Studies in Economic History

Patrick Gray
Joshua Hall
Ruth Wallis Herndon
Javier Silvestre *Editors*

Standard of Living

Essays on Economics, History, and Religion in Honor of John E. Murray

Springer

Studies in Economic History

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Faculty of Economics
The University of Tokyo
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Editors
Patrick Gray
Religious Studies
Rhodes College
Memphis, TN, USA

Joshua Hall
College of Business and Economics
West Virginia University
Morgantown, WV, USA

Ruth Wallis Herndon
Department of History
Bowling Green State University
Bowling Green, OH, USA

Javier Silvestre
Applied Economics
Facultad de Economia y Empresa
Zaragoza, Spain

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Preface

John Edward Murray was the Joseph R. Hyde III Professor of Political Economy and Professor of Economics at Rhodes College in Memphis, Tennessee, when he passed away suddenly on March 27, 2018, at the age of 58.

He was born on April 9, 1959, in Cincinnati, and became the first member of his family to attend college. He worked at a variety of jobs to pay his tuition, including phlebotomist, house painter, roofer, and ice cream vendor, graduating in 1981 from Oberlin College with a degree in economics. He later added an MS in mathematics from the University of Cincinnati, and the MA and PhD in economics from The Ohio State University, where he wrote his dissertation under Rick Steckel.

John taught high school math before pursuing his graduate work in economics. After finishing at Ohio State, he accepted a position at the University of Toledo, where he remained for 18 years before accepting the Hyde Professorship at Rhodes College in 2011.

He had a lifelong penchant for learning, spending a summer studying the German language in Schwabish Hall in 1984, and summers as an NEH scholar in Munich in 1995 and at Duke in 2013.

Murray authored two books and co-edited a third. His first book, *Origins of American Health Insurance: A History of Industrial Sickness Funds* (Yale University Press, 2007) was named one of ten "Noteworthy Books in Industrial Relations and Labor Economics" in 2008 by the Industrial Relations Section, Princeton University. His second book was co-edited with Ruth Wallis Herndon and titled *Children Bound to Labor: The Pauper Apprentice System in Early America* (Cornell University Press, 2009). *Economic History Review* said it was "a model for both comparative and national studies" of childhood and labor in historical context. His third book, *The Charleston Orphan House: Children's Lives in the First Public Orphanage in America* (University of Chicago Press, 2013), received the George C. Rogers, Jr. Prize, awarded by the South Carolina Historical Society for the best book on South Carolina history.

He published book chapters, monographs, encyclopedia and handbook contributions, and numerous articles in refereed journals including the *Journal of Economic History*, *Explorations in Economic History, Economic History Review, Agricultural*

History, and many others. His clear, crisp writing style and ability to explain complicated economic concepts made him a frequent choice to write for the popular press as well.

John's scholarly interests were varied, which is reflected in the essays in this volume. His most recent work centered on coal mine safety, post bellum African-American labor supply, and families in nineteenth-century Charleston. He published extensively in the areas of the history of healthcare and health insurance, religion, and family-related issues from education to orphanages, fertility, and marriage, not to mention his work in anthropometrics, labor markets, and literacy. His intellectual work was often informed by his religious convictions, and he spent time studying Catholic theology at Sacred Heart Major Seminary in Detroit.

John had a deep commitment to his family. His first book was dedicated to his wife Lynn, and his second and third books to his children Rose and Sarah. He would share with delight information about his family with colleagues, and his office was filled with artwork by his children and family photos.

This anthology honors John E. Murray, whose scholarly interests and collegial network ranged well beyond the economics departments in which he worked throughout his professional life. His sudden death in March 2018 ended many ongoing conversations in economics, history, and religion. John considered himself a historian as well as an economist, and he held himself to the scholarly standards of both disciplines. He interpreted economic data and put it to work in the service of history. He read history and put it to work in the service of economics. His work was also informed by his lifelong study of religion, and he maintained lively and collegial friendships with scholars of religion. The essays in this volume reflect John's scholarly interests and were written with his interests in mind.

John Murray was a person who conversed with others. The following chapters continue conversations that John started, encouraged, or inspired. He read secondary literature voraciously and would quickly contact the author of an article or book that caught his interest. His gift for starting conversations brought many people into his network and led to wonderful collaborations. The four editors of this volume met him at different moments of his professional life and in very different circumstances.

1996: John started the conversation that brought Ruth Herndon into his scholarly community. In 1996, when Herndon was at the Philadelphia Center for Early American Studies at the University of Pennsylvania (now the McNeil Center), she published a brief "Research Note" in the *Journal of Social History* about the signature literacy of poor people warned out of New England towns in the latter eighteenth century. Literacy and poor people being two of John's interests, he naturally read the essay and promptly wrote Herndon at the Philadelphia Center, unaware that since the article's publication she had taken up a faculty position in the Department of History at the University of Toledo, where John was himself teaching in the Department of Economics. When Herndon received John's letter, forwarded from the Philadelphia Center, she picked up her office phone, and called her new UT colleague. After John got over the shock of this serendipity, he initiated a series of brown bag lunch conversations that gradually grew into co-authored conference papers, then a co-authored journal article, then a major research grant proposal supporting their co-edited anthology *Children Bound to Labor.* Although Herndon subsequently moved to Bowling Green State University and Murray moved to Rhodes College, they continued their conversation on childhood, parenting, education, and labor in historical context. Shortly before he died, they had proposed a conference session together.

2003: Josh Hall first met John when he was teaching at Capital University in Columbus Ohio. Economic history was what first got Josh interested in economics and he had heard that there was an Ohio economic history meeting that he might attend. Having been born in Toledo, he figured that was enough of a connection to reach out to John Murray by email. And so a correspondence began that touched on baseball, the Wright Brothers, graduate school in economics, and economic history. In 2004, John provided advice when Josh applied to doctoral programs in economics. In 2007, Josh was a finalist for a job at Rhodes College he didn't get. However, a year later they were searching for an endowed chair and he encouraged John to apply. The rest, as they say, is history. Josh greatly misses John's occasional email exchanges and is not surprised that so many were touched so deeply by John and his work.

