The Decline in Mortality in Philadelphia from 1870 to 1930: The Role of Municipal Services

The Christmas season of 1880 should have been a happy occasion for Charles and Caroline Kautz. Charles, a German immigrant in his mid-forties, had operated a three-person bakery in the Moyamensing section of Philadelphia over a decade. Caroline, several years his junior and his wife of over fifteen years, had married him during her teens and soon assumed the responsibilities of parenthood. Though Pennsylvania born, Caroline also came from German stock and, with her husband, worshipped at a local German Lutheran church. Caroline and Charles Kautz and their three sons and three daughters must have eagerly anticipated a joyous holiday celebration.

But it was not their fate to enjoy this Christmas. In three and one-half weeks from late November to mid-December, smallpox took the lives of five of the six Kautz children. Six-year-old Clara died on November 20, followed by Albert (aged 2) two weeks later, then Edward (aged 4) on December 10, Charles (aged 8) on December 11, and Bertha (aged 10) on December 14. Only twelve-year-old Sophia survived. Burial in the Lutheran church cemetery followed each of the deaths in numbing succession.

The tragedies that befell the Kautzes over a century ago illustrate in a concrete way part of the enormous gap separating the twentieth and the nineteenth centuries in America. Epidemic diseases, childhood death, and low adult life expectancies dominated life. Indeed, in the space of a decade, the Kautzes had witnessed smallpox epidemics in Philadelphia in 1871-72 and 1876 prior to the 1880-81 epidemic that devastated their family. The difference between the two centuries is often meas-

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We also wish to thank William Kreider, Jeffrey Seaman, Wayne Dunlap, and Mara Weitzman for computer support, and Alicia Gilham for graphics and typing.
ured in terms of the rapid diffusion of communications, transportation, and machine technologies throughout our society. These forces, without doubt, make our lives much different. But they are no more important to us than the lengthening of adult life and the elimination both of frequent early death and the constant anticipation of epidemic disease. Recurrent smallpox epidemics, for example, which in Philadelphia alone took 4464 lives in 1871 and 1872 and 1760 lives in 1880 and 1881, seem to be remnants of a distant past.\(^1\) Illnesses that rarely confront us today were frequently present only a century ago.\(^2\)

Yet, as significant as the reduction in mortality has been, scholars still search for the reasons for the "mortality transition." Rising personal income, improved diet, better sanitation and personal hygiene, public health activities, advancing medical technology, are offered as competing, complementary, or interacting explanations.\(^3\) How any or all of these factors affect the propensity for a disease to be present in the environment (exposure), or for a given population to avoid infection from a disease which is present (resistance), or for survival when individuals contract a disease (case survival) is also open to considerable debate.

Although the origins and sources of the mortality transition are not fully understood, scholars have developed a commonly accepted portrait of the change. It occurred during the nineteenth and early twentieth centuries in most of Europe, the United States, Canada, Australia, and New Zealand. In American cities, for example, mortality levels were high at the beginning of the nineteenth century and remained high for most of the century. Although mortality rates for some age groups

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and from some diseases (e.g., cholera and typhus) began declining earlier, a substantial and sustained decline in overall mortality levels did not begin until late in the nineteenth century.\(^4\)

The changes in mortality rates in Philadelphia closely paralleled in both timing and magnitude those in other large cities of the United States and in urban areas in other industrializing nations.\(^5\) These trends can be traced fairly well after 1860 when the official registration of deaths with the issuance of a death certificate began. The deaths were aggregated and published in annual reports of the Board of Health and included in the mayor's yearly report. The published data provide a classification of the deaths by age and cause for the total population of the city. In addition, deaths by cause are published for the wards within the city.

Using an average of these registration data for three years surrounding each federal decennial census date from 1870 to 1930 and base population figures from the decennial censuses, one can observe the pattern of mortality change.\(^6\) The description of changing mortality is expressed in two ways: as the probability that an individual in a particular age group will die during a given five-year age period and as the expectation of life at selected ages. For each year, the expectation of life for a given age is the average number of years that would be lived by a hypothetical group of persons who reached that age in the year and who were subjected to that year's probabilities of dying at each subsequent age.

