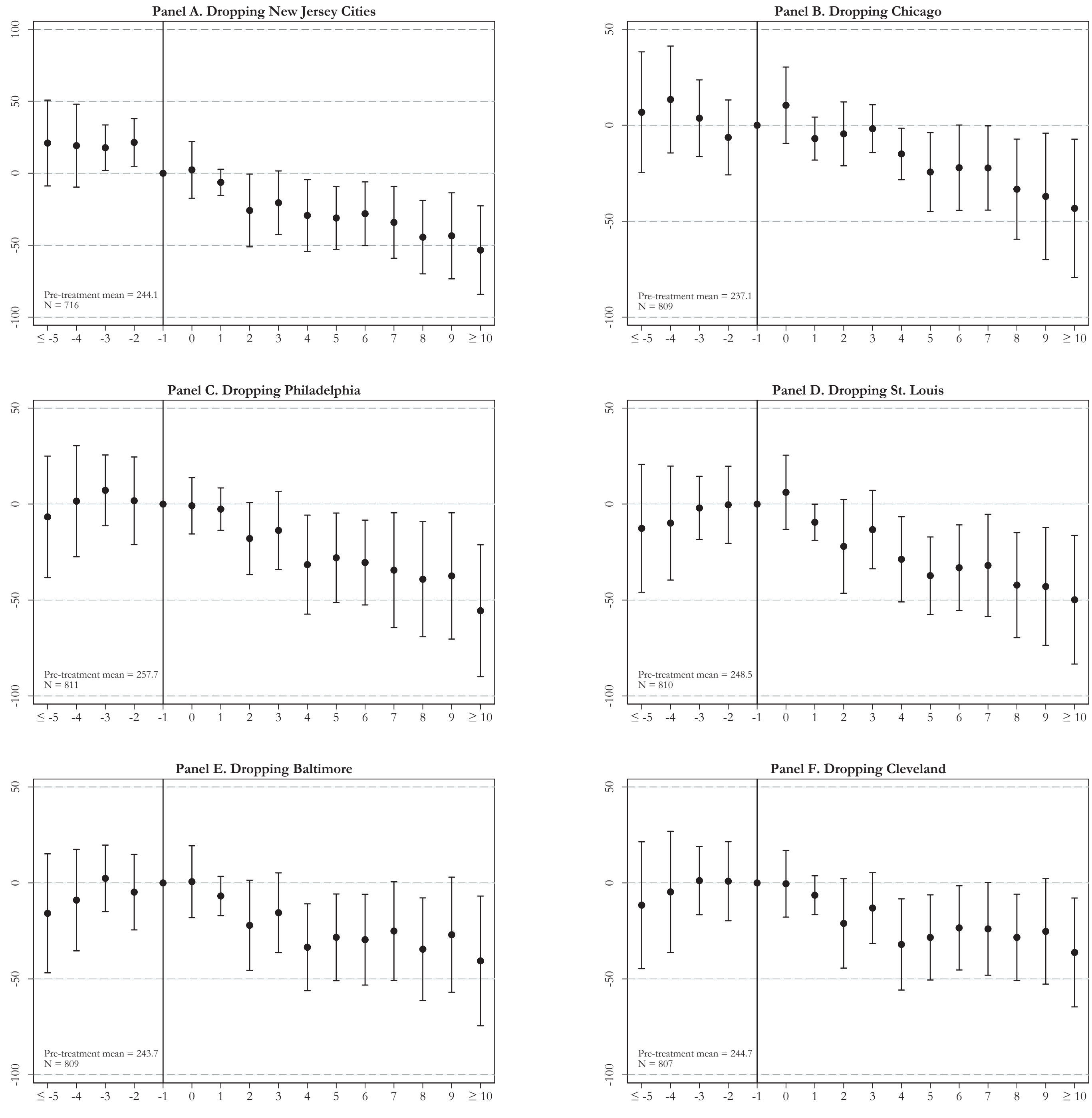
Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910).

Appendix Figure A2. Milk Inspections and Waterborne Mortality: Alternative Lead Structures