2004: Javier Silvestre met John at the 2004 Cliometrics World Congress, in Venice, where the latter chaired the session in which the former presented a paper. Both shared a broad interest in workplace safety in different countries. Some time after the Congress, John proposed that Silvestre coauthor a paper on safety in European coal mining, using an almost unexploited source. However, it was not until several years later that the real work began. The resulting paper ended up with a strong focus on technology, to that point an almost entirely unexplored field for both authors. Once the paper was accepted for publication, in 2014, such an amount of information on technological change in nineteenth-century European coal mining had been gathered that John proposed that he and Silvestre embark on a project together. The premise was that, as far as technological change is concerned, perhaps different strands of the literature, economic history in particular, had been more focused on the eighteenth and twentieth centuries. Technology in nineteenth-century coalmining needed to be reassessed. John's enthusiasm was contagious. Over the years, regular emails were exchanged on the subject of improvements in mechanical fans, safety lamps, or explosives. He travelled to Spain a few times. In Zaragoza, intense work sessions on the "coal project," as John called it, were combined with long evening walks and talks. It was difficult not to share some of his many interests: from freedom of speech to sports, via blues music, as well as dogs, of course, to mention but a few. He was also a visiting scholar at the University of Barcelona. His *Origins of American Health Insurance* book came at a time when the study of the genesis of the Spanish welfare state was gathering strength among young economic historians.

2011: Patrick Gray met John through mutual acquaintances in the Department of Economics when he moved from Toledo to Memphis in 2011 to become the Joseph R. Hyde III Professor of Political Economy at Rhodes College. Lunch conversations regularly turned to such topics as baseball—especially John's beloved Cincinnati

Reds—and raising children. John was very well read, and he wore his learning lightly. This made him an outstanding scholar. John was not a member of the Austrian School, but he agreed with the remark attributed to Friedrich Hayek that "if you only understand economics, then you don't understand economics," and he exemplified the spirit it expressed. His wide-ranging publications attest to a boundless intellectual curiosity and a punctilious attention to detail. John's endowed chair came with a generous book budget, and he was not afraid to use it. Theology was a special interest. His home and office bookshelves groaned under the additional weight of volumes related to biblical studies, church history, and philosophy. Copious notes in the margins and underlined passages show that, far from being just for show, he had actually read them. How to read and teach Augustine and Luther in the interdisciplinary humanities sequence offered at Rhodes were frequent topics of conversation. His approach to these texts bespoke an admirable humility that comes with knowing the limits of one's knowledge and expertise. Along with his gentle spirit and hearty laugh, this is what his colleagues will miss.

Religious Studies
Rhodes College
Memphis, TN, USA
Patrick Gray

College of Business and Economics
West Virginia University
Morgantown, WV, USA
Joshua Hall

Department of History
Bowling Green State University
Bowling Green, OH, USA
Ruth Wallis Herndon

Applied Economics
Facultad de Economia y Empresa
Zaragoza, Spain
Javier Silvestre

Contents

Contributors

Howard Bodenhorn Clemson University, Clemson, SC, USA

Louis P. Cain Northwestern University, Evanston, IL, USA

Art Carden Samford University, Birmingham, AL, USA

Amílcar E. Challú Bowling Green State University, Bowling Green, OH, USA

Metin Coşgel University of Connecticut, Storrs, CT, USA

Daniel Cullen Rhodes College, Memphis, TN, USA

Sergio Espuelas Universitat de Barcelona, Barcelona, Spain

Price Fishback University of Arizona, Tucson, AZ, USA

Vincent Geloso George Mason University, Fairfax, VA, USA

Semih Gokatalay UC San Diego, La Jolla, CA, USA

Martin Gorsky London School of Hygiene and Tropical Medicine, London, UK

Patrick Gray Rhodes College, Memphis, TN, USA

Farley Grubb University of Delaware, Newark, DE, USA

Aravinda Guntupalli University of Aberdeen, King's College, Aberdeen, Scotland

Joshua Hall West Virginia University, Morgantown, WV, USA

Bernard Harris University of Strathclyde, Glasgow, UK

Joshua R. Hendrickson University of Mississippi, Oxford, MS, USA

Ruth Wallis Herndon Bowling Green State University, Bowling Green, OH, USA

Andrew Hinde University of Southampton, Alton, Hampshire, UK

Trevon Logan Ohio State University, Columbus, OH, USA

Phillip W. Magness American Institute for Economic Research, Great Barrington, MA, USA

Kristin Mammen College of Staten Island –CUNY, Staten Island, NY, USA

Jerònia Pons-Pons Universidad de Sevilla, Sevilla, Spain

Elyce J. Rotella University of Michigan, Ann Arbor, MI, USA

Garrett T. Senney Office of the Comptroller of the Currency, Washington, DC, USA

Joanna Short Augustana College, Rock Island, IL, USA

Javier Silvestre Universidad de Zaragoza, Zaragoza, Spain

John Singleton Sheffield Hallam University, Sheffield, UK

Richard H. Steckel Ohio State University, Columbus, OH, USA

Margarita Vilar-Rodríguez University of A Coruña, Coruña, Spain

Simone A. Wegge College of Staten Island and the Graduate Center, City University of New York, New York, NY, USA

Chapter 1
Urbanization, Sanitation, and Mortality in the Progressive Era, 1899–1929

Louis P. Cain and Elyce J. Rotella

Abstract Between 1899 and 1929, deaths from waterborne diseases declined dramatically in American cities. The major cause of such declines was spending on sanitation systems (water, sewers, and refuse collection). Cities spent enormous amounts to build and maintain water and sewer systems, and to collect and dispose of refuse. We first estimate the size of the payoff to cities of such expenditures, where the payoff is measured in averted deaths. Using a panel of annual mortality and municipal expenditure data from 152 cities, we estimate that a 1% increase in sanitation expenditures was associated with a 3% decline in the mortality rate. In the second section of the paper, we ask whether the mortality reducing effects of sanitation expenditures differed by the type of water resources available to the city (ocean, lake, river). The answer is unambiguously yes, with cities located on lakes facing the most difficult sanitary situation.