The magnitude of the overall mortality decline in Philadelphia is apparent for all age groups (see Table 1). In 1870, for example, about 175 of every 1000 children born never survived to their first birthday.


\(^6\) The values of \(q_t\) in Table 1 were estimated using the values of \(4q_t\) fit to South Model Life Tables. For a full explanation of the estimating procedure see Gretchen A. Condran and Rose A. Cheney, 91-102.
### TABLE 1  
The Table Probabilities of Dying \( (q_x \times 1\text{, 000}) \) and Expectations of the Adjusted Ages  
Philadelphia 1871 to 1951  

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**Probabilities of Dying \( (q_x \times 1\text{, 000}) \)**

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**Expectation of Life**

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*For more information, see the sources cited in the footnote.*


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By 1930, fewer than 75 of every 1000 infants perished during the first year of life—a decline of about 175 percent in the probability of dying. Indeed, the late nineteenth century was still a difficult time for all children. Over a third of all infants born in 1870 died before they were ten. Sixty years later, about a tenth did not survive to that age, a substantial improvement in life chances. Young adults also suffered from a harsh mortality regime in 1870—114 of every 1000 individuals reaching age 20 never lived to age 30—but by 1930 less than 20 of 1000 twenty-year olds died within ten years. The elderly also enjoyed a moderation in their mortality rates. In 1870, about 320 of every 1000 individuals reaching 60 years of age died within the next decade; by 1930, the corresponding figure was 183.

The declines in infant mortality were particularly important for raising life expectancies between 1870 and 1930. At birth in 1870 an individual could expect on average to reach age 40; by 1930, an infant could expect to reach age 58—an increase in life expectancy of about 46 percent. The impact of the mortality transition, however, was not as substantial for those who could survive their childhood and adolescent years. In 1870, for example, individuals who made it to age 20 could on average expect to see age 60; by 1930, the group of young adults might expect to celebrate their 66th birthday—an increase of life expectancy of but 15 percent. Clearly, the major consequence of the transition was to increase the numbers who survived infancy and childhood. Those who had already reached adulthood gained fewer additional years of life.

Although mortality rates declined for each age group between 1870 and 1930, the timing of the reduction differed by group (see Table 1). Childhood and infant mortality levels declined throughout each of the six decades, but the declines were uneven. The expectation of life at birth and at age 1 in Philadelphia rose almost three years between 1870 and 1880, but increased at a slower rate between 1880 and 1900. After 1900, the rate of improvement in mortality levels increased again.

On the other hand, substantial declines in adult mortality did not occur in Philadelphia until after the turn of the century, except for 20 to 29 year olds. This group exhibited the highest rates of death from tuberculosis, and declines in its overall death rates occurred steadily from 1870 to 1930, largely because the deaths from tuberculosis were de-
clining. In contrast to the other groups, the elderly actually exhibited rising mortality rates until the 1910-1920 decade, but then a precipitous drop between 1910 and 1930.

Cause-of-death data provide the first clues to the explanation of these trends and age group differentials, but these data must be used with caution. A correct assessment of the levels of a disease in a population is dependent upon the consistency of classification schemes and reporting procedures over time. In Philadelphia, data are available from 1870 to 1930 but are not of uniform quality for the entire period. Between 1870 and 1900, the number of causes of death reported by the Bureau of Health steadily increased. Much of the increase resulted from changes in diagnostic ability and the replacement of general cause-of-death categories with more specific descriptions of the sources of mortality. In 1904, the Bureau of Health began to group individual causes into broader nosological headings.\(^7\)

Thirteen causes of death can be followed with reasonable certainty from 1870 to 1930. Although these infectious diseases represent but a minority of all causes of death reported in Philadelphia, they account for 45 percent of all deaths occurring in 1870, about 40 percent of those in 1900, and about 24 percent of those in 1930. As we will see, these declining proportions indicate that increasing control of infectious disease played a significant role in the overall mortality decline. Even for these selected causes of death, however, causes for which diagnosis was probably very accurate throughout the period must be separated from those in which trends may be obscured by changes in diagnosis over time (see Table 2). The mortality rates for each disease are standardized on the age distribution of Philadelphia's population in 1870 and, therefore, the rates for each cause are those which would have occurred if the age distribution of Philadelphia's population had not changed in the time period.