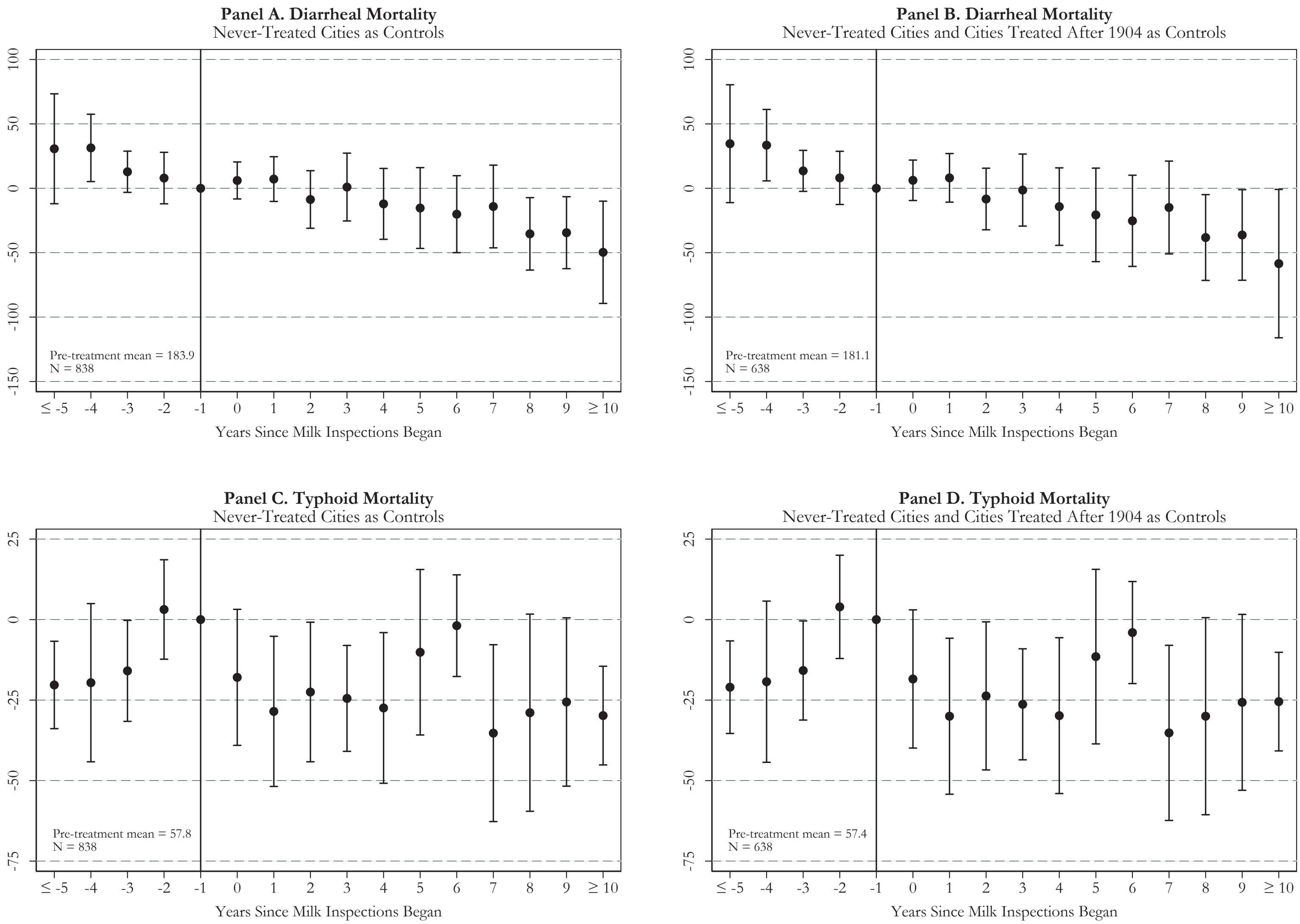
Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910). Two-way fixed effects estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of waterborne deaths per 100,000 population in city *c* and year *t*. All models control for city fixed effects, year fixed effects, and the other public health efforts listed in Appendix Table A4. Estimates are weighted by city population and standard errors are corrected for clustering at the city level.

Appendix Figure A3. Milk Inspections and Waterborne Mortality: Exploring Sample Restrictions



Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910). Two-way fixed effects estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of waterborne deaths per 100,000 population in city *c* and year *t*. All models control for city fixed effects, year fixed effects, and the other public health efforts listed in Appendix Table A4. Estimates are weighted by city population and standard errors are corrected for clustering at the city level.

Appendix Figure A4. The Effect of Milk Inspections on Diarrheal and Typhoid Mortality: Interaction-Weighted Estimates



Notes: Based on annual data from municipal and state public health reports (1880-1899). Interaction-weighted estimates (and their 90% confidence intervals) are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of specified deaths per 100,000 population in city *c* and year *t*. All models control for city and year fixed effects. Estimates are weighted by city population and standard errors are corrected for clustering at the city level.

Appendix Table A1. Municipal Milk Inspection Dates and Data Availability

City and state	Year milk inspections began	Years covered for infant mortality	Years covered for waterborne mortality
Mobile, AL	1905	1889-1910	1889-1894, 1900-1909
San Francisco, CA[a]	1895	1881-1897, 1900-1910	1881-1887, 1889, 1891-1897, 1900-1910
Bridgeport, CT	…	1880-1910	1880-1882, 1887-1896, 1898-1910
Hartford, CT	1883	1880-1910	1880-1882, 1887-1888, 1890-1896, 1898-1909
New Haven, CT	…	1880-1910	1880-1882, 1887-1896, 1898-1910
Waterbury, CT	…	1880-1910	1880-1882, 1887-1896, 1898-1909
Washington, D.C.	1893	1880-1910	1880-1910
Atlanta, GA	1895	1893-1910	1880-1910
Chicago, IL	1893	1880-1910	1880-1897, 1900-1910
Indianapolis, IN	1896	1884-1887, 1895-1896, 1899-1910	1891-1910
New Orleans, LA	1892	1881-1910	1880-1910
Portland, ME	1902	1887-1910	1894-1898, 1900-1909
Baltimore, MD	1894	1880-1910	1880-1890, 1892-1898, 1900-1910
Grand Rapids, MI	1897	1890, 1892-1910	1890-1894, 1896-1910
St. Paul, MN	1887	1885-1910	1885, 1887, 1889-1910
St. Louis, MO	1887	1880-1896, 1900-1910	1880-1896, 1900-1910
Omaha, NE	1904	1891-1910	1892-1893, 1895-1910
Manchester, NH	1884	1883-1910	1883-1909
Camden, NJ	1883	1880-1910	1880-1886, 1900-1909
Elizabeth, NJ	1883	1880-1910	1880-1886, 1900-1909
Hoboken, NJ	1883	1880-1910	1880-1886, 1900-1909
Jersey City, NJ	1883	1880-1910	1880-1886, 1900-1910
Newark, NJ	1883	1880-1910	1880-1886, 1900-1910
Paterson, NJ	1883	1880-1910	1880-1886, 1900-1910
Trenton, NJ	1883	1880-1910	1880-1886, 1900-1909
Buffalo, NY[b]	1883	…	1881-1910
Rochester, NY[c]	1891	1881-1910	…
Cleveland, OH	1888	1880-1910	1880-1910
Dayton, OH	1887	1880, 1890-1891, 1893-1896, 1898-1910	1880-1910
Toledo, OH	1884	1881-1883, 1885, 1898-1910	1882-1886, 1888, 1894-1898, 1900-1910
Philadelphia, PA	1889	1880-1910	1880-1888, 1890-1894, 1896, 1899-1910
Scranton, PA	1891	1887-1897, 1900-1910	1888-1897, 1900-1910
Charleston, SC	1907	1880-1883, 1885-1894, 1897, 1900-1910	1880-1883, 1885-1894, 1896-1897, 1899-1909

