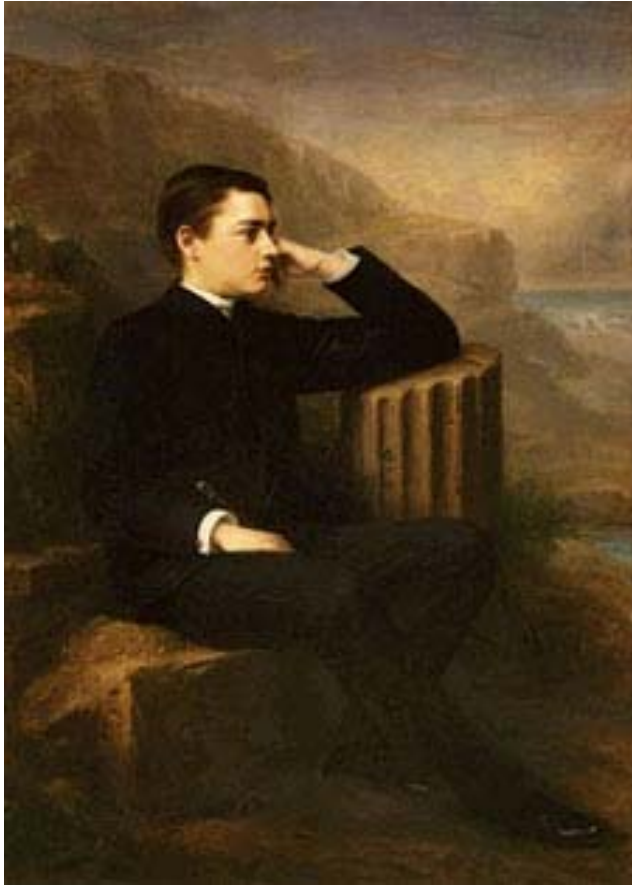
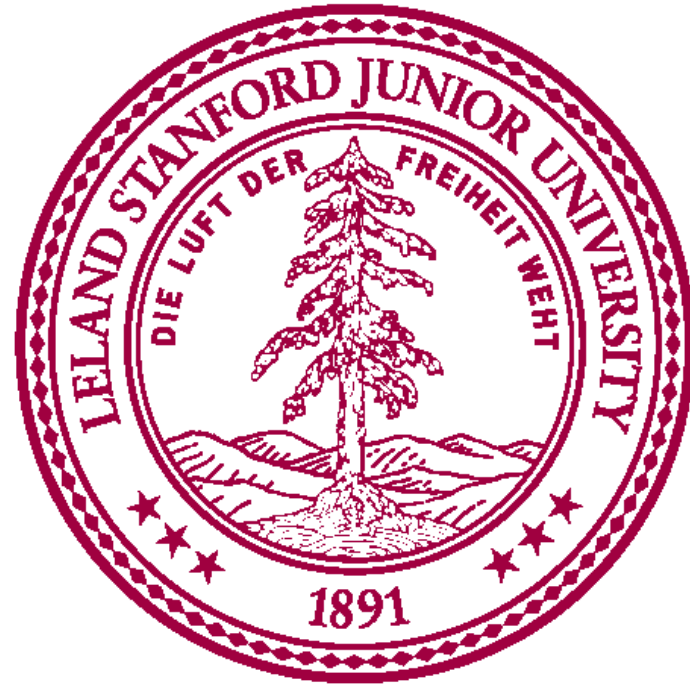


# A Timeline for Typhoid Elimination



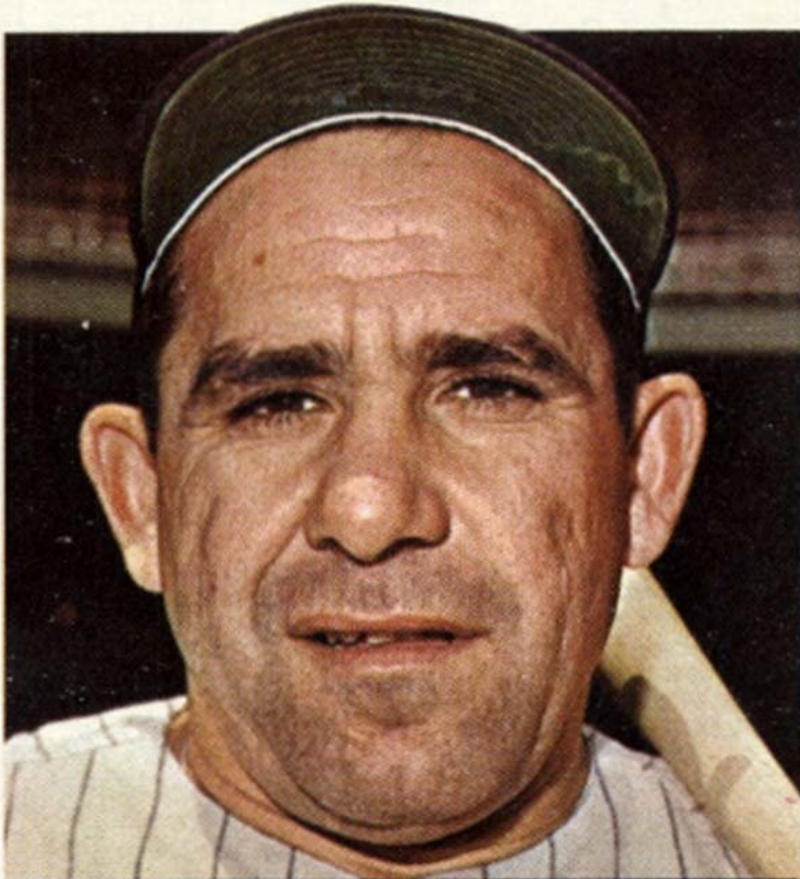
Leland Stanford, Jr.  
(1868 – 1884)



Steve Luby, MD

11th International Conference on Typhoid and Other Invasive Salmonellosis  
Hanoi  
28 March 2019

**YANKEES**



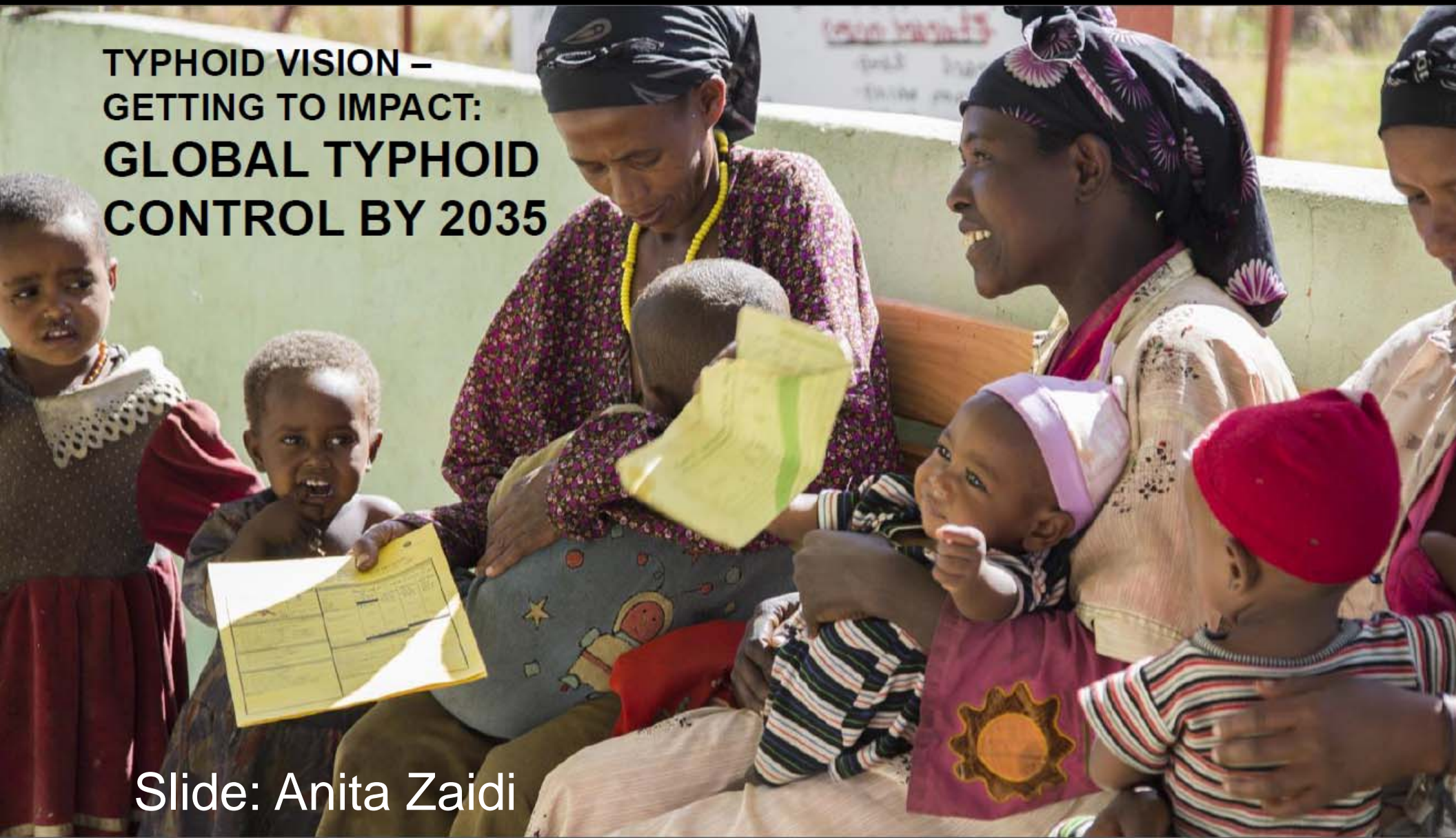
**YOGI BERRA**

manager

“It’s tough to make predictions, especially about the future.”