The group of infectious diseases for which diagnosis was very good showed a spectacular decline over the period. In 1870, about 600 of every 100,000 Philadelphians died from these causes; sixty years later fewer than 80 did. Scarlet fever, small pox, typhoid, and diphtheria, all major killers in 1870, were virtually eliminated as causes of death by

### Table 2

**Percent Contribution of Causes of Death to Overall Decline in Age Standardized Death Rates, Philadelphia, 1870-1900 and 1930**

<table>
<thead>
<tr>
<th>Causes of Death</th>
<th>Percent Decline Explained by Cause*</th>
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<td>1870(1)</td>
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<tr>
<td><strong>Infectious</strong></td>
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<tr>
<td>Specific Diagnosis</td>
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<tr>
<td>Diphtheria and Croup</td>
<td>52 1</td>
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<tr>
<td>Pneumonia</td>
<td>0 5</td>
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<tr>
<td>Smallpox</td>
<td>0 4</td>
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<tr>
<td>Measles</td>
<td>0 7</td>
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<tr>
<td>Scarlet Fever</td>
<td>8 8</td>
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<tr>
<td>Tuberculosis</td>
<td>8 5</td>
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<tr>
<td>Typhoid</td>
<td>1 7</td>
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<td>Whooping Cough</td>
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<tr>
<td><strong>Primarily Infectious</strong></td>
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<tr>
<td>Diagnosis Less Specific</td>
<td>14 1</td>
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<tr>
<td>Diarrheal Diseases</td>
<td>16 4</td>
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<td>Epidemic Meningitis</td>
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<td>Influenza</td>
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<td>Pneumonia</td>
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*The percent decline was calculated using 1900 and 1930 death rates standardized on the age distribution of the 1870 Philadelphia population*

1930. The timing in declines differed by specific disease, however. Most of the individual disease categories declined between 1870 and 1900 and continued to decline between 1900 and 1930, but diphtheria, typhoid, and whooping cough exhibited declines only after 1900.

The second group of diseases, those whose diagnoses were more problematic in the nineteenth and early twentieth centuries, showed less clear downward trends than the more easily diagnosed causes of death. Death rates from diarrheal diseases declined throughout the period, although the decline was much greater after 1900 than before. Epidemic meningitis changed little between 1870 and 1930, while influenza death rates rose for both thirty-year periods. Pneumonia death rates increased substantially between 1870 and 1900 but demonstrated a large decline in the next thirty years. The fairly steady decline which occurred in the residual category of cause of death is difficult to interpret. This category contains many different causes of death, including all those that are ill-defined such as marasmus and debility. Therefore, actual changes in the death rates cannot be distinguished from improvements in the diagnosis over time.

Examining the contribution of the thirteen cause-of-death categories to the overall decline in mortality establishes that the control of these infectious diseases was the most important component of the mortality transition (see Table 2). The percentage of the total decline in mortality due to each cause of death was calculated for the whole period from 1870 to 1930 and for each of the two thirty-year periods separately. Over the sixty-year period, two-thirds of the mortality transition is accounted for by the decline in the combined thirteen disease categories alone. Over half of the total reduction is explained solely by decreases in diseases subject to specific diagnoses. These diseases were particularly responsible for the decline from 1870 to 1900, but also contributed heavily to mortality decline after the turn of the century. In contrast, mortality rates from the group of infectious diseases which were less easily diagnosed actually rose until 1900, but became a significant part of the overall decline afterward.

The fluctuations in the trends of particular diseases bring us closer to the mechanisms governing the transition. For both time periods, tuberculosis explained the largest percentage of the decline in the age-standardized death rates. It accounted for 26.8 percent of the decline in
mortality from 1870 to 1900, 19.8 percent of the decline from 1900 to 1930, and over 22 percent for the entire six decades. Decreasing death rates from diarrheal diseases explain about 16 percent of the mortality decline from 1870 to 1930, contributing slightly more to the overall decline during the initial thirty years. The severity of scarlet fever and smallpox epidemics declined so much from 1870 to 1900 that they represent the third and fourth most significant contributions. After 1900, however, they were no longer important causes of death, and they no longer contributed to the decline in mortality. Other diseases actually increased in destructiveness before becoming sources of the mortality decline. Deaths due to diphtheria and, particularly, to pneumonia rose between 1870 and 1900, but these diseases became important sources of mortality decline between 1900 and 1930. Quite clearly, the mortality transition was largely a consequence of the reduction in fatalities from infectious diseases. Why did this reduction occur?