Appendix Table A1. Municipal Milk Inspection Dates and Data Availability (continued)

City and state	Year milk inspections began	Years covered for infant mortality	Years covered for waterborne mortality
Memphis, TN	1898	1880-1897, 1900-1910	1881-1882, 1884-1888, 1890-1893, 1895-1898, 1900-1910
Richmond, VA	1904	1887-1910	1887-1910
Milwaukee, WI	1891	1885-1890, 1892-1910	1880-1910
N		951	838

[a] San Francisco briefly suspended milk inspections in the fall of 1897, but resumed them the following year ("Liquid Death Once Again to be Sold to Mothers and Babes" 1897; "After the Milkmen" 1898).
[b] Buffalo, NY is not included in the sample on infant mortality because mortality counts are unavailable for the pre-treatment period.
[c] Rochester, NY is not included in the sample on waterborne mortality because mortality counts are unavailable for the pre-treatment period.

Appendix Table A2. Location of Municipal and State Public Health Reports for Pre-1900 Mortality Data

City and state	Sources
Mobile, AL	National Library of Medicine Archives
San Francisco, CA	National Library of Medicine Archives
Bridgeport, CT	HathiTrust Digital Library
Hartford, CT	HathiTrust Digital Library
New Haven, CT	HathiTrust Digital Library
Waterbury, CT	HathiTrust Digital Library
Washington, D.C.	HathiTrust Digital Library
Atlanta, GA	National Library of Medicine Archives
Chicago, IL	Chicago Municipal Library (1880), HathiTrust Digital Library (1881-1899)
Indianapolis, IN	National Library of Medicine Archives
New Orleans, LA	HathiTrust Digital Library
Portland, ME	National Library of Medicine Archives
Baltimore, MD	HathiTrust Digital Library (1880-1888, 1890, 1892-1899), Google Books (1889), National Library of Medicine Archives (1891),
Grand Rapids, MI	National Library of Medicine Archives
St. Paul, MN	National Library of Medicine Archives
St. Louis, MO	St. Louis Public Library (1880-1896), HathiTrust Digital Library (1897-1899)
Omaha, NE	National Library of Medicine Archives
Manchester, NH	HathiTrust Digital Library
Camden, NJ	HathiTrust Digital Library
Elizabeth, NJ	HathiTrust Digital Library
Hoboken, NJ	HathiTrust Digital Library
Jersey City, NJ	HathiTrust Digital Library
Newark, NJ	HathiTrust Digital Library
Paterson, NJ	HathiTrust Digital Library
Trenton, NJ	HathiTrust Digital Library
Buffalo, NY	National Library of Medicine Archives
Rochester, NY	National Library of Medicine Archives
Cleveland, OH	HathiTrust Digital Library (1880-1883), Cleveland Public Library (1884-1885), National Library of Medicine Archives (1886-1899)
Dayton, OH	National Library of Medicine Archives
Toledo, OH	National Library of Medicine Archives
Philadelphia, PA	HathiTrust Digital Library (1880-1887, 1890, 1892), National Library of Medicine Archives (1888-1889, 1894-1896, 1899), Google Books (1891, 1893, 1897-1898)
Scranton, PA	National Library of Medicine Archives
Charleston, SC	National Library of Medicine Archives
Memphis, TN	National Library of Medicine Archives
Richmond, VA	National Library of Medicine Archives
Milwaukee, WI	HathiTrust Digital Library (1880-1884, 1896-1899), University of Wisconsin-Madison Library (1891-1895)

Appendix Table A3. Pre-1900 Diarrheal Mortality by City

City and state	Categories included in diarrheal mortality
Mobile, AL	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, gastroenteritis, enterocolitis
San Francisco, CA	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, gastroenteritis, enterocolitis
Bridgeport, CT	diarrhea, cholera infantum, dysentery, enteritis
Hartford, CT	diarrhea, cholera infantum, dysentery, enteritis
New Haven, CT	diarrhea, cholera infantum, dysentery, enteritis
Waterbury, CT	diarrhea, cholera infantum, dysentery, enteritis
Washington, D.C.	diarrhea, cholera infantum, dysentery, cholera morbus, enterocolitis
Atlanta, GA	diarrheal diseases
Chicago, IL	diarrhea, cholera infantum, dysentery, cholera morbus, gastroenteritis
Indianapolis, IN	diarrhea, enteritis
New Orleans, LA	diarrheal diseases
Portland, ME	cholera infantum, dysentery, enterocolitis
Baltimore, MD	diarrhea, cholera infantum, dysentery, cholera morbus, gastroenteritis, enterocolitis
Grand Rapids, MI	cholera infantum
St. Paul, MN	cholera infantum, enteritis, gastroenteritis, enterocolitis
St. Louis, MO	diarrheal diseases
Omaha, NE	cholera infantum, gastroenteritis
Manchester, NH	diarrhea, cholera infantum, dysentery, enteritis
Camden, NJ	diarrheal diseases
Elizabeth, NJ	diarrheal diseases
Hoboken, NJ	diarrheal diseases
Jersey City, NJ	diarrheal diseases
Newark, NJ	diarrheal diseases
Paterson, NJ	diarrheal diseases
Trenton, NJ	diarrheal diseases
Buffalo, NY	cholera infantum
Rochester, NY	…
Cleveland, OH	diarrhea, cholera infantum
Dayton, OH	diarrheal diseases
Toledo, OH	diarrhea, cholera infantum, dysentery, enteritis
Philadelphia, PA	diarrhea, cholera infantum, dysentery, cholera morbus
Scranton, PA	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus
Charleston, SC	diarrhea, dysentery, enteritis, cholera morbus, gastroenteritis, enterocolitis
Memphis, TN	diarrhea, cholera infantum, dysentery, enteritis, gastroenteritis, enterocolitis
Richmond, VA	diarrhea, cholera infantum, dysentery, enteritis, cholera morbus, gastroenteritis, enterocolitis
Milwaukee, WI	diarrheal diseases