Keywords Urbanization · Mortality · Sanitation · Water · Sewers · Refuse

1.1 Introduction

As the nineteenth century drew to a close, the demand for public sanitation works in American cities began to accelerate. No city can exist without a supply of freshwater, but the widespread acceptance of the germ theory made it clear that the water should be clean – and not just clean to the senses of taste, smell, and sight, but clean

L. P. Cain
Northwestern University, Evanston, IL, USA

Loyola University Chicago, Chicago, IL, USA
e-mail: lcain@northwestern.edu

E. J. Rotella (✉)
University of Michigan, Ann Arbor, MI, USA
e-mail: rotella@umich.edu

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according to accepted biological standards. Especially after the adoption of the flush toilet, it became necessary to help the water that made its way into homes and businesses find its way back out. And, it became imperative that both wastewater and solid waste be removed as potential breeding grounds for diseases that plagued cities. In the early years of the nineteenth century, water for firefighting was a principal driving force behind the demand for improved urban water supplies. In the later years of that century, citizens' demand for urban water supplies became more complex. In the middle of the century, sanitarians such as Edwin Chadwick (1842) in London and Lemuel Shattuck (1850, 1948) in Massachusetts demonstrated the correlation between bad water and disease. Once the germ theory was promulgated, there was an explanation for the relationship. Cities with existing sanitary facilities were now pressed to improve them; cities which lacked facilities were now pressed to build them. Disease prevention required that the water be treated, and both filtration and chlorination were adopted in a wide variety of cities. Similarly, wastewater required treatment, and a variety of sewage treatment technologies were invented and adopted in the first decades of the twentieth century. The question that motivates this study is: what kind of return did cities realize from the investments they made in sanitary infrastructure?

In *Constructing Urban Culture*, Stanley Schultz (1989) explores the relationship between American cities and city planning. Public health problems as they emerged in rapidly growing metropolises at the end of the nineteenth century led to technological solutions. As part of his examination of the effect of sewering the cities, Schultz presents data on death rates and miles of sewer constructed and concludes: "Filtration of water and sewage brought a dramatic drop in typhoid mortality rates, a drop that averaged 65 percent in selected major cities" (174). In Schultz's analysis, the cause of the drop in typhoid deaths is simply asserted. Earlier studies by economic historians of public health determinants of mortality include Edward Meeker (1972, 1974) and Gretchen A. Condran and Eileen M. Crimmins-Gardner (1978, 1983).

The goal of our study is to estimate the direction and magnitude of the relationship between the public works improvements of the Progressive era and the decline in mortality from waterborne diseases. Did cities' expenditures on water, sewers, and refuse "pay off" by reducing the death rate from typhoid, diarrhea, and dysentery? If yes, how big was the payoff?

Among economic historians who have scrutinized other dimensions of the Progressive movement is John Murray. In his *Origins of American Health Insurance* (2007), he examined sickness funds which would have mitigated the expenses of getting sick. We do not have as good data on morbidity as there are for mortality, but it seems reasonable to believe that a reduction in mortality attributable to waterborne diseases is consistent with a reduction in morbidity as well. Consequently, we argue that sanitation works which reduced morbidity and mortality thereby ameliorated a portion of the risks that sickness insurance would have covered. Murray's project is complementary to this paper. Our results help explain Murray's finding of little popular support for compulsory health insurance. People preferred to push municipalities to spend money on avoiding illness by reducing waterborne diseases as opposed to mitigating through insurance the expenses incurred as a result of getting sick.

David Cutler and Grant Miller (2005) studied the effectiveness of urban water supplies in the early twentieth century by using what they argue is exogenous variation in both the timing and location of the new technologies to identify the effects of water improvements. They conclude that the causal influence of water purification (specifically filtration and chlorination) on mortality was large. They find that clean water was responsible for nearly half the total mortality reduction in those cities, as well as for three-quarters of the reduction in infant mortality and nearly two-thirds of the reduction in child mortality. In a later paper (2006), they argue that this improvement was not limited to the largest cities. Similarly, Joseph Ferrie and Werner Troesken (2008) estimate that 35–56% of the decrease in Chicago's crude death rate up to 1925 can be attributed to water purification and the eradication of waterborne diseases. Marcella Alsan and Claudia Goldin (2019) examine the development of clean water and effective sewerage systems in Boston between 1880 and 1920 and estimate that those works were responsible for much of the first sustained decrease in child (under 5) mortality.

In this study, we expand the list of expenditures to include sewage works and refuse collection as well as waterworks. If such expenditures were effective in reducing the death rate from waterborne diseases, did they pay off by reducing the total death rate as well? A decline in the total death rate could have resulted because deaths from waterborne causes were a large share of total deaths, and the factors that were responsible for the decline in waterborne deaths determined the decline in total deaths. Secondly, improvements in water, sewers, and refuse could have led to reductions in deaths from causes other than waterborne diseases because such diseases were spread by the same vectors, or because declines in morbidity from the causes responsible for waterborne diseases reduce the likelihood of deaths from other causes. To paraphrase demographers, people accumulated fewer insults when these waterborne diseases were averted, and, therefore, they were less likely to succumb to other diseases. For example, Preston and Van de Walle (1978) argue that, in the case of intestinal diseases, public health changes led to this effect (see also Szreter 1988; Wohl 1984; Woods 2000).

This paper examines relationships between US municipal expenditures and death rates from 1899 to 1929. Urban historians (Glaab and Brown 1967; Mohl 1985) consider this to be an era of reform, the first awakening of the environmental movement leading to a dramatic expansion in budgetary expenditures on such works. By 1907, virtually every American city had installed sewers, and most big cities were using filtration and chlorination to assure the safety of their water supplies (Galishoff 1980; Tarr et al. 1980).

From the very late 1890s to the very early 1930s (with a few missing years), the federal government published compilations of both financial and mortality statistics for cities.[1] This paper stops in 1929 before the onset of the Great Depression and the

[1] Data on both finances and mortality are contained in *Bureau of Labor Statistics Bulletin*, #24, 30, 36, and 42, for the years 1899–1902, and *Census Bulletin* #20 for 1902–1903. The Bureau of the Census published *Mortality Statistics of Cities* annually between 1900 and 1936 and *Financial Statistics of Cities* more or less annually between 1905 and 1931.

availability of federal funds for municipal improvements. Its main focus is to link statistically both the total death rate and the death rate from diarrhea, dysentery, and typhoid (diseases spread by impure water and filth) to the expenditures on sanitation (water supply, wastewater, and refuse works).