Much of the demographic literature seeking to explain the mortality transition asserts that in the past mortality declines in more developed areas resulted from economic growth and changes in living standards and that the importation of modern technology has been responsible for recent mortality reductions in less-developed areas. This contention is generally true, but it remains a general hypothesis implying specific relationships which have yet to be empirically verified. The specific determinants of declines in mortality remain a central question in studying the demographic changes of industrialized nations, historically, and of developing nations, presently.

Thomas McKeown and his colleagues have emphasized the importance of economic development and accompanying increases in food

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supplies and per capita income as sources of the historical decline in mortality in the West. From an examination of the diseases which contributed to the decline in mortality in England and Wales during the nineteenth century, the McKeown group concludes that the major influence on declining death rates was the rising standard of living, the most significant feature of which was an improvement in diet. They argue that improvements in hygiene and public sanitation had some impact on mortality rates after 1850 and that minor changes in overall mortality levels resulted from a favorable shift in the relationship between micro-organisms and the human hosts. Advancing medical technology had but a limited impact on mortality decline. According to McKeown, therapies made no contribution and immunization accounted for only a small part of the reduction in the death rates before 1935. A comparison of other studies with that of McKeown is hampered by variations in the research methods and classification schemes used to elaborate the determinants of mortality decline. Regardless of the broad categories used, however, the literature suggests that the factors responsible for the spectacular decline in mortality which occurred in late nineteenth and early twentieth-century Europe and the United States were numerous and complex. The importance of each factor has, by no means, been firmly established. In many previous discussions, economic development has been considered mainly in terms of increases in per capita income and has been related to mortality through advances in nutrition. However, economic development and industrialization encompass not only additions to per capita income, but also technological changes, increases in knowledge (including medical knowledge), mass education, urbanization, and changes in the social organization of both governmental and other groups. All these aspects of economic development affect mortality levels by influencing a number of other factors which more immediately determine mortality levels: density, crowding, immigration, water supplies, food purity, per capita food supplies, expenditures on public health and personal hygiene practices.


Thomas McKeown, 153-154.
Many of these phenomena are related to each other, often in complicated ways. Explanations of the decline of mortality usually juxtapose the variables relating to changes in income, medical technology, public health activity, or the environment. Such explanations should be replaced by a model which sees income changes operating through a number of these variables. Increased per capita income leads to increases in the purchase of health-enhancing goods—especially better food and better housing. It also potentially improves an individual’s health by increasing his access to medical care and services and, on a more aggregate level, by increasing the funds available for public expenditures on health activities. At the same time, many of the intermediate variables which influenced mortality were probably also affected by aspects of economic development other than the change in per capita income. Improvements in nutrition resulted from changes in per capita income but also from technological changes, particularly those in transportation and food processing.

Because the decline in mortality was largely a result of a decline in infectious diseases, we can begin an explanation of mortality decline with the relatively simple notion that the chances of dying from a particular disease depend on three things: the exposure of a population to the disease; the population’s resistance to the disease; and, once the disease is contracted, the ability of the people to survive its effects. Although these three are not easily distinguished empirically within populations, they can help us to organize some of the more easily identified variables which have affected mortality levels.\(^{12}\)

In general, the decline in mortality prior to 1930 resulted largely from a decrease in exposure, and/or an increase in resistance, so that individuals were less likely to die from a given disease because they were less likely to contract it in the first place. This is not to say that there were no improvements in survival rates once a disease was contracted. Some researchers, for example, argue that improvements in case survival

were a major part of the decline in the death rate from diphtheria.\textsuperscript{13} Our analysis will concentrate on the prevention of illness, largely because it appears to have been a more significant factor in the early mortality decline than efforts to treat illness once it occurred.

Disease prevention resulted from a series of explicit public and private efforts in conjunction with economic forces that were beyond the public's immediate control. It is unwise to single out any particular factor as central to disease control, though we can conclude that a rising standard of living, promoted by rapid economic development, was a significant cause of this phenomenon.