Appendix Table A4. Descriptive Statistics

	Mean (SD)	Description
Inspection	0.635 (0.482)	= 1 if city sampled and inspected its milk supply, = 0 otherwise
Filtration	0.085 (0.278)	= 1 if city had a water filtration plant, = 0 otherwise
Chlorination	0.006 (0.071)	= 1 if city treated water supply with chlorine, = 0 otherwise
Clean Water Project	0.040 (0.196)	= 1 if city had completed a clean water project, = 0 otherwise
N = 951		

Notes: Unweighted means with standard deviations in parentheses.

Appendix Table A5. The Effect of Milk Inspections on Infant and Waterborne Mortality, 1880-1910: Estimates from Figure 3

	(1)	(2)	(3)	(4)
	Infant Mortality	Infant Mortality	Waterborne Mortality	Waterborne Mortality
5+ Years Prior to Inspection	4.35	-1.25	-2.80	-6.75
	(17.4)	(22.5)	(17.0)	(19.0)
4 Years Prior to Inspection	12.9	10.1	1.21	-0.266
	(18.7)	(22.0)	(16.7)	(17.4)
3 Years Prior to Inspection	0.361	-0.958	5.87	4.57
	(13.6)	(13.4)	(10.8)	(10.4)
2 Years Prior to Inspection	17.5	16.8	2.66	2.30
	(18.7)	(18.0)	(11.8)	(11.7)
1 Year Prior to Inspection	…	…	…	…
Year 0	31.1***	30.7***	3.25	2.99
	(9.05)	(9.35)	(10.4)	(10.0)
1 Year After Inspection	6.46	7.38	-6.71	-5.67
	(11.5)	(10.9)	(5.83)	(5.45)
2 Years After Inspection	-1.26	0.101	-22.1	-20.4
	(15.6)	(13.5)	(15.0)	(13.2)
3 Years After Inspection	-9.49	-7.23	-16.1	-14.3
	(18.9)	(15.4)	(13.4)	(11.4)
4 Years After Inspection	-7.36	-5.10	-32.6**	-30.5**
	(23.3)	(20.0)	(15.2)	(13.2)
5 Years After Inspection	-9.53	-6.79	-35.2**	-30.3**
	(21.3)	(17.6)	(14.1)	(12.2)
6 Years After Inspection	-1.66	0.667	-31.0**	-26.9**
	(23.7)	(20.3)	(14.1)	(12.7)
7 Years After Inspection	-12.3	2.34	-40.0**	-29.6*
	(32.8)	(23.4)	(17.9)	(14.7)
8 Years After Inspection	-21.4	-6.96	-49.2**	-38.0**
	(26.6)	(20.3)	(18.1)	(15.3)
9 Years After Inspection	-5.96	8.23	-46.7**	-35.8*
	(29.1)	(25.5)	(18.2)	(18.2)
10 Years After Inspection	-11.6	-1.30	-54.0***	-46.2**
	(27.8)	(28.6)	(19.6)	(19.2)
Pre-treatment mean	539.0	539.0	246.6	246.6
N	951	951	838	838
Other public health controls	No	Yes	No	Yes

Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910). Two-way fixed effects estimates are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of specified deaths per 100,000 population in city *c* and year *t*. All models control for city and year fixed effects. Other public health efforts are listed in Appendix Table A4. Estimates are weighted by city population and standard errors are corrected for clustering at the city level.

Appendix Table A6. The Effect of Milk Inspections on Diarrheal and Typhoid Mortality, 1880-1910: Estimates from Figure 6

	(1)	(2)	(3)	(4)
	Diarrheal Mortality	Diarrheal Mortality	Typhoid Mortality	Typhoid Mortality
5+ Years Prior to Inspection	15.5	15.0	-18.3***	-21.7**
	(13.9)	(14.3)	(6.06)	(8.32)
4 Years Prior to Inspection	19.7	19.7	-18.4*	-19.9*
	(12.1)	(12.1)	(10.1)	(11.2)
3 Years Prior to Inspection	15.7*	15.6*	-9.87*	-11.0**
	(9.15)	(9.12)	(5.15)	(5.25)
2 Years Prior to Inspection	5.01	4.98	-2.35	-2.69
	(10.0)	(10.1)	(5.91)	(5.62)
1 Year Prior to Inspection	…	…	…	…
Year 0	19.8**	19.6**	-16.6*	-16.6*
	(8.39)	(7.90)	(8.44)	(8.54)
1 Year After Inspection	12.6	12.9	-19.3*	-18.5*
	(9.22)	(9.43)	(10.2)	(9.19)
2 Years After Inspection	0.886	1.33	-23.0	-21.7
	(7.61)	(8.23)	(14.8)	(13.3)
3 Years After Inspection	6.74	7.17	-22.8*	-21.4*
	(7.29)	(8.12)	(12.4)	(10.7)
4 Years After Inspection	-4.55	-3.97	-28.1**	-26.6**
	(7.04)	(7.91)	(12.9)	(11.0)
5 Years After Inspection	-16.7**	-15.6	-18.5	-14.7
	(8.04)	(9.98)	(14.1)	(12.0)
6 Years After Inspection	-14.6	-13.9	-16.4	-13.0
	(10.2)	(10.8)	(11.9)	(9.77)
7 Years After Inspection	-10.6	-8.53	-29.4*	-21.1**
	(11.0)	(13.9)	(16.0)	(10.4)
8 Years After Inspection	-22.8*	-20.9	-26.4*	-17.1*
	(13.0)	(14.9)	(15.1)	(8.68)
9 Years After Inspection	-22.9	-21.1	-23.8*	-14.8*
	(14.7)	(16.7)	(12.8)	(7.38)
10 Years After Inspection	-28.3	-26.7	-25.7*	-19.5*
	(17.9)	(20.1)	(14.9)	(10.1)
Pre-treatment mean	188.6	188.6	58.1	58.1
N	838	838	838	838
Other public health controls	No	Yes	No	Yes