A second question addressed in this paper derives from Cain's (1977) argument that there are four distinct urban sanitary histories. The differentiating feature is the type of water resource on which a city is located. Cities located on *salt water* cannot draw their water supply from the abundant water close at hand and often have to rely on sources hundreds of miles removed from the city. On the other hand, these cities can dispose of their wastes in the adjacent salt water. Cities located on *freshwater lakes* have historically used the lake for both water supplies and waste disposal. Such cities are forced to geographically separate the water intake and sewer outfall as far as possible to avoid befouling their drinking water with their wastes. This interdependency creates what are arguably the most difficult sanitation problems faced by any type of city. Cities located on *major rivers* simply have drawn their water upstream from the city and disposed of their wastes downstream, taking care that the potential sewage backwash cannot reach the water intake. Cities located on smaller, *minor rivers* often have had to look elsewhere for an adequate water supply; they utilize distant lakes and rivers or rely on well water. Such small river cities still dispose their wastes in the river, but they may have to build sewers to a downstream point where the river can receive a large volume of wastewater.

Each of the cities in our sample has been identified as belonging to one of these groups. We will examine whether the effects of the water, sewer, and refuse variables differed by city type. Since the different city types faced different costs and constraints in attempting to reduce mortality by investing in water, sewage, and refuse works, we expect that the payoff to such investments varied between cities. Therefore, cities facing different costs and constraints had incentives to invest in sanitation strategies involving different mixes of these variables.

1.2 Data

Annual data on mortality and municipal expenditures were collected for 152 cities for the period 1899–1929. The sample was defined to include all cities with populations over 25,000 in the 1910 Census. A few smaller freshwater lake cities were added in order to increase the number of observations in that group. While some cities had to be dropped from the sample because of insufficient data, the pooled sample used in the reported regressions includes data from 87 cities in 1902 and 125 cities in 1929.

1.2.1 Mortality Data and Variables

The mortality data used in this study were collected from the *Mortality Statistics of Cities* which annually published death-by-cause statistics. Data were collected on deaths from typhoid fever, dysentery, and diarrhea as well as all causes taken together. While historical evidence on death-by-cause is notoriously problematic because of changing definitions of diseases and changes in diagnoses, the diseases studied in this paper were well identified in this period.

Typhoid, dysentery, and diarrheal diseases were spread by impure water and food, and by contact with feces and other filth. In this paper, we follow the convention of referring to this group of diseases as "waterborne," even though water is not the exclusive means of transmission. We expect, as did contemporaries, that these diseases were controlled by programs to deliver clean water, remove and treat sewage, and collect and dispose of refuse.

Deaths from all causes and deaths from waterborne diseases were used together with population data to calculate the total death rates (TDR) and waterborne disease death rates (WDR) used as dependent variables in the regressions reported in Sect. 1.4.

1.2.2 Financial Data and Variables

This study makes use of data on annual operating costs and capital acquisition costs of waterworks, sewage works, and refuse collection and disposal systems. These data were published in various bulletins up to 1903 and in *Financial Statistics of Cities* beginning in 1905. There are few direct figures available for 1904. Not every series was reported every year, and no *Financial Statistics* were published in 1913, 1914, or 1920. For 1921 and 1922, information on sewers and refuse were reported together under the heading "Sanitation." Interpolation based on expenditures in the same city in adjacent years was used to apportion the 1921 and 1922 reported figures between refuse and sewers.

Financial data were used to construct two kinds of variables employed in the regression analysis: capital variables and current operating cost variables. Expenditures on capital were aggregated over all years up to the year of observation and then divided by the population in the year of observation thereby producing an estimate of the per capita value of the works. The per capita value of sewage facilities (SEWKALL) and refuse collection and disposal facilities (REFKALL) were constructed in this manner. The accumulated value of capital in waterworks (WATKALL) includes the value of the waterworks at the beginning of the period. This value was reported in the Census bulletins, and, for most cities, this is the value in 1899. Galishoff (1980, 52) includes a graph based on US Public Health Service data indicating that most cities had selected the source they used and constructed municipal works before the turn of the twentieth century. Treatment, principally filtration, and disinfection, principally chlorination, were adopted after the turn of the century. A small minority of cities in the sample did not have municipal waterworks and were not included in the main regressions reported in Sect. 1.4.

Information on annual operating expenditures for water, sewers, and refuse were used to create the variables WATERAV3, SEWERAV3, and REFUSEAV3 which are the average operating expenditures per capita for the year under observation and the previous 2 years.

1.2.3 Control Variables

Six variables were collected for control purposes. These include each city's land area (LANDAREA) and assessed valuation (ASSDPC) for each year. Land area provides a measure of geographical size and change within the study period, while the assessed valuation measures the city's ability to pay. Since the Progressive era was a period of annexation and consolidation, the inclusion of these variables controls for this type of city size growth.[2]

Two series were collected from the historical weather records to control for climatological differences in time and space. The total rainfall in inches measures the wetness of a particular year, while the length of the growing season in days measures for how much of the year climactic conditions (temperature, altitude, and rainfall) permitted normal plant growth.[3]

Finally, two dummy variables were employed. The first, WAR, includes the period of the First World War and its aftermath, which included a vigorous inflation and a virulent outbreak of influenza. The other, LATE20, controls for 3 years in the late 1920s when many cities overestimated their populations, the figure used to make per capita calculations.

1.3 The Regression Model

Annual statistics from 1899 through 1929 were pooled to create a panel data set. The data used in the regressions cover the period 1902–1929 with data on 1899–1901 used to create variables based on averages and aggregates of past expenditures. The effects of capital and operating costs on death rates were estimated using a one-way fixed effects regression model. This technique runs an ordinary least squares regression on the entire panel, estimating a separate intercept term for each city.