The history of tuberculosis, the disease most important to mortality decline in Philadelphia, illustrates well the difficulties in explaining why the exposure of a given population to a particular disease declined. Overt efforts to contain this disease were not especially effective, largely because medical and public officials debated its contagious nature until nearly the turn of the century and took virtually no effective actions to limit it before 1930.\textsuperscript{14} Nevertheless, its decline as a source of mortality is evident, both during the late nineteenth century when little was known about this debilitating affliction and during the first thirty years of the twentieth century when tuberculosis was at last recognized as a contagious disease. Explanations citing improvement in diet resulting from economic advance and the growing resistance of populations to the disease as a consequence of exposure both suggest possible answers, but it is clear that explicit attempts at containment do not account for its decline.\textsuperscript{15}

Other diseases were effectively limited by direct and knowledgeable action, particularly by public health authorities. The emergence of the

\textsuperscript{13} See for example John Duffy, \textit{A History of Public Health in New York City 1866-1966} (New York, 1974), 157


public health bureaucracy is an important aspect of the process of economic development and population growth. In Philadelphia from 1870 to 1930, the government apparatus concerned with the health and welfare of the population considerably expanded its scope. The growth of its power and influence helped produce lower mortality rates from a number of specific causes of death. Initially, the public health sector had an impact on medical science through the institution of data collection systems which informed the activities and pronouncements of public health officials. Later, as in other cities, public health efforts were concentrated primarily on decreasing the population's exposure to disease by decreasing the number of pathogens in the environment. Public health activities encompassing quarantines, disinfection, purification of water supplies, and advocacy of particular child care practices all focused on prevention of illness, a focus that has to some extent been lost in the more recent emphasis on antibiotics and high technology medical treatment. Even in the instances where medical treatment played a central role in disease control, as with smallpox, public campaigns were largely responsible for promoting such medical remedies as vaccination.\(^\text{16}\)

The history of public health activities in the nineteenth and early twentieth centuries has been written for a number of cities and our aim is not to add Philadelphia to these histories. Rather, we seek to illuminate the connections between those activities and the shifts in mortality levels outlined above. To do that, we will focus on two causes of death on which public health activities were focused. By concentrating on one city and, at times, on small sections of Philadelphia, we will attempt to establish patterns and explanations that might apply to other urban areas during their mortality transitions.

The most dramatic impact of the city's activity can be observed in the efforts to combat high death rates from typhoid fever by cleaning up city water supplies. The pollution of water supplies quite often accompanied city growth. Impure water was not a problem in every large city, but Philadelphia shared with many cities the pollution of a central water system. The centralization of water systems allowed typhoid fever, transmitted through human excreta, to spread throughout the city.

\(^\text{16}\) Thomas McKeown, 99; City of Philadelphia, *First Annual Message of Charles Waranck*, 1895, 83-84; Samuel Preston and Etienne van de Walle, 282.
As early as 1860, the Bureau of Health found two problems with the water supply system in Philadelphia. First, especially in summer, the quantity was inadequate to meet the needs of the population. The Bureau of Health argued that the shortage of water had adverse consequences, because more water was needed both for personal hygiene and to clean streets and sewers. In addition, the water supply was being polluted. In 1861, the annual report of the Bureau of Health contained a scathing account of the pollutants of the water supply. The city received water from several water stations, but all water came ultimately from the Schuylkill and Delaware rivers. According to the Bureau of Health, the Schuylkill was being polluted by sulphate of iron from coal mines, by the infusion of refuse dyes and wastes from the various factories on the eastern bank, and, most objectionable of all, by the emptying of city sewers into the river. The sewers received drainage from the streets and were connected to privies and cesspools. The Delaware River was even more foul. In 1874, the Bureau of Health suggested that the Delaware be terminated as a source of water in favor of the Schuylkill, which, by that time, was protected from some pollutants. The city had acquired land along both sides of the river for park land to prevent further growth of pollution-producing industries along the river banks.