Notes: Based on annual data from municipal and state public health reports (1880-1899) and *Mortality Statistics* (1900-1910). Two-way fixed effects estimates are reported, where the omitted category is one year before treatment. The dependent variable is equal to the number of specified deaths per 100,000 population in city *c* and year *t*. All models control for city and year fixed effects. Other public health efforts are listed in Appendix Table A4. Estimates are weighted by city population and standard errors are corrected for clustering at the city level.

APPENDIX B

For Online Publication

Sources for the Boston Case Study

"Agricultural News." 1888. *The New England Farmer*, March 17 p. 4.

"Good and Bad Milk." 1886. *The Boston Globe*, Feb. 16, p. 3.

"Annual Report of the Milk Inspector." 1885. *The Boston Globe*, June 3, p. 5.

City of Boston. 1880. *Documents of the City of Boston for the Year 1879*. Boston, MA: Rockwell and Churchill, City Printers.

City of Boston. 1883. *City of Boston, For the Year 1882*. Boston, MA: Rockwell and Churchill, City Printers.

City of Boston. 1889. *City of Boston, Thirtieth Annual Report of the Inspector of Milk and Vinegar*. Boston, MA: Office of the Inspector of Milk and Vinegar.

"Mayor's Appointments Confirmed by the Aldermen." 1889. *The Boston Globe*, May 14, p. 8.

"Milk and Vinegar" 1889. *The Boston Globe*, Feb. 5, p. 8.

"Milk Inspection: The System in Boston and How it Works." 1885. *The Baltimore Sun*, Dec. 10, p. 5.

"Notes and Gleanings" 1885. *The Boston Globe*, Aug. 18, p. 5.

Parker, Horatio N. 1917. *City Milk Supply*. New York, NY: McGraw-Hill Book Company, Inc.

"Praises Boston's Milk Inspection." 1893. *Chicago Tribune*, Jan. 11, p. 14.

"'Prepared,' not 'Adulterated Milk.'" 1883. Everett Press, Dec. 19, p. 5.

"Report of the Inspector of Milk." 1878. *Boston Post*, April 2, p. 3.

"Spirit of the State Press". 1885. *The Boston Globe*, Sept. 24, p. 4.

"The Assumption of Milk Inspector Davenport Condemned." 1884. *The Boston Globe*, Dec. 19, p. 2.

"The Inspection of Milk" 1879. *The Boston Globe*, Jan. 7, p. 2.

"The Milk Inspector's Annual Report Presented to the Board." 1884. *The Boston Globe*, April 15, p. 6.

"Watching Milkmen." 1885. *The Boston Globe*, May 20, p. 4.

"Where Milk's Always Good: Regulation and Inspection of Supply in Three Large Cities." 1906. *The Kansas City Star*, Jan. 23, p. 3.

"Work Performed by Milk Inspector Babcock." 1885. *The Boston Globe*, July 7, p. 5.

APPENDIX C

For Online Publication

Sources for Milk- and Water-Related Public Health Interventions

Mobile, AL

Kay, Edgar B. 1913. "Mobile Water Supply." In the *Proceedings of the Thirty-Third Annual Convention of the American Water Works Association,* 33: 587-596.

Parker, Horatio N. 1917. *City Milk Supply*. New York, NY: McGraw-Hill Book Company, Inc.

"Wants a Milk Inspector." 1905. *Jones Valley Times*, June 8, p. 2.

San Francisco, CA

"After the Milkmen." 1898. *San Francisco Examiner*, May 29, p. 20.

"After the Milk Inspector's Scalp." 1895. *San Francisco Chronicle*, Oct. 12, p. 14.

"The Affairs of this City Reviewed." 1894. *San Francisco Chronicle*, Dec. 9, p. 17.

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

Eagle, Alexander. 1929. "The San Francisco Milk Supply and its Problems." *Eighteenth Annual Report of the International Association of Dairy and Milk Inspectors*, pp. 218-226.

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.

Bridgeport, CT

Barrows, Frank. C. 1933. "Steps in the Purification of the Bridgeport Water Supply." *Journal of the New England Water Works Association*, 47(2): 219-222.

Woodward, Edwin G. 1936. "History of the Dairy and Milk Commission from its Creation in 1886. Fifty Years of Progress." *Thirty-First Report of the Dairy and Food Commissioner*. Hartford: State (State of Connecticut Public Document No. 32), pp. 13-22.

Hartford, CT

Board of Water Commissioners (Harford, CT). 1916 *Sixty-Second Annual Report of the Board of Water Commissioners of the City of Hartford, Conn. for the year ending March 1, 1916*. Hartford, CT: The Case, Lockwood, and Brainard Company.

"Milk Inspection." 1882. *Hartford Courant*, Nov. 25, p. 3.

"Milk Inspection." 1882. *Hartford Courant*, Dec. 4, p. 2.

