What has the past taught us about water and health? Some introductory thoughts.

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• Between 1850 and 1925:
• Crude population death rate drops by 60%
• 30-50%, in modeling, due to ‘eradication’ of diarrheal diseases, typhoid, and sequelae
• Mills-Reincke phenomenon (Hazen theorem): for every death from typhoid avoided, ≥ 3 deaths not usually considered waterborne also prevented, such as tuberculosis and pneumonia.

Before 1880: > 50% deaths were in children under 5; leading causes diarrheal diseases (dysentery, ‘cholera infantum,’ typhoid) and respiratory diseases: pneumonia, TB, influenza, bronchitis.

By 1925: < 25% deaths in the <5s; typhoid ‘largely eradicated,’ heart disease and cancer eclipse respiratory diseases – old age diseases replace infectious diseases, especially in children, as primary causes of death.
• Same transition occurred in New York, Boston, Philadelphia, other large US cities; in smaller cities, occurred with about a decade lag. Historically referred to as the demographic transition.

• Same conditions in 1875 as found in poor ("developing") world today.

• Policy questions: what promoted this change? What policies hindered it? Was this due to rising per capita income, or to public health projects – water and sewer systems, vaccination, behavioral change…
Chicago, continued…

- 3 significant periods of improvement in sanitation and in drinking water treatment
- At least in Chicago, initial efforts were aimed at decreasing fecal contamination of drinking water sources, later followed by drinking water treatment
- Note that one early improvement had to do with provision of water for fighting fires
- Sewage into Lake Michigan / Chicago River – d.w. source
- 1867: 2-mile tunnel under LM provides d. water intake away from shore
- 1869: water tower fire pumping station
- 1871: deepening of Illinois & Michigan canal, reversing current of Chicago River – sewage flows away from water intakes in LM
2\textsuperscript{nd} and 3\textsuperscript{rd} stages

- 1893: 4 mile intake; 68\textsuperscript{th} street intake crib; closure all shoreline sewage outlets
- 1917: Wilson Ave intake crib, city-wide chlorination of public water supply
- Dramatic effects \textit{before} chlorination due to sanitation

\begin{figure}[h]
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\includegraphics[width=\textwidth]{fig1.png}
\caption{Typhoid rate in Chicago: deaths per 10,000 persons.}
\end{figure}
1. Due to other improvements: Not due to changes in milk supply. Diptheria anti-toxin developed in 1890s (5% of all deaths).

2. Could this have resulted from behavioral changes (is it a coincidence that this happens just as improved water and sanitation occur?)

Sedgwick & McNutt 1910: US and Europe identical patterns: Death rates from non-waterborne diseases decrease: pneumonia, cardiac, TB, kidney, bronchitis...

3. Diffuse benefits, perhaps because the sequelae of waterborne diseases are prevented.
Mills & Reincke, Hazen & Sedgwick

• Hiram Mills, late 1880s-early 1890s, chief engineer of Lawrence MA water company, served at MA State Board of Health. J J Reincke was a public health official in Hamburg, same period. No contact with one another. Documented improvements in non-typhoid death rates after water filtration in Lowell, Lawrence, and Hamburg.

• Hazen & Sedgwick, others: Zurich, Albany, Binghamton, Watertown NY, Newark, Jersey City, Manchester, Cincinnati, Boston, Baltimore, Pittsburgh, US military bases, ‘countless’ other cities / towns – same thing.

• Most decreased: Infantile diarrhea, TB, pneumonia, influenza, bronchitis, heart disease, kidney disease
3 possible explanations for the Mills-Reincke phenomenon…

Were typhoid deaths *misdiagnosed*? e.g. pneumonia, heart disease really was typhoid.

Accurate surveillance, Case Definitions, Diagnostics

Was typhoid so *virulent* *that it weakened people* so they died of other, co-morbid diseases?

Extensive evidence that typhoid weakens many organs, and survivors have elevated death rates thereafter x 2 years.

Were there diffuse benefits such as better nutritional status (from *not* being ill) that led to fewer deaths from other causes?