The pollution problems remained, however, and city officials linked impure water with diseases, particularly typhoid fever. Filtration of the water supply was first broached as early as 1853 but not implemented until after the turn of the century. At the time filtration was begun, the city was divided into six water districts that received water from different waterworks. The timing of the introduction of water filters

20 City of Philadelphia, Report of the Board of Health of the City and Port of Philadelphia to the Mayor for the year 1874 (Philadelphia, 1875), 45-47.
differed across the six districts. The death rates from typhoid fever from 1890 to 1920 have been calculated for each of the water districts and are shown in Figure 1. The graph points out the importance of
water filtration in combatting the disease. The Roxborough (1902) and Belmont (1904) districts were the first to receive filtered water. In these two districts, the 1905-1906 typhoid epidemic that showed up in the other four water districts did not occur. The Torresdale district had high rates of typhoid in 1905, 1906, and 1907 but showed a precipitous decline by 1908. Its water filtration system was put into operation in 1907. By the end of 1908, 56 percent of the city’s water was being filtered. Subsequently, filtered water was supplied to the East Park, Queen Lane, and Fairmount water districts so that on March 1, 1909, “the entire city was supplied with filtered water.” No epidemics of typhoid fever occurred after the filtration began.23

For the city as a whole the picture is clear. The year 1906 is the peak typhoid year for the city—over 1000 deaths occurred in just one year. Epidemics had occurred with regularity before that. The number of deaths grew in each epidemic as the city’s population grew and as an increasing proportion of the city’s population was exposed to the polluted water supply. Epidemics ceased in 1906, for by the time the next epidemic would have likely occurred, the water supply was filtered.

While it was agreed that the purification of the polluted water supply affected the death rate from typhoid fever, contemporaries were intrigued by the notion, supported by data in several cities, that the death rates from diseases other than typhoid fever would decline following the purification of public water supplies. The idea arose from the work of two individuals, Hiram F. Mills of Lawrence, Massachusetts, and J.J. Reincke of Hamburg, Germany. In 1893-94, they observed that the

purification of polluted water supplies in Lawrence and Hamburg produced a significant decline in the general death rate. The relationship was named the "Mills-Reincke phenomenon." It was tested on a number of other cities by Allen Hazen, who in 1904 reached the conclusion that "where one death from typhoid fever has been avoided by the use of better water, a certain number of deaths, probably two or three, from other causes have been avoided." He hypothesized that the decline in the overall death rate following the water purification would be two or three times greater than that from the decline in typhoid fever alone.24

Although some of the excess decline in the overall death rates observed by Mills, Reincke, and Hazen was attributable to changes in other water-borne diseases, it was not totally accounted for by these. Changes in typhoid rates were related to pneumonia, tuberculosis, and other diseases which were not water-borne. In Philadelphia, during the period when water filtration was introduced, there was no constant multiplicative relationship between the decline in typhoid death rates and the decline in death rates from other causes. The existence of six water districts with differences in the timing of filtration affords us an opportunity to examine more carefully the relationship between the conditions of the water supplied to the population and the deaths from diseases other than typhoid. The water district data for Philadelphia show very little evidence of the Mills-Reincke phenomenon. None of the causes of death which we examined showed the decline coincidental to water filtration which is seen in the typhoid fever death rates. There was little or no association between deaths from typhoid fever and deaths from tuberculosis or pneumonia, the leading causes of adult mortality. More surprisingly, however, even diseases like infant and childhood diarrhea, dysentery, and enteritis, which might be water-borne, did not decline in water districts immediately following filtration. Water filtration did put an end to epidemic outbreaks of typhoid fever, but it did not go beyond that.

24 W.T. Sedgwick and J. Scott MacNutt, "In the Mills-Reincke Phenomenon and Hazen's Theorem Concerning the Decrease in Mortality from Diseases Other Than Typhoid Fever Following the Purification of Public Water-Supplies," The Journal of Infectious Disease, 7, no 4 (August, 1910), 489-563.
The major cause of death among infants and young children was diarrheal disease. In these age groups, diarrhea is generally precipitated by contaminated food or water supplies and/or malnutrition. The immediate cause of death is dehydration, which occurs most quickly in very young infants with low body weights. In nineteenth-century Philadelphia, there was a definite seasonal pattern to infant and childhood diarrheal deaths, the frequency having been much greater in the summer months.