"Sealer Robert's Annual Report—Marked Improvement in the Quality of Milk." 1883. *Hartford Courant*, May 15, p. 2.

Woodward, Edwin G. 1936. "History of the Dairy and Milk Commission from its Creation in 1886. Fifty Years of Progress." *Thirty-First Report of the Dairy and Food Commissioner*. Hartford: State (State of Connecticut Public Document No. 32), pp. 13-22.

New Haven, CT

McCluskey, Dorothy S. and Claire C. Bennitt. 1997. "Partnerships Protect Watersheds: The Case of the New Haven Water Company." *Land Lines*, 9(1): 1-3.

Woodward, Edwin G. 1936. "History of the Dairy and Milk Commission from its Creation in 1886. Fifty Years of Progress." *Thirty-First Report of the Dairy and Food Commissioner*. Hartford, CT: State of Connecticut Public Document No. 32, pp. 13-22.

Waterbury, CT

Pape, William Jamieson. 1918. *History of Waterbury and the Naugatuck Valley, Connecticut*. New York: The S.J. Clarke Publishing Company.

Woodward, Edwin G. 1936. "History of the Dairy and Milk Commission from its Creation in 1886. Fifty Years of Progress." *Thirty-First Report of the Dairy and Food Commissioner*. Hartford: State (State of Connecticut Public Document No. 32), pp. 13-22.

Washington, D.C.

"A Milk Inspector Needed." 1890. *Evening Star*, April 4, p. 6.

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.

"Milk Inspection" 1893. *Evening Star*, April 17, p. 7.

"Samples of Milk Tested" 1893. *Evening Star*, June 5, p. 6.

"The Work of the Inspectors." 1893. *Evening Star*, May 17, p. 6.

Atlanta, GA

Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

Elmore, Bartow. 2010. "Hydrology and Residential Segregation in the Postwar South: An Environmental History of Atlanta, 1865-1895." *The Georgia Historical Quarterly,* 94(1): 30-61.

Garrett, Franklin M. 2011. *Atlanta and Environs: A Chronicle of Its People and Events, 1880s-1930s*. Athens: University of Georgia Press.

"Notice to Milk Dealers and Dairymen." 1895. *The Atlanta Constitution*, July 16, p. 5.

"Ruined His Milk." 1895. *The Atlanta Constitution*, Aug. 29, p. 10.

"Sanitary Condition Vastly Improved by Recent City Ordinances." 1889. *The Atlanta Constitution*, Feb. 23, p. 8.

"The Ordinance" 1888. *The Atlanta Constitution*, July 17, p. 8.

"Their Report Out." 1896. *The Atlanta Constitution*, May 15, p. 2.

"Want More Money." 1895. Heads of City Departments Tell Finance Committee What They Want." *The Atlanta Constitution*, Jan. 9, p. 5.

Chicago, IL

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.

"Milk Must be Pure." 1892. *The Chicago Tribune*, Oct. 17, p. 6

"Municipal Notes." 1893. *Chicago Tribune*, Jan. 12, p. 9.

"Strike for Reform." 1892. *Chicago Tribune*, Nov. 22, p. 1.

Indianapolis, IN

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

"Dairymen's Milk Examined Dailey." 1897. *The Indianapolis News*, Nov. 8, p. 2.

"Death Rate Decreases." 1897. *The Indianapolis Journal*, Jan. 28, p. 7.

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

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.

"Milk Inspector Named." 1896. *The Indianapolis Journal*, Jan. 30, p. 8.

"Water from Dairy Wells." *The Indianapolis Journal*, March 12, p. 8.

New Orleans, LA

"A Milk Standard." 1892. *The Times-Picayune*, July 15, p. 6.

"Board of Health." 1890. *The Times-Picayune*, May 9, p. 3.

"Milk Adulteration." 1892. *The Times-Democrat*, Oct. 1, p. 4.

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.

"Pure Milk." 1892. *The Times-Democrat*, Sept. 24, p. 4.

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

"The Milk Crusade." 1892. *The Times-Picayune*, July 29, p. 3.

"The Proposed Milk Inspection Ordinance." 1892. *The Times Picayune*, July 9, p. 3.

Portland, ME

Parker, Horatio N. 1917. *City Milk Supply*. New York, NY: McGraw-Hill Book Company, Inc.

"The Portland Water Works System." 1916. *Fire and Water Engineering*, 60(10): 169-171.

Baltimore, MD

"City Ordinances." 1894. *Baltimore Sun*, May 22, p. 9.

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." *Municipal Engineering*, LV(1): 249-251

"Milk that was Below the Standard." 1894. *Baltimore Sun*, July 3, p. 8.

"To Test a Law." 1894. *Baltimore Sun*, Aug. 3, p. 8.

"Sanitary Conditions." 1894. *Baltimore Sun*, Sept. 3, p. 8.

Grand Rapids, MI
Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

Etten, William (editor). 1926. "Water Supply." In *A Citizens' History of Grand Rapids, Michigan*, Grand Rapids, MI: A.P. Johnson Company for the Campau Centennial Committee, pp. 122-127.

Michigan Dairy and Food Commission. 1897. Bulletin No. 28 (December). Lansing: Robert-Smith Printing Company.

St. Paul, MN
"Adulterated Milk." 1887. *Saint Paul Globe*, April 6, p. 2.

"Cut the Fee in Two." 1899. *Saint Paul Globe*, April, 18. p. 3.

"Found in Our Food." 1890. *Saint Paul Globe*, April 10, p. 2.

"Health Officer's Staff." 1899. *Saint Paul Globe*, May 2, p. 2.

"Milk for Millions." 1888. *Saint Paul Globe*, June 10, p. 13.