[2] Data on Allegheny, Pennsylvania, were collected and added to those of Pittsburgh to incorporate that annexation explicitly in the sample.

[3] Unfortunately, the weather bureau did not collect information for all the cities in the sample, so in some cases what has been included comes from a city which is a climatological clone of a sample city.

Chi-squared tests confirm the superiority of this specification over the simple OLS model without fixed effects.

The simple OLS model was estimated with the full set of control variables discussed above plus variables for population density (population/land area), population growth (the population this year/the average population in the three previous years), and the year. The weather variables proved to be very powerful with mortality substantially higher in the wetter and warmer cities. All the control variables had the expected signs. While they were important for explaining the urban mortality experience, all but YEAR, LANDAREA, ASSDPC, and the two dummy variables (WAR and LATE20) were dropped from the regressions reported in the next section because their impacts are included in the fixed effects.[4]

1.4 Results

The first three decades of the twentieth century were years of considerable improvement in medical practice, food delivery and preparation, and urban sanitation. Also, living standards were rising as personal income was rising throughout the period. The widespread acceptance of the germ theory of disease led to the adoption of procedures designed to reduce the spread of many common nineteenth-century diseases. As Mokyr (1983) emphasizes, the evolutionary diffusion of public health techniques over the twentieth century explains much of the decline in mortality rates and the emergence of a new demographic regime. As life expectancy increased, other diseases came to be more common causes of death. The "Second Industrial Revolution" based on electricity and automobiles introduced potentially more deadly technologies, while accelerated urbanization increased the potential for violence.[5] The overall pattern of change in urban mortality can be seen in Table 1.1.

In 1902, the 15.124 per 10,000 population deaths attributable to waterborne diseases were 8.9% of all deaths. By 1929, the 1.857 per 10,000 deaths from waterborne diseases were only 1.4% of the total. The total death rate dropped by 20% over the period (16.713/1000 to 13.409/1000), but death rates from waterborne disease dropped by almost 90%. We can get some idea of the importance of this rapid decline in waterborne diseases by engaging in a simple counterfactual exercise. If, beginning in 1902, there had been no decline in the death rate from waterborne diseases, and if the death rate from all other causes had declined at its actual rate, then the total death rate in 1929 would have been 14.836 instead of 13.323. That is, instead of falling nearly 20% from 1902 to 1929, the death rate would have fallen by only 12.2%. From this, we can conclude that 43.2% of the actual decline in the

[4] A one-way random effects model was also estimated allowing for city-specific heteroscedasticity correction using a generalized least squares technique. The results were almost identical to the OLS specification, and, therefore, only the OLS fixed effects results are reported.

[5] The proportion of total deaths from accidents, suicides, and other acts of violence does not appear to have increased over the study period.

Table 1.1 Average urban death rates

Year	Total deaths	Deaths from Waterborne diseases	Deaths from Waterborne diseases as a Percentage of all deaths
1902	16.713	15.124	8.9%
1903	16.868	15.064	8.8
1904	16.686	15.377	9.1
1905	16.826	15.673	9.2
1906	17.136	16.455	9.5
1907	17.682	16.749	9.3
1908	16.370	15.171	9.1
1909	15.545	14.105	9.0
1910	16.657	14.232	8.5
1911	15.776	11.824	7.4
1912	15.234	10.072	6.6
1913	n.a.	n.a.	
1914	n.a.	n.a.	
1915	15.197	8.691	5.6
1916	15.503	9.131	5.7
1917	15.861	8.780	5.4
1918	20.691	8.279	3.9
1919	14.489	5.838	4.0
1920	14.721	5.751	3.9
1921	12.958	5.054	3.9
1922	13.272	4.080	3.0
1923	13.661	4.028	2.9
1924	13.128	3.502	2.6
1925	13.367	3.668	2.7
1926	13.774	3.240	2.3
1927	12.660	2.410	1.9
1928	13.715	2.213	1.6
1929	13.409	1.857	1.4
1929/1902	67.828	12.278	
Percentage change			
1902–1929	19.769	87.722	

Total death rates are per 1000 inhabitants; waterborne disease death rates are per 10,000 inhabitants
These rates are averages for the cities included in the pooled sample. Waterborne diseases include diarrhea, dysentery, and typhoid

total death rate between 1902 and 1929 can be attributed to the decline in deaths from waterborne diseases.

The variables included in the regressions are described in Table 1.2; the results with the total death rate as the dependent variable are reported in Table 1.3. The variable WATKALL captures improvements in water quality that resulted from filtration, the construction of filter beds and plants. In each case reported in Table 1.3,

Table 1.2 Definitions of independent variables included in regressions

WATKALL	Sum of all capital expenditures on waterworks prior to the year under observation plus the value of municipal waterworks in 1899 (or in the year acquired) in per capita terms
WATERAV3	Average operating expenditures on waterworks and water treatment over the two preceding years and the year under observation in per capita terms
SEWKALL	Sum of all capital expenditures on sewage facilities up to the year under observation in per capita terms
SEWERAV3	Average operating expenditures on the sewer system over the two previous years and the year under observation in per capita terms
REFKALL	Sum of all capital expenditures on refuse collection and disposal up to the year under observation in per capita terms
REFUSEAV3	Average operating expenditures on refuse collection and disposal over the two preceding years and the year under observation in per capita terms
YEAR	A trend variable, the year under observation
WAR	A dummy variable equal to 1, if year = 1917–1920
LATE20	A dummy variable equal to 1, if year = 1925–1927
ASSDPC	Assessed valuation in hundreds of dollars per person
LANDAREA	Square miles in hundreds of square miles

this coefficient is positive, quite the opposite of what would be expected if there were a spillover to deaths from other causes from the factors one anticipates would reduce waterborne diseases. For all the cities in the sample, and in three of the four city types, the positive coefficient is statistically significant suggesting that an additional dollar spent on waterworks was associated with higher overall death rates, after controlling for sewer and refuse expenditures. The variable WATERAV3 captures improvements in water quality resulting from disinfection, expenditures for chlorination. In only one case, freshwater lake cities, is this variable negative. Similar difficulties are present in the sewer and refuse variables.