The decline in diarrheal death rates for the city as a whole is shown in Figure 2. Mortality rates from infant and childhood diarrhea declined from the mid-1870s to 1900. An upsurge appeared shortly after 1900 and was followed by a relatively steep decline. The rise after 1900 corresponds to a shift in the classification scheme of causes of death, and therefore is likely to be an artifact of the changing nosology. The best estimate of the trend in infant and childhood diarrheal death rates is that they continued downward throughout the first decade of the twentieth century and that the decline became steeper sometime about 1910. The sharp downward trend beginning about 1910 would be consistent with the positive influence of water filtration on the occurrence of the disease. However, as we have stated in the previous section, it is clear that the source of the decline was not the shifts in the water supply. Figure 1, which contains the typhoid fever deaths, includes the numbers of deaths from infant and childhood diarrhea. There is no evidence of a decline in these deaths resulting from filtration of the city's water supply. The factors influencing the levels of mortality from diarrhea in the early years of life must be sought elsewhere.

The Bureau of Health in Philadelphia undertook three activities directed particularly at reducing infant and early childhood mortality rates. The first of these was the issuance of pamphlets on the care and feeding of children. In the mid-to-late 1870s, forty thousand copies of a circular urging mothers to breastfeed their babies and to postpone weaning until after the summer months were distributed. For mothers who did not breastfeed, the pamphlets suggested that clean bottles be

used in feeding infants. The advice contained in the pamphlet was sound. From the scanty data available, it appears that breast-fed babies had lower death rates from diarrheal diseases than did babies fed animal milk. The question which cannot be answered is whether the advice was heeded by enough mothers to have produced a decline in mortality rates. Changes in the seasonal pattern of diarrheal diseases suggests that the advice was heeded and may have resulted in an attenuation of the summer peak of mortality among one-year olds prior to 1880, but a seasonal pattern, particularly for infants, continued until 1920.

The impact created by the establishment of a Child Hygiene Bureau can be somewhat more easily assessed. The bureau was organized in 1910 and located child hygiene clinics in eight wards between 1910 and 1914 and in nineteen wards between 1915 and 1918. Trends in death rates based on births for child hygiene districts are shown in Figure 3. Wards were selected as sites of clinics because of the high infant and childhood death rates. Therefore, the wards with clinics had higher infant diarrheal death rates before the clinics opened than wards without clinics. The wards with clinics, however, showed declines in diarrheal death rates which were steeper than those without clinics, so that by 1930, the infant diarrheal rates in the latter were higher than those in the former. Also noticeable in Figure 3 is that while infant diarrheal death rates were declining for all wards for the time period from 1904 to 1920, clinics appear to have accelerated the decline in the wards that had them.

Finally, the Bureau of Health worked long to improve the quality of the milk being fed to children in the city. In 1889, city council created the post of inspector of milk to insure the wholesomeness of milk in the city. This appointment, however, by no means solved the problems.
FIGURE 3
INFANT DIARRHEAL DEATH RATES IN WARDS CLASSIFIED BY TIMING
OF CHILD HYGIENE PROGRAMS, PHILADELPHIA 1914 - 1923
Between 1890 and 1914, difficult legislative struggles were waged for the city councilmen's votes on various regulations affecting the milk supply. Milk producers favored little or no regulation, while the Bureau of Health argued that the poor quality of the milk supply had adverse health consequences and that regulation of the producers was needed.31

There were a number of problems with the milk supplied to the city. First, it was often skimmed and/or had added water. As a consequence, babies and young children fed the milk were likely to be inadequately nourished. Second, the milk itself was impure. Sloppy handling resulted in pollutants that entered the milk, and lack of refrigeration, especially in the summer, resulted in the growth of bacteria. Third, some of the milk was obtained from tubercular cows and was a source of non-respiratory tuberculosis in the population. The last problem seems not have been servere; a system of inspecting herds for tuberculosis was instituted quite early. The first two problems with the milk supply were likely to have directly affected the incidence of diarrheal diseases in infants and young children. Bureau of Health efforts to prevent the adulteration of milk were only moderately successful between 1890 and 1895. In 1895, the inspector was given authority to check the bacteriological content of the milk.32 Both home and commercial pasteurization of milk was being done by 1905.33 As the result of legislation going into effect in 1911, milk was condemned and destroyed if its temperature was below standard. In that year alone almost 29,000 quarts of milk failed to meet the standard.34 On July 1, 1914 an ordinance requiring all milk in the city to be pasteurized was passed.35