Econometric modeling shows this effect was present in Chicago – explains at least 35-50% of the 60% mortality decrease
Stockholm

- Infant mortality in Stockholm > 200 / 1,000 until 1900. By 1925, rate was 50/1,000, driven by a decline in diarrhea mortality.
- Other causes: TB, meningitis, malnutrition, congenital conditions, other diseases associated with poverty, crowding, adverse living conditions.
- Transition occurred before curative medical therapy and vaccinations became available.
FIGURE 1—Overall mortality and diarrhea mortality among children aged younger than 2 years: Stockholm, 1878 to 1925.
FIGURE 2—Diarrhea mortality rate in relation to daily average water consumption per person and cumulative number of new water pipe connections, Stockholm, 1878 to 1925.
FIGURE 3—Diarrhea mortality rates among children aged younger than 2 years, by socioeconomic group (SEG), Stockholm, 1878 to 1925.

Note: Groups are numbered in order of descending socioeconomic status.
FIGURE 4—Overall mortality rates among children aged younger than 2 years, by socioeconomic group (SEG), Stockholm, 1878 to 1925.

Note: Groups are numbered in order of descending socioeconomic status.
What else was going on then?

- Higher standards of cleanliness in public places
- Improved handling excreta
- Intensified health and milk inspections
- Better food handling
- Improved child feeding practices
- Health education to improve hygienic practices
Fast Forward: USA 1960

• 3,700 sanitation projects on US Native American reservations starting in 1960
• Substantially reduced cost of water; sharp reductions waterborne diarrhea and infectious respiratory disease occurred.
• Also decreased infectious respiratory disease among nearby Caucasian infants
• Explains 40% of ‘convergence’ between Native American and White infant mortality rates in reservation counties since 1970.

Fig. 1. Infant mortality by race in sample areas, 1960–1998.
‘externalities’

• “One other factor that cannot be emphasized too strongly… is that poor sanitation facilities on Indian reservations have a direct effect upon the health of the surrounding Non-Indian communities. You cannot quarantine these diseases; you cannot quarantine polluted streams; you cannot quarantine polluted flies, they get from one place to the other. And when an effort is made to improve sanitation facilities on Indian reservations, we are, in fact, performing a service for non-Indian communities in the same area… So in those terms I think this is merely legislation for the general welfare.” Arthur Lazarus, Assoc. on American Indian Affairs, Congressional testimony, May 5-6 1959.
4. Sarawak, Malaysia 1963 - 2002

- 200 – fold decrease in incidence of dysentery, 60 – fold decrease in incidence of enteric (typhoid) fever during this period.
- Cholera and dysentery outbreaks still occur when rural populations rely on contaminated rivers for their water supply.
- Piped gravity feed systems, wells, rain water storage tanks – no treatment – 44% in 1980 to 97% in 2002. Complemented by a latrine project that had to be in place before water project (latrine coverage 45% 1980, 98.2% 2002).

Figure 1 Incidence rate of dysentery (A), enteric fever (B), cholera (C) and cholera viral hepatitis (D) in Sarawak from 1963 to 2002.
1. Sanitation, combined with water provision, led to marked decreases in waterborne diseases especially once the majority of the population was serviced.

2. Cholera still occurs in epidemics when drought occurs and contaminated water is used – lots of 2ndary transm.
Two paradigms:

Rising wealth leads to diffuse improvements in health, lifespan

Specific, targeted public health social / infrastructure interventions (sanitation, water, hygiene, etc) improve health, lifespan
Increase in Lifespan

Social Factors

TIME (DECADES)

LIFESPAN IN YEARS

RICH

POOR
Figure 5: Distribution of child deaths by cause in five profiles for the 42 countries with 90% of global child deaths in 2000

POOR (DEVELOPING) WORLD TODAY
Thoughts and challenges

• What do we really know about the benefits of sanitation and safe drinking water?
• What contribution can be made to health and lifespan in the poor countries, as well as protecting the advances made to date? How? What are emerging concerns and concepts?
• Social factors are important; environmental justice addressed with public infrastructure; will this be as paramount if individual household treatment becomes a norm? How do we include ‘externalities’ (often ignored) into our cost-benefit models?