We conclude from Table 1.3 that a consideration of expenditures on urban sanitation in the years 1899–1929 produces little understanding of what determined the *total* death rate. Even though the decline in waterborne diseases was a very large part of the decline in total urban mortality in this period, the results do not show that the total death rate responded as one might expect from the expenditures on water, sewers, and refuse. Hereafter, consideration of the effects of urban sanitation expenditures will focus on their impact on the *waterborne disease* death rate. These results are reported in Table 1.4.

For all cities taken together, the existence of a waterworks and the addition of filtration works during this period (WATKALL) had an important effect on reducing waterborne deaths. On the other hand when we examine the impact of operating expenditures (WATERAV3), we see that cities with higher waterborne disease death rates either spent more on disinfection or the addition of disinfection marginally increased deaths. Examining these results by the various city types puts the findings into sharper relief. The negative coefficient on the water capital variable is significant only for saltwater cities that must travel the greatest distance to find a source of

Table 1.3 Total death rate regression results

Fresh water					
Variable	All	Salt water	Lake	Major river	Minor river
WATKALL	0.00205[a]	0.00047	0.00515[a]	0.00297[a]	0.00260[a]
WATERAV3	0.01193[a]	0.01190	−0.04553[a]	0.00888	0.01692
SEWKALL	0.00115[b]	0.00144	0.00174	0.00219[b]	0.00126
SEWERAV3	0.01842[b]	0.03447[a]	−0.00999	0.00009	−0.00884
REFKALL	0.00495	−0.01396	−0.06731[a]	−0.00965	0.06949[a]
REFUSEAV3	−0.03913[a]	−0.04246[a]	−0.01679	−0.06290[a]	−0.02534
YEAR	−0.01301[a]	−0.01583[a]	−0.00268	−0.00902[a]	−0.01488[a]
WAR	0.15811[a]	0.11243[a]	0.13657[a]	0.16132[a]	0.18510[a]
LATE20	−0.02067[a]	−0.01242	−0.03640[b]	−0.02714	−0.03270[b]
ASSDPC	0.00177[a]	−0.00231[b]	0.00123	0.00188[a]	0.00310[b]
LANDAREA	0.00008[a]	0.00003	−0.00107[a]	−0.00036[a]	−0.00095[a]
R^2	0.657	0.760	0.737	0.568	0.680
n	2609	716	291	883	723

Dependent variable is the log of the total death rate
[a]Statistically significant at the 95% confidence level
[b]Statistically significant at the 90% confidence level

Table 1.4 Waterborne disease death rate regression results

Fresh water					
Variable	All	Salt water	Lake	Major river	Minor river
WATKALL	−0.00349[a]	−0.00818[a]	0.00653	−0.00075	−0.00028
WATERAV3	0.00945	−0.01690	−0.09220[b]	−0.01414	0.02982
SEWKALL	−0.01332[a]	−0.00951[a]	−0.00119	−0.01201[a]	−0.02099[a]
SEWERAV3	−0.04766[b]	0.00126	−0.10747	0.09388	−0.37971[a]
REFKALL	−0.07875[a]	−0.13693[a]	−0.64572[a]	−0.08444[a]	0.01024
REFUSEAV3	−0.05264[a]	−0.05707[b]	0.17879[a]	−0.07358[a]	−0.11522[a]
YEAR	−0.07369[a]	−0.08113[a]	−0.05024[a]	−0.06788[a]	−0.06652[a]
WAR	0.21762[a]	0.16005[a]	0.11556	0.20325[a]	0.25446[a]
LATE20	0.00264	−0.08883[a]	0.01338	0.10020[a]	−0.04403
ASSDPC	0.00408[a]	0.00338	−0.02260[a]	0.00393[b]	−0.00235
LANDAREA	0.00029[a]	0.00042[a]	−0.00326[a]	0.00002	0.00018
R^2	0.840	0.897	0.825	0.824	0.829
n	2609	716	291	883	723

Dependent variable is log of the waterborne disease death rate.
[a]Statistically significant at the 95% confidence level
[b]Statistically significant at the 90% confidence level

fresh water. The expected negative effect is present in both types of river cities, but the coefficient is in fact positive for freshwater lake cities. While this coefficient is not statistically different from zero, the positive sign may be interpreted as a consequence of these cities customarily drawing water from the same water source into which they deposit their wastes. The differences in the size of the coefficients are also worthy of note. An additional dollar spent on water capital in saltwater cities has ten times the impact as in major river cities, and expenditures in major river cities have three times the impact as in minor river cities.

The only city type in which annual expenditures for the water department show a positive coefficient is minor river cities, those which rely most heavily on groundwater supplies.[6] Since this city type is the only one for which refuse capital expenditures do not have a significant negative effect, where the effect is in fact positive, one might conclude that refuse could be leeching into groundwater supplies. It is only in freshwater lake cities where disinfection has a significant negative effect, and it seems likely chlorination was important in combatting impurities in the wastewater that was discharged into these cities' water supply sources.

The two sewage variables both have a statistically significant negative effect on the waterborne disease death rate in the regression for all cities taken together. In each type of city, the expenditure on sewer construction and sewage treatment works has a negative effect. It is significant for all but the freshwater lake cities, who, given the interdependency between water supply and wastewater disposal, have to spend a great deal more to get the same effect on death rates as the other city types. The variable means reported in Table 1.5 do not indicate, however, that these freshwater lake cities spent a great deal more for sewage capital than did the other city types.[7]

Annual expenditures on sewers have a more complex pattern across city types. While the all city regression has a significant negative coefficient, the same is true only for the minor river cities. Lake cities also have the expected negative coefficient, but those for saltwater cities and major river cities are in fact positive. None of these latter three coefficients is statistically significant. In almost every case, minor river cities use the river as their disposal source, but they may have to convey their wastewater several miles downstream to a point where the river is sufficiently large to handle the city's volume. It is a simple matter of disposal strategy, which is less of a problem for the other three types. Both saltwater cities and major river cities locate their water supply sources in such a way as to minimize the cost of wastewater disposal. They have located their sewage works such that sewage services have an effect on the death rate, but the annual expenditures on sewer maintenance get short shrift relative to the need to maintain the purity of their water supplies.