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31 A record of the battles waged can be found in the Annual Reports of the Bureau of Health for the years from 1890 to 1914
34 City of Philadelphia, *Annual Reports of the Director of the Department of Public Health and Charities and of the Chief of the Bureau of Health for the year ending December 31, 1911* (Philadelphia, 1912), 21-23
Limited statistics available on the quality of the milk supply indicate that improvements occurred over time. Between 1889 and 1893, an average of 8.5 percent of inspected milk was found to be skimmed or watered. During the next five years that percentage had dropped to 3.3. From 1899 through 1903, an average of about 1.5 percent was skimmed or watered, and for two five-year periods after that, average yearly percentages dropped to .5 and .2 percent. Statistics from 1899 to 1911 on the bacteriological content of milk show a much less consistent downward trend. A substantial drop occurred between 1908 and 1909 and in the years following. These improvements happened before universal pasteurization became law. In summary, improvements in the milk supply came largely after the turn of the century, but were substantial enough to have accelerated the decline in infant and childhood diarrhea.

The decline in mortality experienced by Western industrialized nations in the late nineteenth and early twentieth centuries creates a major historical question. As illustrated by our case study of Philadelphia, life expectancies at birth significantly increased and propensities to die from infectious disease, particularly tuberculosis and infant diarrhea, decreased during the period from 1870 to 1930. Certain epidemic diseases, notably typhoid fever, smallpox and scarlet fever, virtually disappeared as causes of death. Of particular importance was the sharp drop in the frequency of infant and childhood death, which propelled the marked increase in life expectancies. The circumstances surrounding the deaths of the Kautz children a hundred years ago have long been gone from the Western world.

The reasons for this remarkable change remain elusive. We can say with some assurance that mortality declines occurred because the population became less exposed and more resistant to infectious disease, rather than because medical technology increased chances of survival once a disease was contracted. But explaining this reduced exposure and greater resistance is difficult.

36 The statistics presented are from the Annual Reports of the Bureau of Health for the years from 1889 to 1913.
Certainly, no single factor can account for the mortality transition. Our brief discussion of the diseases central to the mortality decline indicates a multitude of possibilities. Tuberculosis, for example, declined in impact for no clearly discernible reason, although improved diet and growing resistance among the population to the disease were probable factors. Smallpox was eradicated through a combination of advancing medical technology and governmental crusades promoting vaccination. Typhoid fever was eliminated by water filtration, and infant and childhood diarrheal deaths were sharply decreased by several factors, including public dissemination of information about the diseases, the establishment of locally-based child hygiene clinics, and improvement in the quality of milk.

Underlying the overall transition was a general improvement in living standards, concurrent with rapid economic development. Economic advance in itself, however, would not have produced the evident declines in death rates of certain diseases without the efforts of public officials who proposed, debated, and carried out many actions to further the health of their community. Typhoid fever, smallpox, and infant and childhood diarrhea, in particular, were severely curtailed by their activities.

Governmental intervention in Philadelphia occurred in spite of opposition from various special interest groups and constant bickering between the Board of Health and City Council. Regulation often came, too, with officials possessing only limited knowledge about the health problems against which their efforts were directed. But its impact was not small. Considering only typhoid fever, diarrheal diseases, and smallpox, direct public health activities probably account for almost one-third of the mortality decline in Philadelphia between 1870 and 1930. And this conservative estimate ignores possible indirect effects on other diseases.

Skepticism voiced today about the role of government too often neglects the very beneficial impact public agencies have made in the lives of their citizenry, particularly in the field of public health. Many commentators also mistakenly think of public intervention and regulation as phenomena associated with the expansion of government in the 1930s. Yet by 1930 infectious epidemic disease and exceedingly high mortality rates had been brought largely under control with the direct
assistance of a well-established municipal services bureaucracy. The health issues we face today are not the same as those a century ago, but we would be prudent to recognize past successes and how they were achieved.