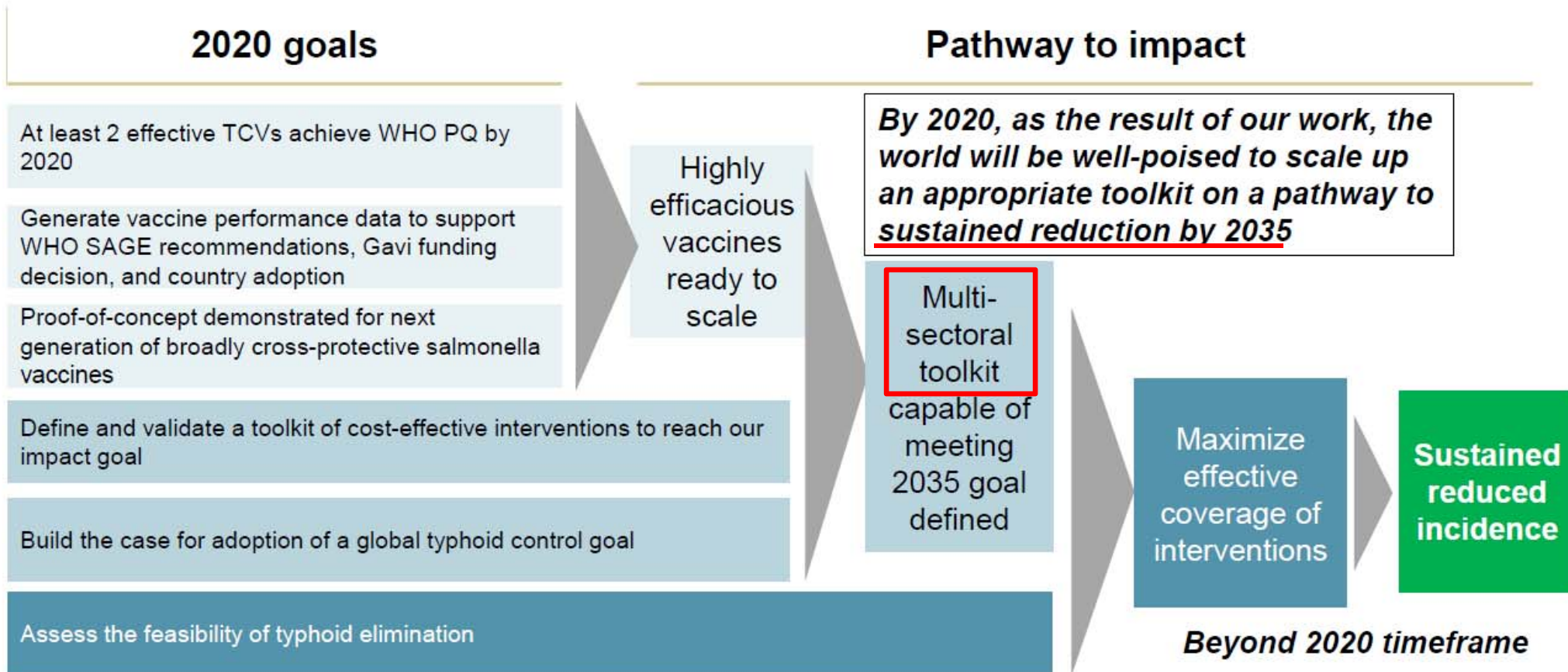


**TYPHOID VISION –  
GETTING TO IMPACT:  
GLOBAL TYPHOID  
CONTROL BY 2035**



Slide: Anita Zaidi

# DRIVING TOWARDS IMPACT THROUGH OUR 2020 GOALS



Slide: Anita Zaidi

# The planning fallacy

Kahneman, D. *Thinking, Fast and Slow*, 2011

Planning based on best case scenario

Ignores experience of similar projects

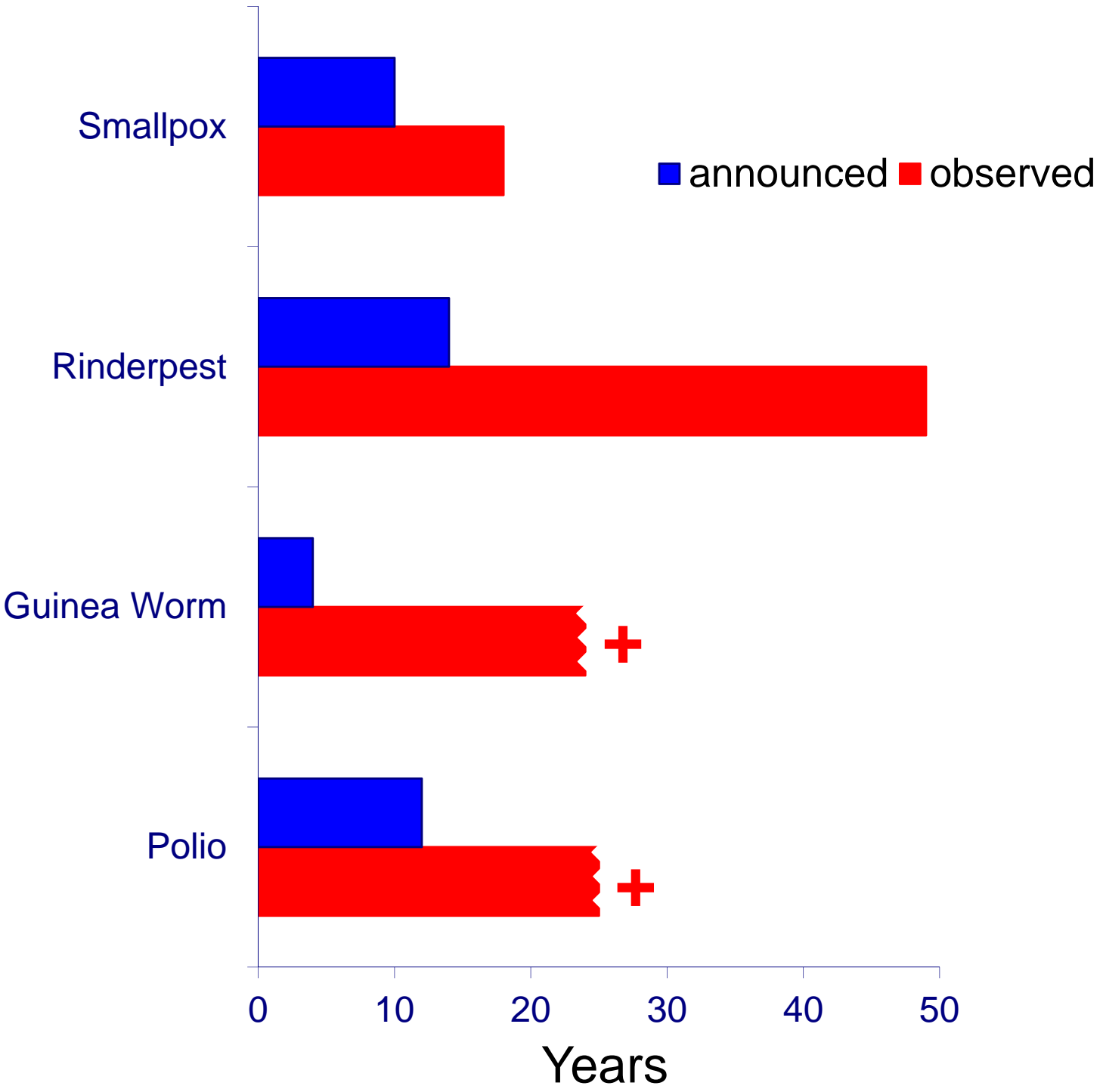
– “This won’t happen to us.”



