

## Public Health Implications of Water Supply Improvements

Did Environmental Engineers save the world?

The greatest obstacle to discovery is not ignorance – it is the illusion of knowledge

- Daniel J. Boorstin

### Public Health

- Environmental Engineers help protect communities from waterborne disease
- Water related Public Health is complex
  - Hygiene, education,
  - Chlorine may be overrated
  - Household infrastructure matters

### The role of Water Supply, Sanitation, and Hygiene (WASH)

- Contribute significantly to mortality and morbidity on the global level
- Have an enormous influence on U5MR (under 5 mortality rate)
- What is the effect of safe drinking water?

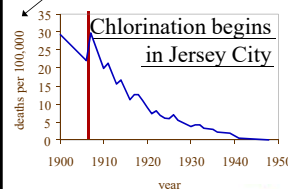
### Mills-Reincke Phenomenon

‘... the purification of polluted public water-supplies reduces the general death-rate much more than it would be reduced by the saving of deaths from the commonly recognized water-borne disease, typhoid fever and Asiatic cholera alone.’

Sedgwick WT, MacNutt JS. On 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. *J.Infect.Dis.* 1910; 7 : 489-564.

This is the “Environmental Engineers Saved the World” Hypothesis.

### U.S. Typhoid Fever Mortality



- **Chlorination** was begun in Jersey City, N.J., in 1908. Adoption by other cities and towns across the US **soon** followed and **resulted in** the virtual **elimination of waterborne diseases** such as cholera, typhoid, dysentery and hepatitis A

Chlorine saved the day

*Salmonella typhi*

oral (e.g., ingestion of contaminated food, fecal particles, or contaminated water).

## Chlorine Cause and Effect: What else would you like to know...

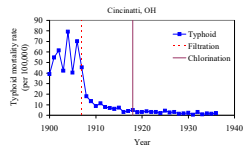
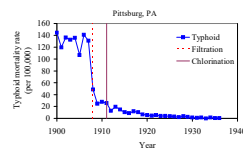
- What was the mortality rate before the introduction of chlorine?
- When did other cities adopt chlorination?
- How did the mortality rate change for cities when they began chlorinating?
- What other changes were occurring during the 1900s that may have influenced mortality?

## Disease rates as measures of efficiency

“The final criterion of the efficiency of a purification plant is the absence or prevalence in the community of water-borne diseases. Typhoid fever being the most typical and widespread of such diseases, statistics of its prevalence are of much significance. Prior to the general introduction of purification works, the typhoid death rate was invariably high in many of our large cities drawing their supply from polluted rivers and lakes. Most of these cities are now supplied with satisfactory water, and many records could be given showing the marked effect of water treatment on the typhoid rate. The following data for the cities of New Orleans, Pittsburgh and Cincinnati will suffice.”

Public Water-Supplies by Turneaure, Russell, Mead, Baker. John Wiley & Sons (1924) pages 430-431.

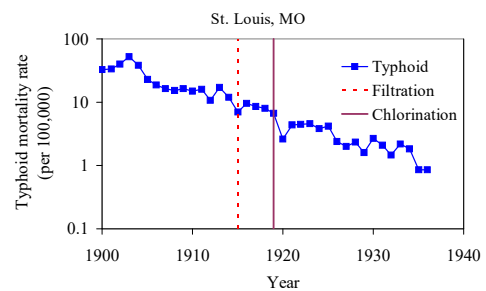
## Evidence for a Causal Link: New Orleans, Pittsburgh, Cincinnati



Pittsburgh, Cincinnati and New Orleans were used as evidence of the efficacy of filtration

Public Water-Supplies by Turneaure, Russell, Mead, Baker. John Wiley & Sons (1924)

## Let's look at all the data using log scale (showing improvement ratio)



## Correlation between Water Supply Improvements and Public Health?

- A causal link?
  - Filtration
  - Chlorination
- Delayed response?
- No link?
- US 1900 – 1940 interpretation?



## Trying to Understand the Data

- “The steady reduction... is probably due in part to improved operation and in part to the gradual elimination of the disease from the community and so removing sources of contamination.”
- “It should be noted that typhoid fever is frequently traced to other causes than the water-supply,....”
- What else was happening?

Public Water-Supplies by Turneaure, Russell, Mead, Baker. John Wiley & Sons (1924)

## Reading the Typhoid Data



- How long did it take for typhoid incidence to decrease? 30 to 40 years
- If typhoid was waterborne how long should it have taken for filtration and chlorination to eliminate typhoid? A few weeks
- How does milk get typhoid?  
Human excrement (milker's hands?)

Since *S. Typhi* and *S. Paratyphi A* are found only in human hosts, the usual sources of these organisms in the environment are drinking and/or irrigation water contaminated by untreated sewage.