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

St. Louis, MO
"Dr. James E. Sullivan Appointed Milk Inspector." 1889. *St. Louis Globe-Democrat*, May 23, p. 12.

"Milk and the Crematory." 1887. *St. Louis Globe-Democrat*, Feb. 24, p. 8.

"Milk Inspection." 1887. *St. Louis Post-Dispatch*, Dec. 5, p. 1.

"Milk Inspection Complications." 1889. *St. Louis Post-Dispatch*, Dec. 3, p. 5.

"The Milk Inspector." 1887. *St. Louis Globe-Democrat*, Sept. 24, p. 9.

"Time is Up, and the Newly Appointed Milk Inspector has not Qualified." 1887. *St. Louis Post-Dispatch*, Sept. 22, p. 2.

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

Omaha, NE
"Meat Inspector is Named." 1904. *Omaha Dailey Bee*, May 26, p. 11.

"Milk from Omaha Dairies." 1905. *Omaha Dailey Bee*, Dec. 5, p. 5.

"Official City Notices." 1903. *Omaha Evening Bee*, Dec. 18, p. 17.

"Water Report by Lumsden." 1910. *Omaha Dailey Bee*, April 25, p. 2.

Manchester, NH

Ahlgren, Clarence L. 1959. "The Manchester Water Works." *Water Works, Water and Sewage Works*, 106(10): 427-430.

Littlefield, Chauncy B. 1884. "Manchester Milk Inspector, First Report of." *Report of the State Librarian to the New Hampshire State Legislature*. Concord, NH: Edward N. Pearson, Public Printer, p. 280.

State Board of Health (New Hampshire). 1884. "General Report." *Report of the State Board of Health of the State of New Hampshire, Volume 3*. Concord, NH: Parsons B. Cogswell, Public Printer, pp. 7-20.

Camden, NJ

Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

Cooper, Howard Mickle. 1909. *Historical Sketch of Camden, N. J.* Camden, NJ: H. B. Ketler.

"Inspecting the Milk." 1883. *Courier-Post*, July 20, p. 1.

"Milk Inspection Suit." 1883. *Courier-Post*, Nov. 9, p. 1.

Newton, William K. 1884. "Sanitary Control of the Food Supply." *Report of the State Board of Health of the State of New Hampshire for the Fiscal Year Ending April 30, 1884*. Concord, NH: Parsons B. Cogswell, Public Printer, pp. 247-269.

Elizabeth, NJ

Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

Newton, William K. 1884. "Sanitary Control of the Food Supply." *Report of the State Board of Health of the State of New Hampshire for the Fiscal Year Ending April 30, 1884*. Concord, NH: Parsons B. Cogswell, Public Printer, pp. 247-269.

"Water Purification in New Jersey." 1914. *Municipal Journal and Public Works*, 37(4): 106-108.

Hoboken, NJ
Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

"Filtration Plant at New Milford." 1906. *Fire and Water Engineering*, July 10, pp. 7-10.
Newton, William K. 1884. "Sanitary Control of the Food Supply." *Report of the State Board of Health of the State of New Hampshire for the Fiscal Year Ending April 30, 1884*. Concord, NH: Parsons B. Cogswell, Public Printer, pp. 247-269.

"The Purification of Water by Aeration." 1885. *Engineering News*, 13: 134.

Jersey City, NJ
Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

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

"Jersey Has a New Reservoir." 1904. *The Sun* (New York, NY), Jan. 24, p. 15.

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

Newton, William K. 1884. "Sanitary Control of the Food Supply." *Report of the State Board of Health of the State of New Hampshire for the Fiscal Year Ending April 30, 1884*. Concord, NH: Parsons B. Cogswell, Public Printer, pp. 247-269.

Newark, NJ
Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

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

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

Newton, William K. 1884. "Sanitary Control of the Food Supply." *Report of the State Board of Health of the State of New Hampshire for the Fiscal Year Ending April 30, 1884*. Concord, NH: Parsons B. Cogswell, Public Printer, pp. 247-269.

"Water Purification in New Jersey." 1914. *Municipal Journal and Public Works*, 37(4): 106-108.

Patterson, NJ
Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

Fuller, George W. 1901. "The Water Purification Works of the East Jersey Water Company at Little Falls, New Jersey." *The Engineering Record*, 43(19): 442-444.

Newton, William K. 1884. "Sanitary Control of the Food Supply." *Report of the State Board of Health of the State of New Hampshire for the Fiscal Year Ending April 30, 1884*. Concord, NH: Parsons B. Cogswell, Public Printer, pp. 247-269.

Trenton, NJ
Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

Newton, William K. 1884. "Sanitary Control of the Food Supply." *Report of the State Board of Health of the State of New Hampshire for the Fiscal Year Ending April 30, 1884*. Concord, NH: Parsons B. Cogswell, Public Printer, pp. 247-269.

"Water Purification in New Jersey." 1914. *Municipal Journal and Public Works*, 37(4): 106-108.

"Water Purification at Trenton." 1914. *Municipal Journal and Public Works*, 37(17) 589-591.

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

"Better than Nothing." 1883. *Buffalo Evening News*, July 24, p. 1.

"Board of Health Matters." 1884. *The Buffalo Commercial*, April 28, p. 3.

"Doctored Milk." 1883. *Buffalo Evening News*, July 13, p. 5.

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

"Mr. Quack, The Drake." 1883. *Buffalo Evening News*, July 24, p. 1.

Rochester, NY
Horton, Theodore. 1922. "The Influence of Engineering Work of Public Health Departments in the Reduction of Mortality." *Transactions of the Second Annual Antimalaria Conference of Sanitary Engineers* (Public Health Bulletin No. 120). Washington, D.C.: U.S. Government Printing Office, pp. 5-15.

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

"Milkmen Arrested." 1891. *Democrat and Chronicle*, Sept. 16, p. 8.