# Planning Fallacy Examples

- 1997 New Scottish parliament building in Edinburgh could be constructed for <£40 million.
- Scottish parliament building completed in 2004 for £431 million.
- In 2002, a survey of American homeowners who had remodeled their kitchens found that, on average, they had expected the job to cost \$18,658
- On average ended up paying \$38,769
- Many ways for any plan to fail
- Most are too improbable to anticipate
- The likelihood that something will go wrong in a big project is high

# Announced versus Observed Global Eradication Timelines



# How has typhoid been eliminated?

(hint: not using the proposed approach)

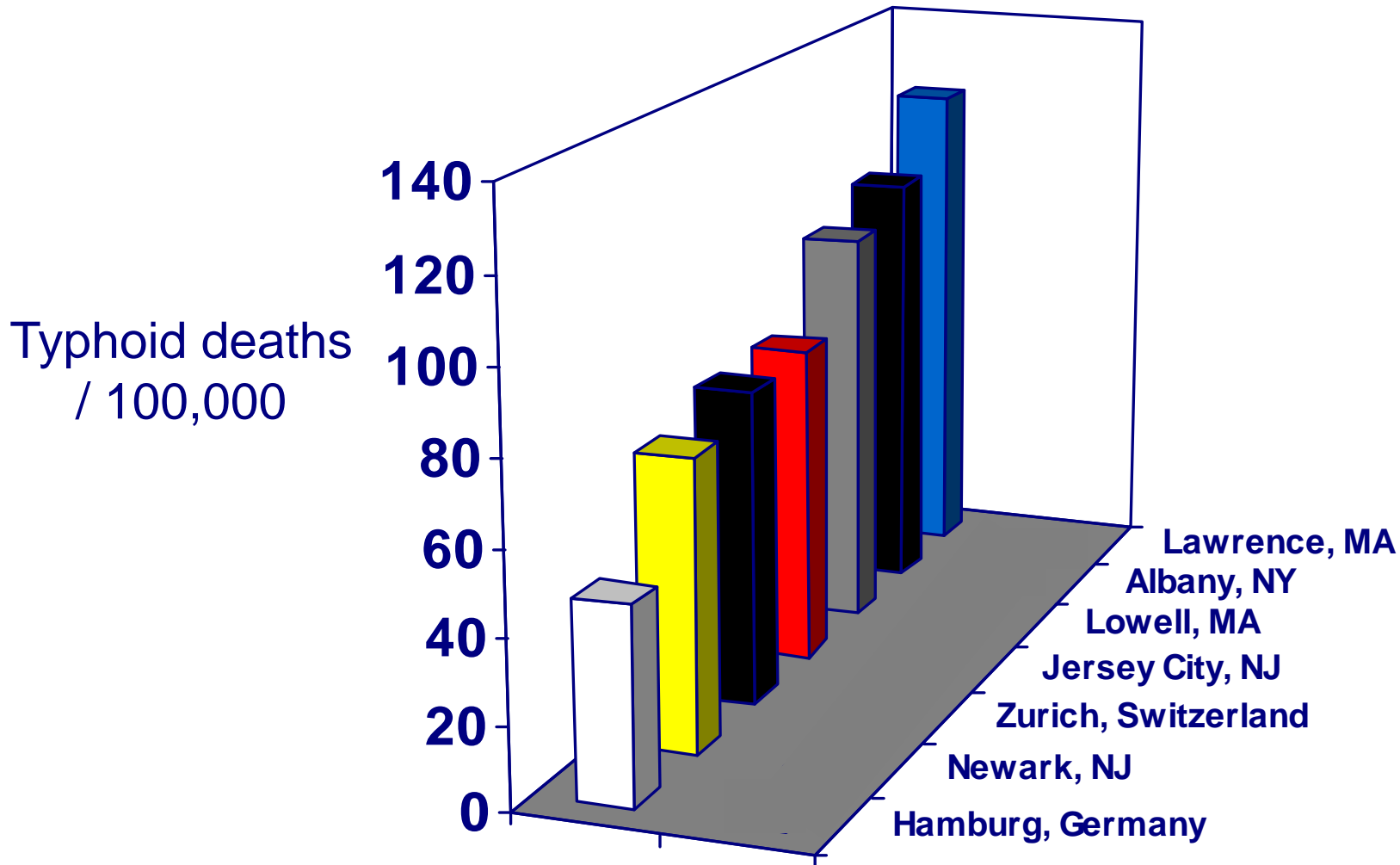