## My Typhoid Conclusions



- The reduction was not due to a one time centralized change
  - Not due to filtration
  - Not due to chlorination
- Was due to changes that occurred at different times throughout the population
  - Improved hygiene
    - Installation of toilets in bathrooms with sinks to wash hands and toilet paper
    - Education encouraging hand washing
  - Better food handling practices
    - Milk pasteurization
    - Refrigeration
  - Public Health Education and medical care

Typhoid was likely **not waterborne**

## Typhoid isn't the only waterborne disease!

## Causes of diarrhoea according to 'Diseases of children'

1889	1899
Sour milk	'no doubt that the immediate cause is an infection of the alimentary canal, by ...bacteria contained in milk or other forms of food'
Unripe fruit	
Inhalation of sewer gas	
Emanations from the soil	

Powerlessness!

Empowerment

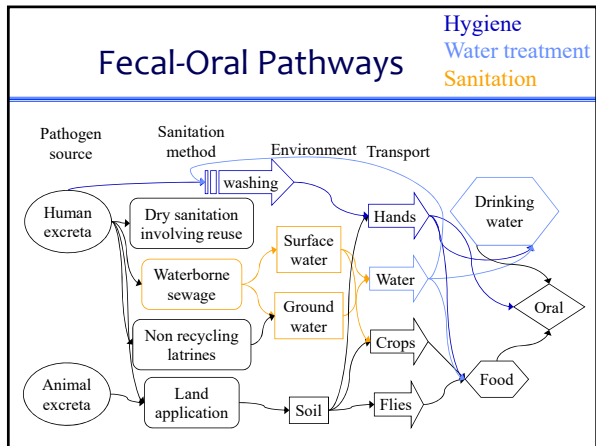
## Changes recommended: public health campaign

- Breast feed
- Boil cow's milk, sterilize bottles
- Protect infants from persons known to be ill
- Control flies
- Wash hands

You can improve your health!

## Maybe we are helping to save the world from stunted growth

- Of the 555 million preschool children in developing countries, 32% are stunted and 20% are underweight.<sup>1</sup>
- A key cause of child undernutrition is a subclinical disorder of the small intestine known as tropical enteropathy
- Caused by faecal bacteria ingested in large quantities







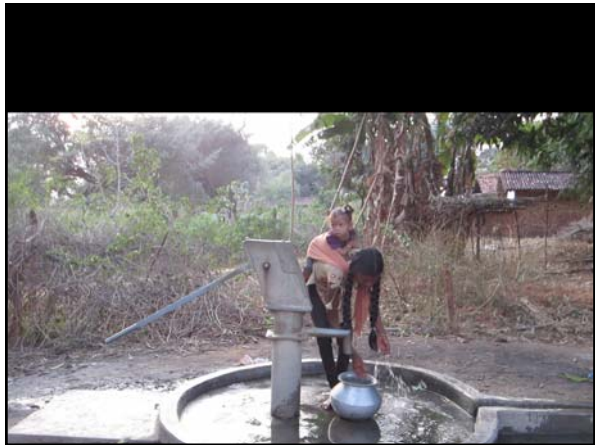
### Improved or Safe?

<p><b>Improved</b></p> <p>Came out of a pipe that was near the town.</p> <p>Met the Millennium Development Goal!!!!!!</p> <p>Doesn't meet the Sustainable Development Goal!!!</p>		<p><b>Safe</b></p> <p>Was treated to remove contamination and won't make you sick</p>
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✓ Improved

✓ Safe

✗ Convenient



✓ Improved

✗ Safe

✗ Convenient

✓ Improved

✗ Safe

✓ Convenient



## The customer wanted safe water on tap

- What do people want? (see SDG 6)
  - Reliable, easy access to plenty of safe, **aesthetically pleasing** water
  - Judge based on **looks and taste/smell**
- Will they be willing to pay for and maintain more expensive infrastructure to have aesthetically pleasing water? **YES! (at least in many cases)**
  - We are competing with expensive bottled water and cheap unsafe, inconvenient, unreliable water sources
  - We can make tap water as reliable as bottled water and almost as cheap as dirty water

Should we measure health outcomes in Honduran communities before building more AguaClara plants?

Should we measure health outcomes in US communities before building more Water Treatment plants?

## Safe water infrastructure extends from watershed to watershed

- Watershed protection to minimize erosion and reduce contamination
- Water treatment to remove contaminants
- Safe water transport to households
- Household infrastructure (sinks)!
- Waste water collection
- Waste water treatment and return to the environment

## Creative solutions needed for villages

- In cities water distribution systems and storage tanks are designed for fire protection
- In villages fire protection may not be as critical
- Household storage would enable a lower cost, smaller diameter, distribution system
- Households could manage their water consumption

## Creative solutions needed for cities

- Consider smaller scale wastewater collection and treatment for local reuse
  - Reuse wastewater for lower quality water needs
    - Flush toilets
    - Fire protection pond
    - irrigation
  - Reduce pumping costs with distributed/decentralized wastewater collection, treatment, and reuse
  - Watch out for unintended consequences!

## Summary

- Fecal oral routes are complicated and thus may require multiple interventions
  - Safe water
  - Household infrastructure for washing and safe water handling
  - Safe food handling
  - Safe waste disposal
- We need creative environmental engineering solutions as
  - populations continue to grow
  - climate changes
  - water resources are stretched