The solid waste variables, which involve many fewer dollars than the other two as the table of variable means (Table 1.5) documents, prove to have a statistically significant negative effect in almost every city type and for all cities taken together. Given the close connection between waterborne and foodborne diseases, the regular removal and disposal of food wastes in such a way as to remove them from water supply sources has important consequences. The only exception to the significant

[6] Some, such as Denver, constructed systems reminiscent of saltwater cities to tap distant sources.

[7] In the case of the Sanitary District of Chicago, more than 10 years of capital expense led to a large decrease in cholera deaths in the first year after the Main Channel was opened. Unfortunately, the District is a supra-governmental body and, therefore, not included in the *Financial Statistics of Cities*. When the North Side Treatment Works opened in the mid-1920s, Chicago had spent more on sewage treatment than the expenditures in the next ten largest cities combined.

Table 1.5 Means of variables included in regressions

Fresh water					
Variable	All	Salt water	Lake	Major river	Minor river
WATKALL	29.057	34.323	26.706	27.367	26.726
WATERAV3	1.5753	1.7403	1.4698	1.6647	1.3472
SEWKALL	10.900	11.223	11.987	10.369	10.830
SEWERAV3	0.30401	0.44751	0.23902	0.22481	0.28773
REFKALL	0.29401	0.23173	0.29952	0.29795	0.36411
REFUSEAV3	0.79976	0.95536	0.88345	0.72686	0.71077
YEAR	1916.4	1916.2	1916.5	1916.3	1916.7
WAR	0.13147	0.12989	0.12371	0.13137	0.13555
LATE20	0.13952	0.13128	0.15120	0.13930	0.14523
ASSDPC	10.873	11.851	8.7395	12.275	9.1335
LANDAREA	195.11	233.61	256.80	191.35	137.42
TDR	15.208	15.083	13.579	16.008	15.001
WDR	8.6698	8.4624	8.1803	8.8118	8.8762

negative effect for outlays of refuse disposal capital is minor river cities, where the potential that decomposing refuse may pollute groundwater supplies is a possible explanation for the (statistically insignificant) positive effect observed for those cities. The only exception for annual expenditures on refuse disposal is freshwater lake cities, which had a significant positive effect. This coefficient is a puzzle.

Inasmuch as the fixed effects model controls for variation between cities, and since the regressions are estimated on a pooled cross-section, time-series basis, three variables are used to control for variation across time in all the regressions. The first such variable is YEAR, which has the expected negative coefficient and is statistically significant in all cases. These years saw tremendous increases in medical knowledge and education, as well as important changes in food preparation with canning, dehydration, and refrigeration producing large changes in the way the typical household confronted meal planning and preparation.

WAR is a dummy variable for the years 1917–1920 during which three major events may have had a positive effect on waterborne death rates. The first is the effect that wartime controls and postwar inflation might have on expenditure levels, conceivably postponing some sanitation expenditures to postwar years when inflation caused deferred expenditures to be more expensive. The second is rapid population growth in some urban areas, much of it due to the migration of agricultural workers from the south to urban industrial jobs in the north, and to the growth of cities with large military installations. The crowding this created, both during and after the war, put pressure on existing sanitation systems and may have led to increases in waterborne death rates. In fact, there is a marked slowing in the rate of decrease in these diseases revealed in Table 1.1, followed by an acceleration in the early 1920s. The third effect, the influenza pandemic of 1918–1919, may have increased the disease environment so that low levels of waterborne contamination affected more people. The coefficients on WAR are all positive and statistically significant for all cities other than lake cities.

The third of the variables controlling for variation across time is LATE20, a dummy for the period 1925–1927 during which many cities consistently overestimated their population given the levels reported in the 1930 Census. Thus, the death rates would tend to be underestimated.

Finally, ASSDPC and LANDAREA are included to control for the fact that, during these years, many cities grew by annexation and consolidation, although the great age of annexation was ending just as the study period begins (Cain 1983). Since annexed areas could be either healthy or unhealthy, either well-endowed with sanitation capital or not, the diverse pattern of coefficients should not be surprising. Their inclusion in these regressions is attributable to the fact annexation is not considered to be a fixed effect ex ante.[8]

These regression results only pertain to cities with municipal water supplies. In an attempt to assess whether the results of Tables 1.3 and 1.4 might also apply to cities with private water supplies, two additional regressions were run. The results are reported in Table 1.6. Because the number of cities without municipal supplies is relatively small, it is not possible to run regressions by city type. The first regression simply reruns the sample for all cities reported in the earlier tables without the water variables. The second regression repeats this specification for the cities with private supplies.[9] The final column of Table 1.6 reports the results of a simple

Table 1.6 Municipal vs. private water supplies

Variable	Municipal	Private	Test result
SEWKALL	−0.01376[a]	−0.00951[a]	Same
SEWERAV3	−0.05106[b]	0.00246	Same
REFKALL	−0.08150[a]	−0.22241[a]	Differ
REFUSEAV3	−0.04310[a]	0.00941	Same
YEAR	−0.07514[a]	−0.07448[a]	Same
WAR	0.21399[a]	0.19256[a]	Same
LATE20	0.00457	0.09407[a]	Differ
ASSDPC	0.00402[a]	−0.00014	Differ
LANDAREA	0.00028[a]	0.00019	Same
R^2	0.840	0.831	
n	2609	933	

Dependent variable is the log of the waterborne disease death rate
[a]Statistically significant at the 95% confidence level
[b] Statistically significant at the 90% confidence level

[8] Regressions excluding these two variables indicate that the loss of what in the all cities case are two statistically significant coefficients does not affect the overall results reported here.

[9] It should be noted that the distribution of cities by type for these two cases is approximately equal. It should also be noted that the cities included in the private regression are those that had no municipal works at the start of the study period. Inasmuch as several of these cities shifted to municipally owned works during the period, they are also included in the other regression for those years.

statistical test as to whether the coefficients of the first equation are in the confidence intervals of the second equation. By this test, three of the four coefficients for the sewage and refuse variables in the cities with municipal waterworks are in the confidence intervals for the cities with private works. Six of the nine variables included in the equation meet this test. This provides support for a conclusion that the effects of sanitation expenditures on the waterborne disease death rate are similar in cities with municipal and private waterworks.

