Clean Water and Public Health:
Progress that Changed America

At the start of the twentieth century, high mortality rates and substandard living conditions were commonplace in urban America. Mortality rates in major cities were substantially higher than in rural areas, a phenomenon known as the "urban penalty". Yet by 1940, mortality rates had declined by a full 40 percent, mostly due to a reduction in infectious diseases. And, thankfully, the urban penalty had largely disappeared, with life expectancy rising from 47 to 63 years.

What fostered this rapid and revolutionary change, the most dramatic reduction in mortality ever recorded in the United States? While many factors contributed, a study by Harvard University researchers, David Cutler and Grant Miller, finds the most compelling root cause for the drop in U.S. mortality rates in the twentieth century was the adoption of treatment technologies for public drinking water supplies.

In their 2005 article, "*The Role of Public Health Improvements in Health Advances: The Twentieth Century United States*,"[1] Cutler and Miller conclude that clean water technologies, filtration and chlorination, were responsible for *nearly half of the total mortality reduction in major cities* between 1900 and1936, with even greater impact on infant and child mortality rates during that same time period. Significantly, these technologies led to the near-eradication of typhoid fever, the waterborne disease that was one of the major scourges of that era.

Considering the cost of water infrastructure and the value of reduced mortality, Cutler and Miller's analysis concludes that clean water technologies were not only a boon to public health, but were also tremendously cost effective.

The Adoption of Clean Water Technologies

In the later half of 19th century, many large U.S. cities had municipal water and sewer systems. As Cutler and Miller note, however, these early systems did not include treatment and did not prevent significant outbreaks of waterborne diseases. In fact, drinking water quality deteriorated, due to the dumping of untreated sewage into rivers and lakes used as source water.

While modern sewage treatment was not widely adopted until the 1930's and 1940's, many major U.S. cities adopted clean drinking water technologies by 1920. Originally designed to reduce turbidity, discoloration, and bad taste, filtration was also found to improve the microbial quality of water. However, it was clear that filtration did not remove all the bacteria from public-use water. To expand the effect of clean water on urban populations, chlorine disinfection was rapidly and widely adopted as a complementary technology. The first significant adoption of water chlorination took place at the Boonton Reservoir of the Jersey City, New Jersey waterworks in 1908, with most major cities following suit in the ensuing decade.

Impact of Clean Water Technologies on Public Health

To measure how clean water affected mortality, Cutler and Miller matched municipal-level mortality statistics to knowledge of where and when filtration and chlorination were adopted. By examining changes in mortality just around the time that filtration and chlorination were introduced in each city, they were able to distinguish these impacts from other changes occurring during the same time period (such as knowledge of appropriate personal health practices). The final study sample included thirteen cities where sufficiently complete and reliable data were available: Baltimore, Chicago, Cincinnati, Cleveland, Detroit, Jersey City, Louisville, Memphis, Milwaukee, New Orleans, Philadelphia, Pittsburgh, and St. Louis.

In the studied cities, major infectious disease and childhood infectious disease rates plummeted in the first decades of the century, including a massive decline in tuberculosis and the near-eradication of typhoid and malaria (see Table 1). Typhoid fever serves as a marker for other waterborne and diarrheal diseases, which are estimated to account for four times as many deaths as typhoid fever alone.

TABLE 1 -- Percentage of Deaths, by Cause, in Major Cities		
Cause of Death	*1900*	*1936*
Major Infectious Diseases	**39.3**	**17.9**
Tuberculosis	11.1	5.3
Pneumonia	9.6	9.3
Diarrhea and enteritis	7.0	n/a
Typhoid Fever	2.4	0.1
Meningitis	2.4	0.3
Malaria	1.2	0.1
Smallpox	0.7	0.0
Influenza	0.7	1.3
Childhood Infectious Diseases	**4.2**	**0.5**
Measles	0.7	0.0
Scarlet Fever	0.5	0.1
Whooping cough	0.6	0.2
Diphtheria	2.3	0.1
Source: U.S. Census Bureau's Mortality Statistics, 1900 and 1936.		

Cutler and Miller found that filtration and chlorination together reduced mortality by an average of 13%, infant mortality by 46% and child mortality by 50% in major U.S. cities. This accounts for about 43% of the total reduction in mortality observed in these cities from 1900 to 1936. Even more striking, clean water technologies appear to have been responsible for 74% of the reduction in infant mortality and 62% of the reduction in child mortality (see Table 2).

TABLE 2 -- Effect of Filtration and Chlorination on Mortality		
	Total Reduction in Mortality Rate 1900-1936	**Share of Total Attributed To Clean Water**
Typhoid Mortality	96%	91%*
Total Mortality	30%	43%
Infant Mortality	62%	74%
Child Mortality	81%	62%
* Achieved five years after adoption of clean water technologies		

Nearly all of the mortality declines are accounted for by reductions in infectious disease, which caused nearly half of all deaths in 1900 but account for only a small fraction of deaths today. Most

notably, clean water technologies appear to have reduced typhoid fever deaths by 26% initially and by another 65% after five years, leading to the near-eradication of this killer disease by 1936. Cutler and Miller suggest that clean water reduced other infectious diseases, including pneumonia, tuberculosis, and meningitis.

The Economic Impacts of Clean Water Technologies

What is the financial impact of providing clean water and reducing disease to a society? As part of their study, Cutler and Miller estimated the economic benefits of these striking reductions in disease mortality.

To do so, Cutler and Miller estimated the cost of a water system serving 100,000 persons to be $30 million per year (in 2003 dollars). Using the mortality reductions indicated by their research, they also calculated the annual number of deaths prevented by clean water technologies (1,484), the number of person-years saved (57,922), and the associated annual benefits ($679 million, in 2003 dollars).

The result? Cutler and Miller estimate that the introduction of clean water technologies produced an eye-popping $23.00 in benefits for every $1.00 invested in clean water technologies. This eye popping rate of return does not even capture the entire economic impact of clean water technologies, because benefits such as reduced illnesses and productivity gains in the general population are not included.

Conclusions

Cutler and Miller's analysis demonstrates the strikingly large and cost-beneficial role of clean water technologies. The period examined was the era of the most rapid documented decline in mortality in American history, and clean water appears to have played as large a role as any force responsible for this rapid progress.

Although findings from the early twentieth century in the United States cannot be compared directly to the current circumstances of developing countries, the results give some indication of the tremendous health and economic gains achievable through clean water technologies. Worldwide, roughly 1.1 billion people lack access to safe water and 1.7 million people die every year from diarrheal diseases. Applying results from their analysis, and assuming that only 1% of the annual deaths from diarrheal diseases could be prevented by water disinfection, Cutler and Miller estimate the corresponding social rate of return would be about $160 billion annually.

End Notes

[1]Cutler, D. and Miller, G. (February, 2005). The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States. *Demography*, vol. 42, no. 1, 1-22.