# Deaths from typhoid fever

5 years before

improved water supplies

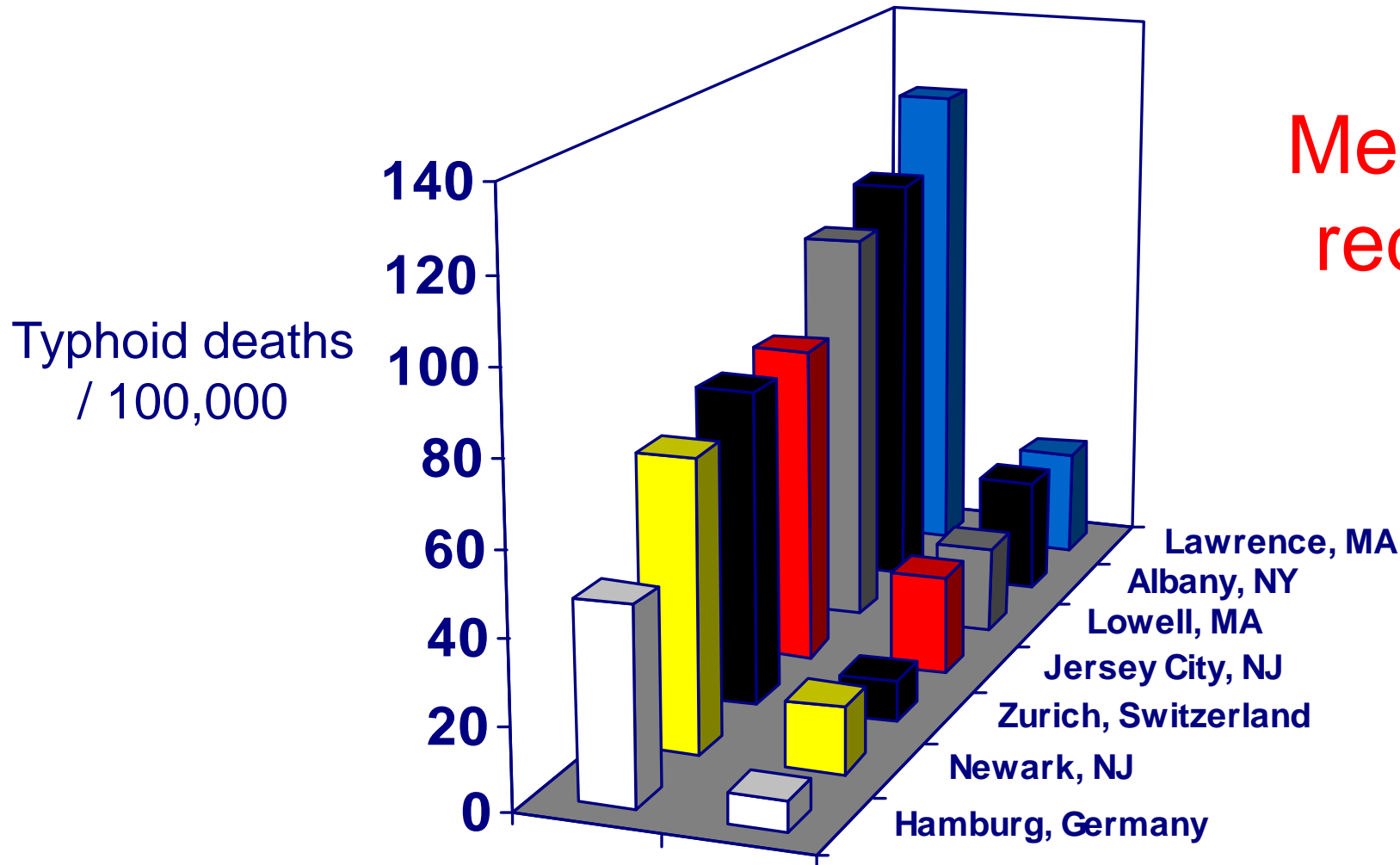
1892 - 1901



# Deaths from typhoid fever

5 years before and 5 years after improved water supplies  
1892 - 1901

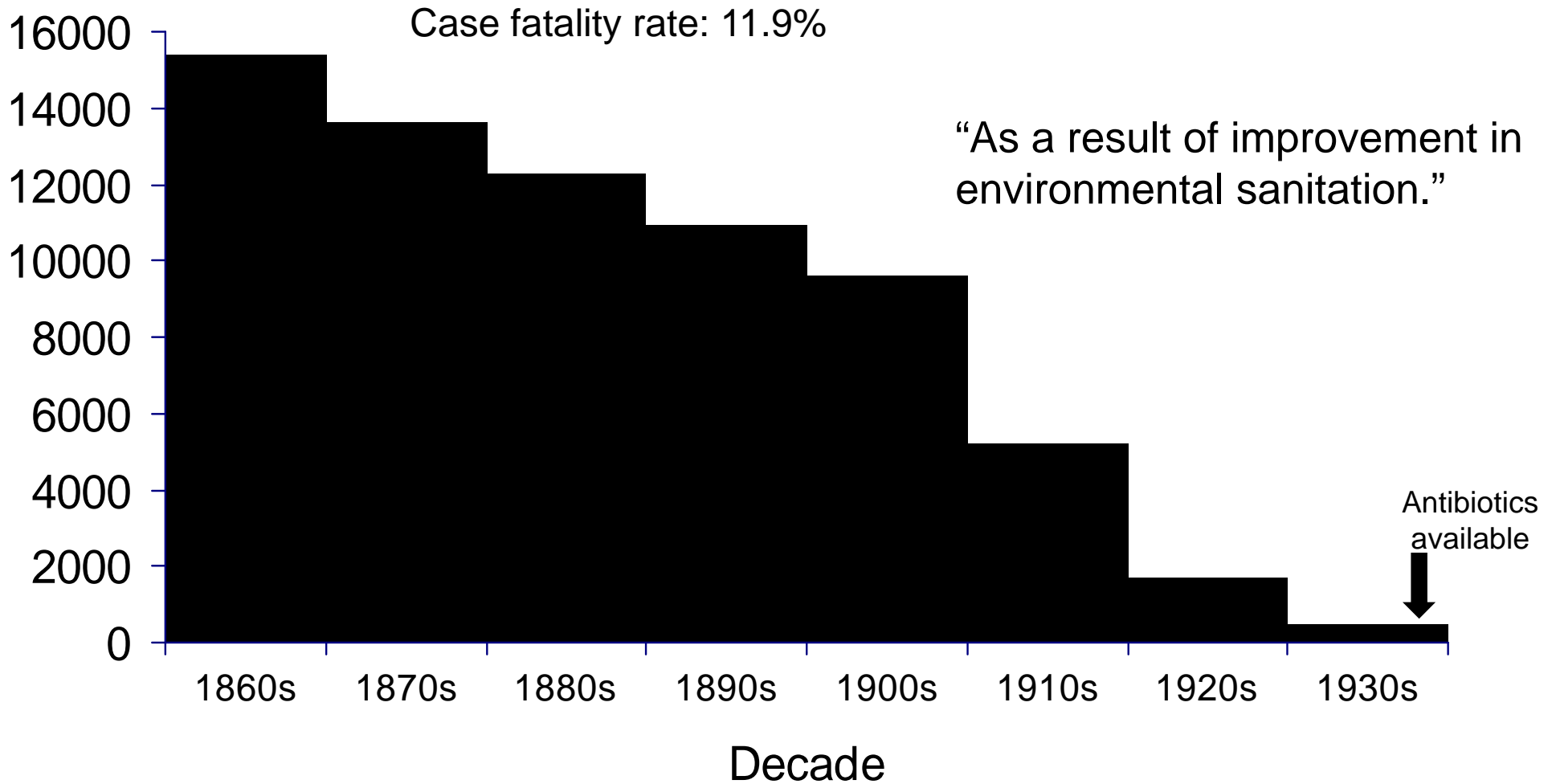
Mean 78%  
reduction



# Typhoid Fever Deaths

New York State exclusive of New York City

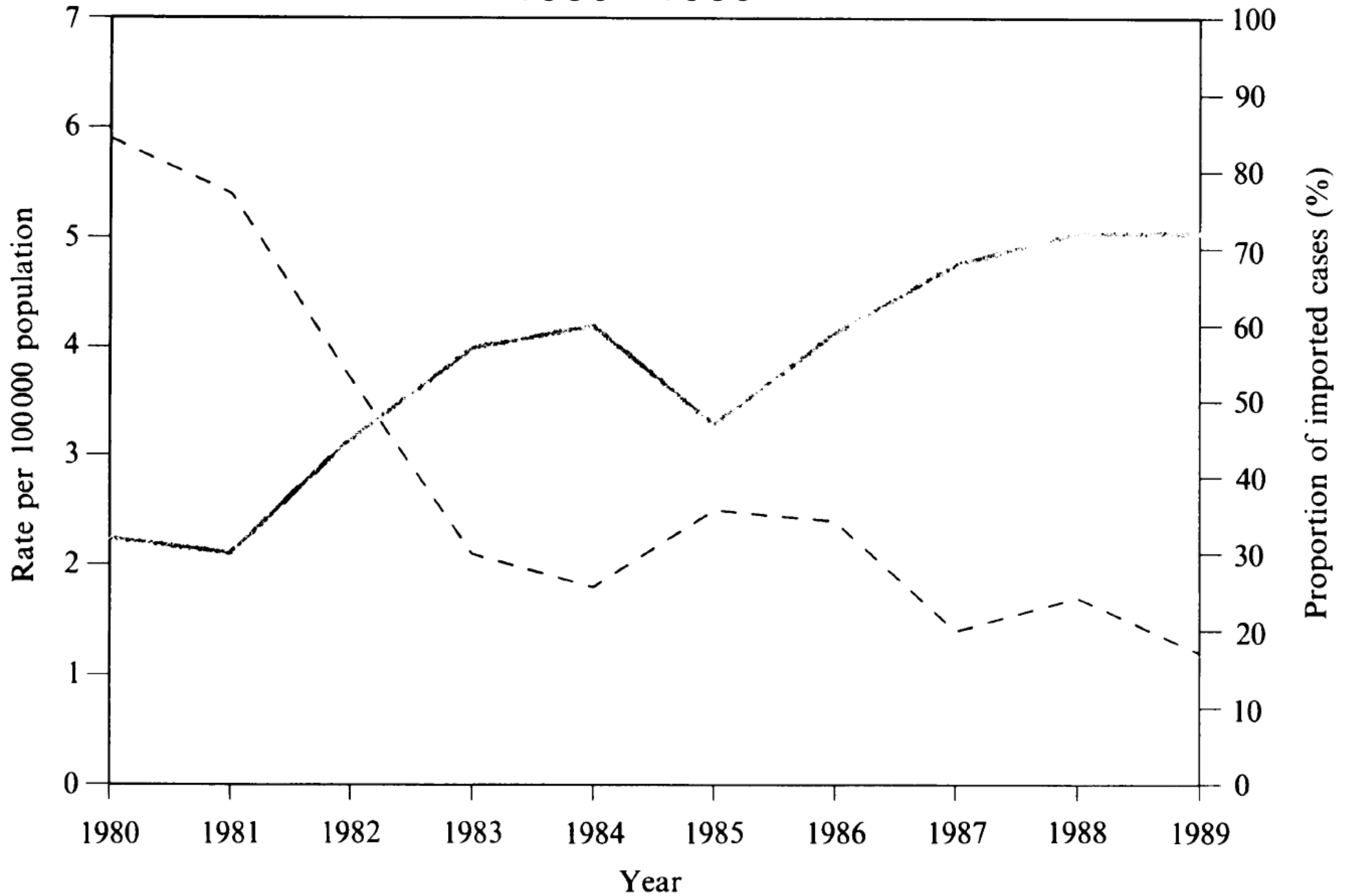
Deaths



# Singapore

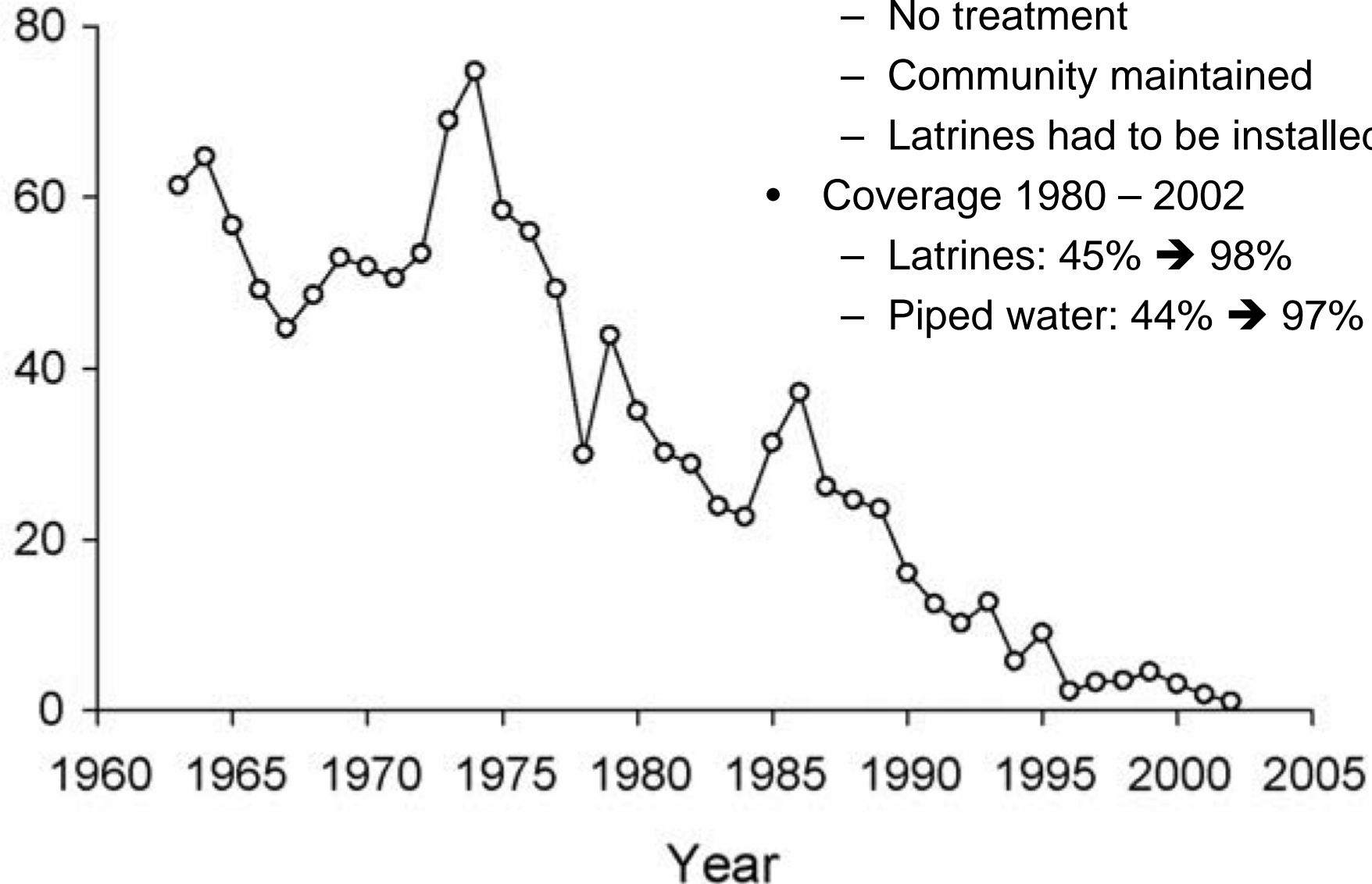
## typhoid incidence

### 1980 - 1989



# Sarawak State, Borneo, Malaysia

Typhoid  
Incidence rate  
(per 100 000 pop)



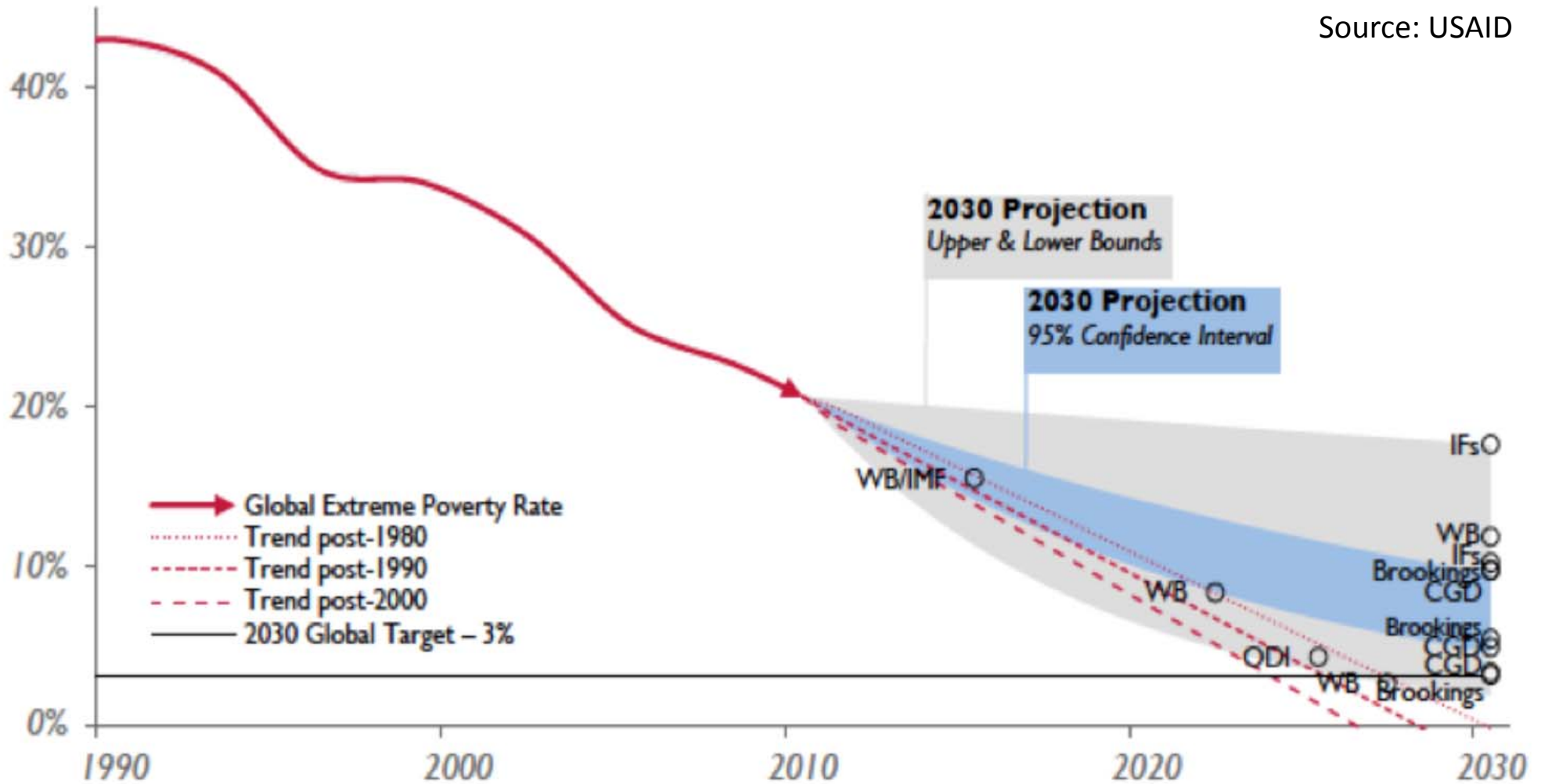
## Rural Health Improvement Scheme

- Simple piped water systems to villages
  - Wells or rainwater
  - No treatment
  - Community maintained
  - Latrines had to be installed first
- Coverage 1980 – 2002
  - Latrines: 45% → 98%
  - Piped water: 44% → 97%



# Reduction in Global Extreme Poverty <\$1.50 per person per day

Source: USAID



Maybe the world will continue to develop  
and typhoid will steadily disappear

Or maybe not

# A few historical shocks

- World War I
- World War II
- Global economic depression, 1929 - 1939
- 1816 : The year without summer
  - Mount Tambora (Indonesia) volcanic eruption
  - Global crop destruction

Is a projection of zero global shocks a prudent assumption?

Because typhoid has a carrier state, shocks that interrupt systems allow re-introduction