1.5 Summary and Conclusion

This paper seeks to answer two questions. First, was there a payoff to cities' expenditure on sanitation works, and how big was that payoff? As Table 1.7 documents, cities received a big payoff to expenditures on waterworks, sewer systems, and refuse collection and disposal in the form of reduced deaths from waterborne diseases.[10] The second question is whether there were observable differences in the four city types. As Table 1.7 illustrates, the answer to that question is yes. This study further demonstrates that the mechanisms which do a good job of explaining the decline in waterborne disease death rates (Table 1.4) do not perform anywhere near as well in explaining the decline in the total death rate (Table 1.3). Indeed, the correlation between the two grows smaller over time, suggesting that additional study is needed to explain the decline in overall urban mortality in the early twentieth century.

The total per capita expenditures that appear in the first row of Table 1.7 are the sum of the variable mean expenditures listed in Table 1.5. The greater expenditures for saltwater cities are attributable to the high expenditure on water capital in those cities. The rest of Table 1.7 lists the annual decrease in the number of deaths attributable to waterborne diseases that would result from a one-percent increase in per capita expenditures on each of the six categories. Over all the cities in the pooled sample, a one-percent increase in each of the six categories would have saved 27 lives annually in a city of average size.

In Table 1.7, we see substantial differences between the types of cities. A one-percent increase in expenditures on water capital in saltwater cities would have averted almost 24 deaths, a much greater effect than elsewhere. A one-percent increase in annual expenditures on water, interpreted as expenditures on disinfection, would have had its greatest effect in freshwater lake cities, averting over 11 deaths. Increased expenditures on sewer capital had their greatest potential impact

[10] In 1902, typhoid deaths were, on average, 26% of all deaths from waterborne diseases; by 1929, this had fallen to 16%. Thus, deaths from typhoid had fallen faster than those from intestinal/diarrheal diseases.

Table 1.7 Reduced waterborne disease deaths from increased expenditures

Fresh water					
	All	Salt water	Lake	Major river	Minor river
Total expenditure per capita	$42.93	$48.92	$41.58	$40.65	$40.27
Averted deaths associated with a 1% increase in expenditures per capita					
Variable					
WATKALL	−8.79	−23.73	14.28	−1.81	−0.66
WATERAV	31.29	−2.49	−11.08	−2.07	3.57
SEWKALL	−12.58	−9.03	−1.17	−10.97	−20.15
SEWERAV3	−1.26	0.05	−2.10	1.86	−9.69
REFKALL	−2.01	−2.68	−15.81	−2.22	0.33
REFUSEAV	−3.65	−4.61	12.93	−4.71	−7.27
TOTAL	−26.99	−42.49	−2.94	−19.92	−33.88

in river cities, particularly minor river cities, where the number of deaths attributable to waterborne diseases would have been reduced by an annual average of more than 20. An additional one-percent increase on annual operating expenditures for sewers in minor river cities would have saved an additional ten lives. The 16 reduced deaths in freshwater lake cities that would have resulted from a one-percent increase in expenditures on refuse capital could have been countered by 13 more deaths from increased annual expenditures on refuse collection and disposal, which worked to reduce mortality in the other three city types.

The differences we see in Table 1.7 are consistent with the sketch of each city type appearing in the first section of this essay. To reiterate with the broadest brushstrokes, the capital expenditures of saltwater cities on water supply and wastewater works helped reduce waterborne disease deaths. While most cities adopted disinfection of their water supplies during this period, disinfection proved to have a significant effect only in the freshwater lake cities. The intelligent location of sewage works was important to both major and minor river cities, and the annual operating expenditures of the sewer system were of additional importance to minor river cities. This study incorporates refuse collection and disposal as part of sanitation, and the effects are as we expected with the exception of the positive effect of annual operating expenditures in freshwater lake cities. Finally, and tentatively, the comparison of cities with municipal versus private waterworks presented in Table 1.6 suggests the analysis of cities with municipal waterworks derived from Tables 1.3, 1.4, and 1.7 applies generally.

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Appendix: Murray Reminiscences

Louis Cain: I first met John at an academic conference, perhaps he was still in grad school. In any event, it was about a quarter century ago when our friendship began. We got to spend an extended time talking about our work when John came to give a seminar at Northwestern in 2000. In the Fall of 2005, I joined Bob Fogel's Center for Population Economics at the University of Chicago and began lobbying to have John come and give a seminar there. Six years later, he came. By then, Bob's health was failing, and we often didn't know until an hour or so before the seminar began whether he would appear. I knew Bob would enjoy John's topic, but Bob's assistant called just before lunch to say that he was not going to make it. I apologized for Bob's absence, but John was just happy to have been invited. He had booked a flight that left several hours after the seminar so we had a lot of time to talk about the books each of us was finishing. As luck would have it, those books were both the subject of an "author-meets-critics" session at the 2012 Social Science History Association meetings in Vancouver. I was grateful and appreciative that one of our critics was John Murray. His comments were always to the point but delivered with the kindness that was the hallmark of this gentle and generous scholar.

Elyce Rotella: I got to know John at meetings of the Economic History Association and the Social Science History Association but did not come to know him well until after I relocated to the University of Michigan in 2007. Because John was at the University of Toledo – less than an hour away from Ann Arbor – he came regularly to our weekly Economic History Seminar. He was an active seminar participant with valuable comments to offer for every paper. It was a pleasure to see him regularly which gave me the opportunity to develop a personal relationship that typically involved sharing stories of our musical daughters. We had many research interests in common. One of my treasured possessions is an autographed copy of his book on health insurance that he gave to me.

In addition to being a highly productive scholar, John was the very definition of a good citizen. He was a stalwart of the Economic History Association, the Social Science History Association, and the Cliometric Society – serving in leadership and service positions for these groups and their journals. When a colleague was elected President of the Social Science History Association, he immediately approached John for the big job of chairing the Program Committee. John had to turn down the offer because he had already done that job a few years earlier.

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