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

"Two New Ordinances." 1891. *Democrat and Chronicle*, May 15, p. 10.

Cleveland, OH

Beckwith, D.H. 1887. "Sophistication of Food and Drinks." *Proceedings the Twenty-Fourth Annual Session of the Homeopathic Medical Society of the State of Ohio Held at Delaware, May 8 and 9, 1888*, pp. 78-85.

Cleveland (Ohio). 1889. "Report of the Milk Inspector." In *Reports of the Departments of Government of the City of Cleveland for the Year Ending Dec. 31, 1888.* Cleveland, OH: The Cleveland Printing and Publishing Co.

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.

Dayton, OH

Drury, Augustus Waldo. 1909. *History of the City of Dayton and Montgomery County, Ohio*. Chicago IL: S.J. Clarke Publishing Company.

"Poor Milk." 1882. *The Dayton Herald*, July 12, p. 4.

"The Milk Tester." 1887. *The Dayton Herald*, Aug. 15, p. 3.

Toledo OH

Fox, Carroll. 1915. "Public Health Administration in Toledo." *Public Health Reports*, 30(26): 1873-1932.

Furman, R. W. 1937. "Experiments with Sub-Surface Filters at Toledo, Ohio." *Journal of the American Water Works Association*, 29(2): 194-200.

Reilly, James. 1888. "Report of the Meat and Milk Inspector." *Annual Statement of the Finances of Toledo: The Mayor's Annual Message and Reports of the Various Municipal Departments for the Year Ending December 31, 1887.* Toledo (Ohio): B.F. Wade Company, pp. 419-420.

Toledo (OH), Auditor's Office. 1885. *City Auditor for the Year Ending December 31, 1884*, *Annual Report, Vol. 14*. Toledo, OH: The B.F. Wade Company, p. 97.

Philadelphia, PA

"Can be Read at a Glance." 1889. *The Philadelphia Inquirer*, Jan. 16, p. 3.

"Death Lurking in Milk". 1888. *The Philadelphia Inquirer*, Dec. 5, p. 2.

"Long Live the Pump." 1890. *The Philadelphia Inquirer*, June 25, p. 8.

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

"Sale of Impure Milk." 1890. *The Times*, June 13, p. 3.

"The City's Milk Supply." 1889. *The Times*, Aug. 18, p. 2.

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.

Scranton, PA

"City and County." 1891. *The Tribune*, Jan. 30, p. 3.

"City and County." 1891. *The Tribune*, June 13, p. 5.

Johnson, George A. 1913. "The Purification of Public Water Supplies." United States Geological Survey, Water-Supply Paper 315. Washington D.C.: Government Printing Office.

"Water Supply is Being Sterilized." 1909. *The Times-Tribune*, Dec. 31, p. 11.

Charleston, SC

Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

Charleston County (SC). 1946. *A Quarter of a Century of Public Health in Charleston, South Carolina: A Progress Report of a Program for the Control of Communicable Diseases and the Promotion of the Public Health, 1920-1945*. Department of Health, Charleston County, South Carolina.

"Charleston News Gathered in a Day." 1908. *The State*, Nov. 12, p. 8.

Ledoux, John Waler. "New Water Supply for Charleston, S.C." 1906. *Proceedings of the Engineers' Club of Philadelphia*, 23(4): 209-231

Memphis, TN
Hardin, Eugene. 1932. "Design and Operation Data on Large Rapid Sand Filtration Plants in the United States and Canada." *Journal of the American Water Works Association*, 24(8): 1190-1207.

JAMA (editorial board). 1921. "Typhoid in the Large Cities of the United States in 1920." *Journal of the American Medical Association*, 76(13): 860-863.

JAMA (editorial board). 1922. "Typhoid in the Large Cities of the United States in 1921." *Journal of the American Medical Association*, 78(12): 890-893.

Montrie, Chad. 2005. "From Dairy Farms to Housing Tracks Environment and Race in the Making of a Memphis Suburb." *Journal of Urban History*, 31(2): 219-240.

"Police are at Work Enforcing Sanitary Laws." 1898. *The Commercial Appeal*, July 19, p. 5.

Preble, Paul. 1921. "Review of Public Health Administration in Memphis, Tennessee." *Public Health Bulletin No. 113*. Treasury Department, United States Public Health Service.

"Under the Milk Ordinance." The Commercial Appeal, December 9, p. 5.

"Will Get a Chemist. Dairymen will have Milk Inspection of their Own." 1898. *The Commercial Appeal*, Dec. 4, p. 13.

Richmond, VA
"Against Impure Milk." 1893. *The Daily Times*, March 24, p. 5.

Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

"Annual Report of Board of Health." 1905. *The Times Dispatch*, Nov. 22, p. 10.

"Dangers from Milk." 1893. *Richmond Dispatch*, Aug. 20, p. 2.

"Our Milk Supply." *Richmond Dispatch*, Oct. 2, p. 4.

Richmond (VA), Office of the City Water Works. 1910. *Annual Report of the Superintendent of the City Water-Works to the Mayor of the City, for the Fiscal Year Ending December 31, 1909*. Richmond, VA: Clyde W. Saunders.

"Richmond's Pure Food Law." 1905. *The Times Dispatch*, June 3, p. 4.

Milwaukee, WI
Alvord, Henry Elijah and Raymond Allen Pearson. 1903. *The Milk Supply of Two Hundred Cities and Towns*. U.S. Department of Agriculture, Bureau of Animal Industry--Bulletin No. 46. Washington, D.C.: U.S. Government Printing Office.

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.

Leavitt, Judith W. 1996. *The Healthiest City: Milwaukee and the Politics of Health Reform*. Madison Wisconsin: University of Wisconsin Press.