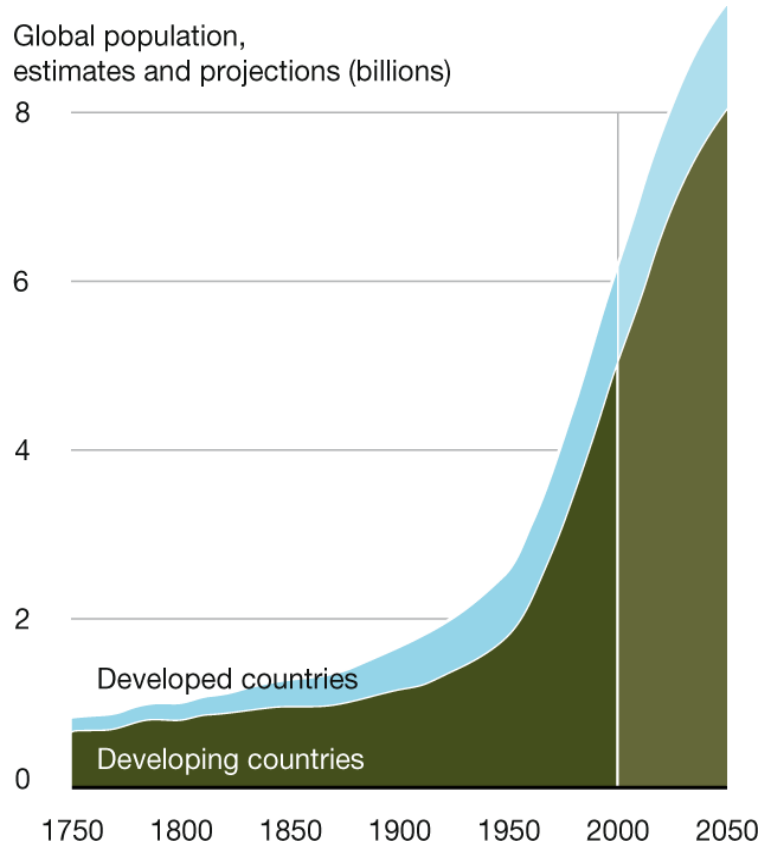


# Climate shocks



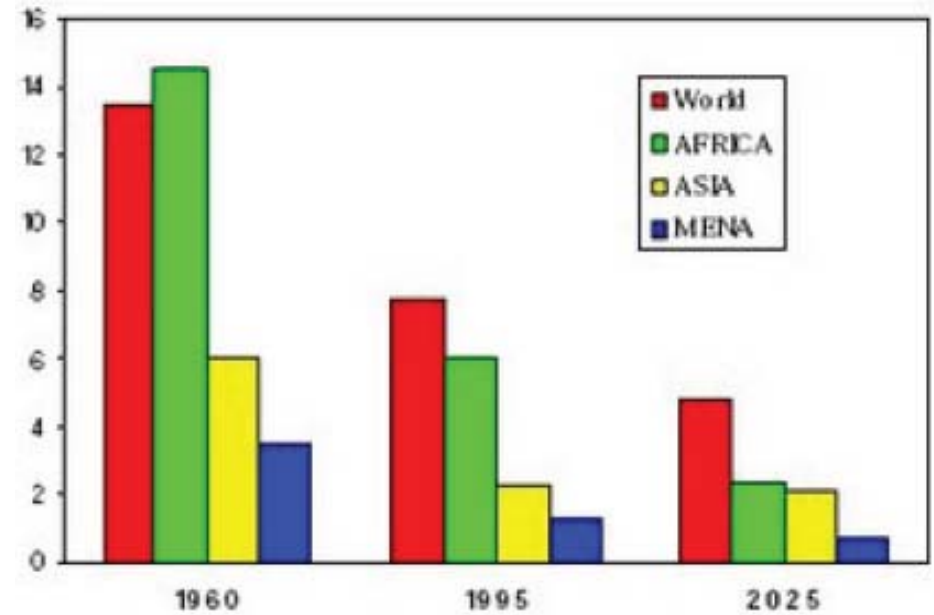


# Population Growth



Renewable water resources 1000 m<sup>3</sup> per capita

# Per capita water availability



World Bank

<http://www.plastemart.com>

UN Population Division, 2007.

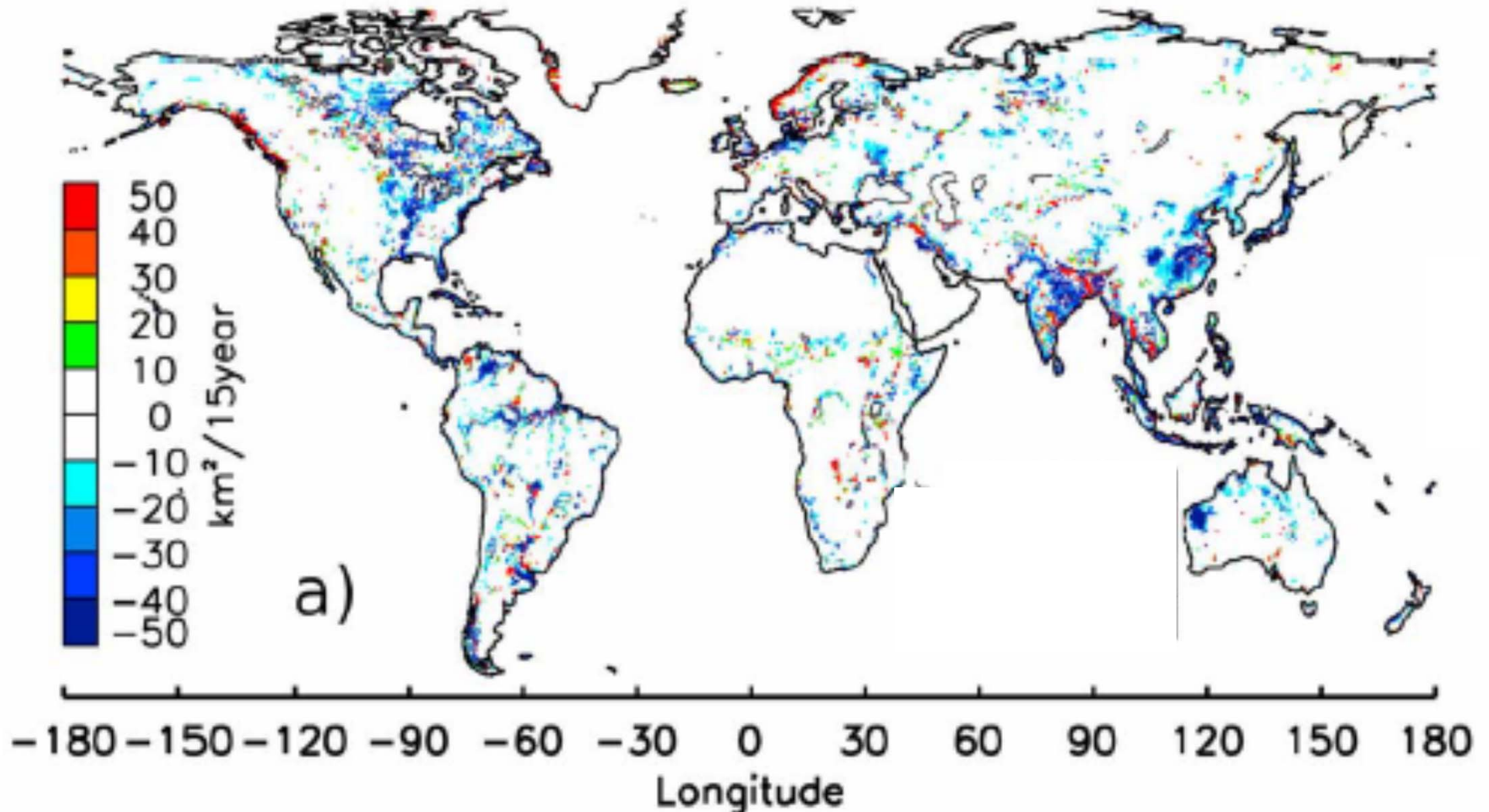
<http://www.grida.no/publications/rr/food-crisis/>



# Global land surface freshwater

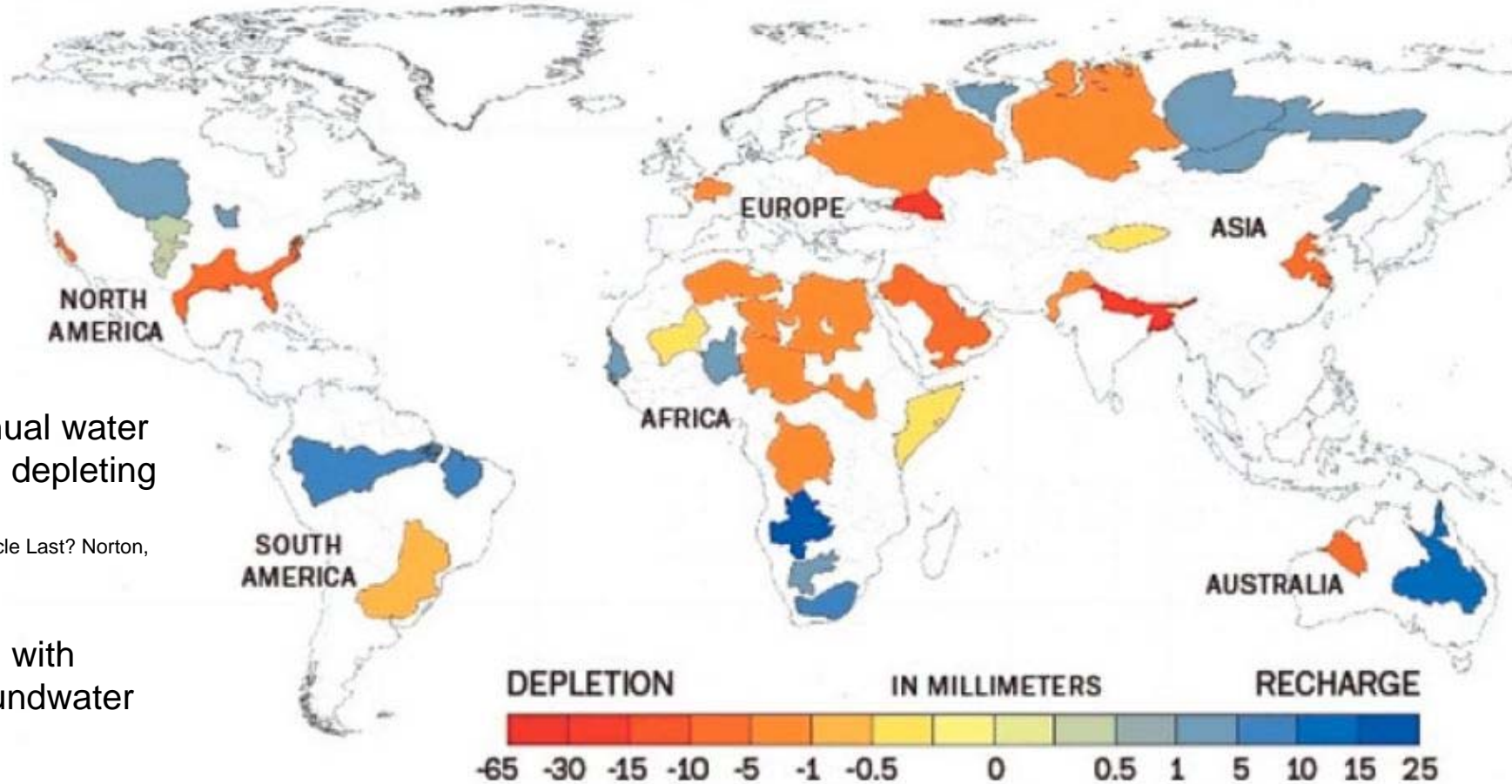
decreased 6% from 1993 – 2007

largest declines in areas of largest population growth



# Satellite system flags stressed aquifers

More than half of Earth's 37 largest aquifers are being depleted, according to gravitational data from the GRACE satellite system.



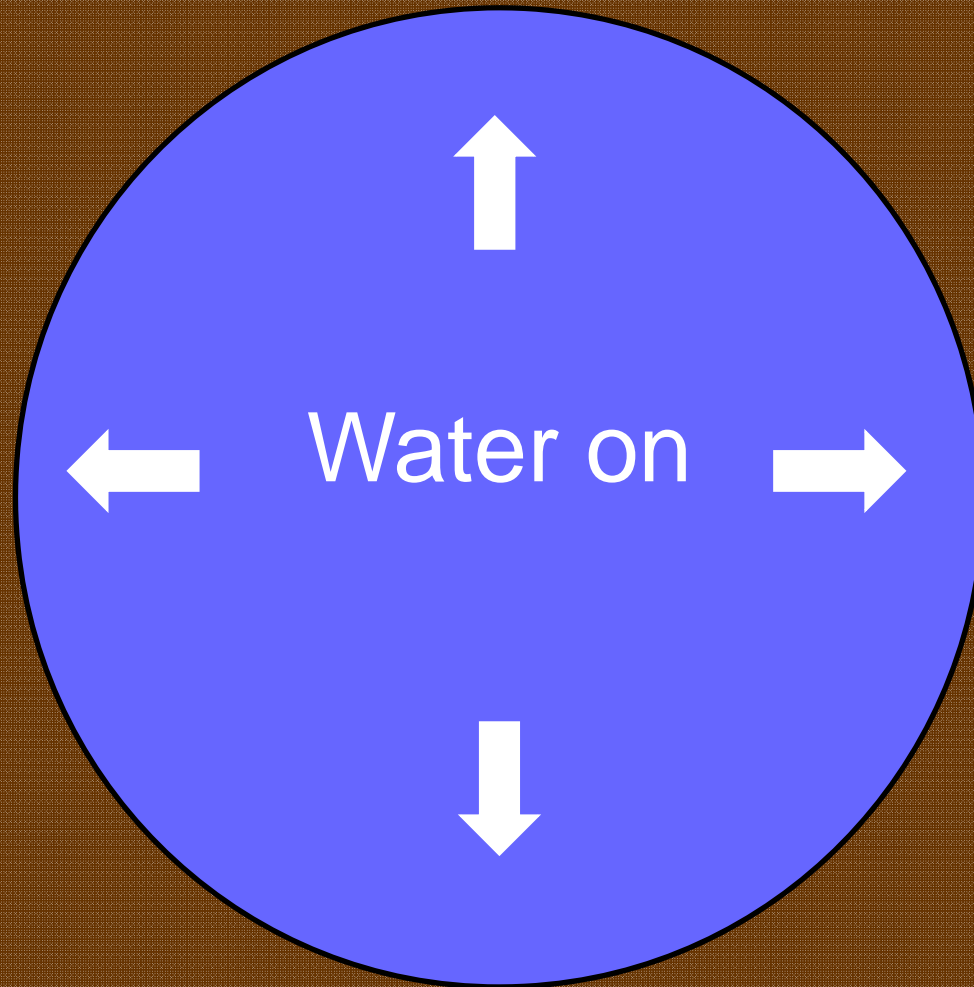
10% of global annual water consumption from depleting groundwater

(Postel, Can the Irrigation Miracle Last? Norton, 1999)

Large populations with rapidly falling groundwater

- China
- India
- Pakistan
- Iran
- Saudi Arabia

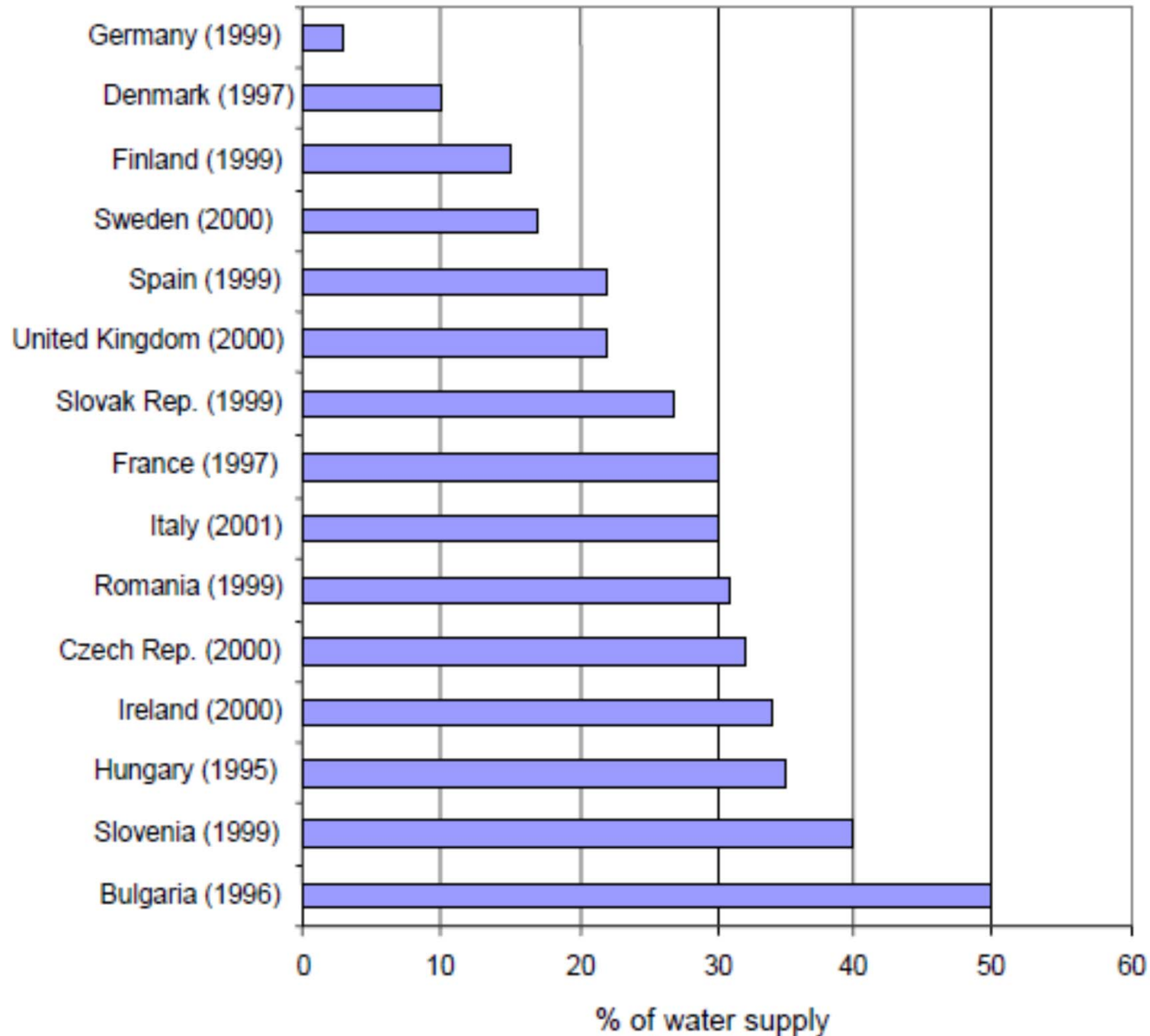
Water Resources Research

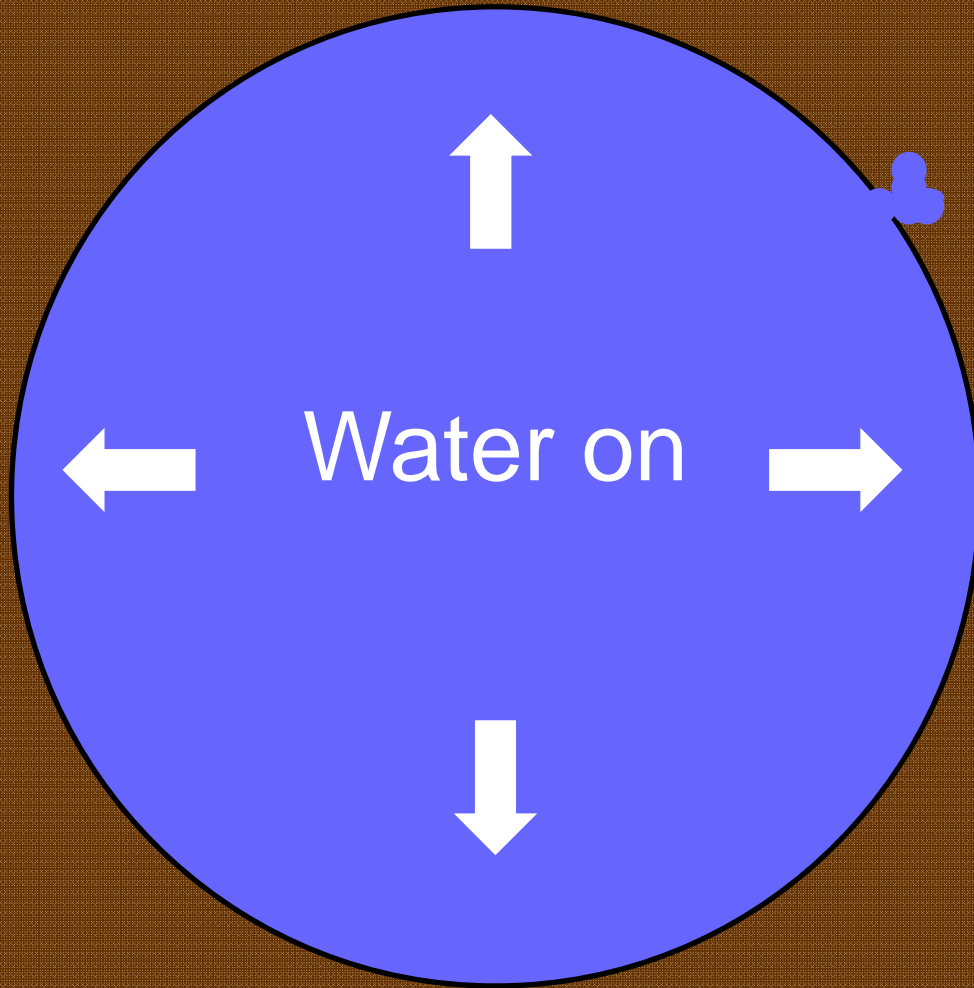


Will there be any breaks in  
the pipe?



# Estimated losses from urban water networks



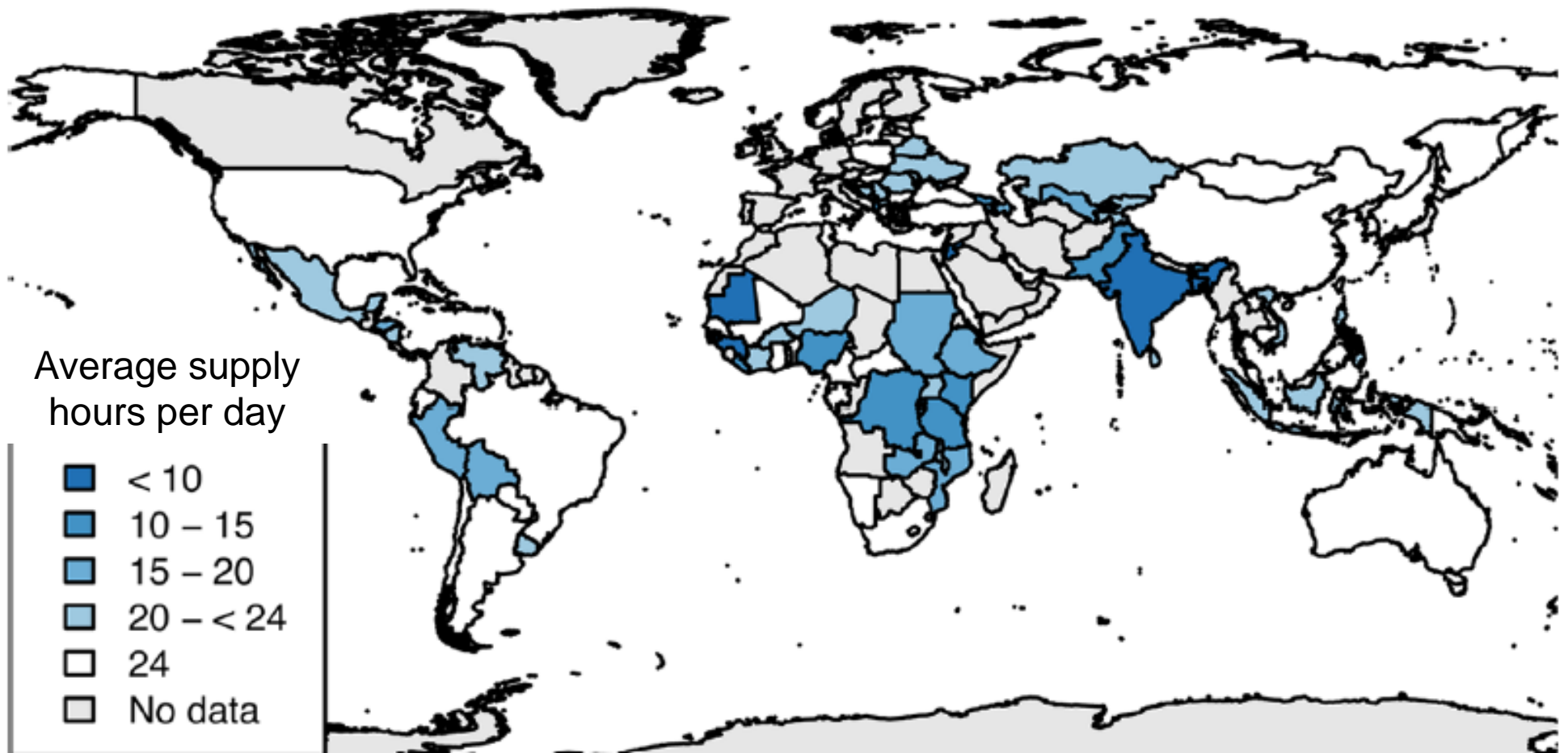






Water off

Intermittent water supply =  
contaminated drinking water



If we have known how to provide safe water in cities for >100 years, why does this problem persist?



<http://www.waterrhapsody.co.za/2010/06/02/water-shortage-looms-for-china-india/>



# Engineering Barriers

London in the 19<sup>th</sup> century  
US cities in the early 20<sup>th</sup> century

≠

21<sup>st</sup> century low income  
country cities

Need new  
approaches

Need new  
framing

19th century approaches are not fit for purpose  
for 21<sup>st</sup> low income city conditions

# Limitations to a vaccine only strategy

- 1) Not everyone will be vaccinated
- 2) Protection will not be 100%
- 3) Cost effectiveness of immunization will erode over time reducing local political support for these investments
- 4) Governments see this as a narrow strategy
- 5) Shocks are likely
- 6) Carriers will re-seed



Eliminating typhoid will likely be difficult

What is the optimal strategy when facing hard problem?

# An organization wants to hire people to solve a hard problem

- Administers an aptitude test to 1,000 applicants
- Assume all score between 60 – 90%, so all are individually capable
- Should the organization hire:
  - a) the person with the highest score?
  - b) 20 people with the next 20 highest scores?
  - c) 20 people randomly selected?

# Modeling problem solving

- Definitions
  - Perspectives : people's internal representation of problems
  - Heuristics: algorithms they use to reach solutions
- Modeled perspective-heuristic pairs in a computational simulation
  - a collection of diverse agents was highly effective in locating good and often optimal solutions
  - a random collection of agents drawn from a large set of limited-ability agents typically outperforms a collection of the very best agents from that same set

# Hong and Page conclude

- “The best-performing agents necessarily become similar in the space of problem solvers. Their relatively greater ability is more than offset by their lack of problem-solving diversity.”
- “In a problem-solving context, a person’s value depends on her ability to improve the collective decision”
  - Ability may be less important than how differently a person thinks
  - Do we need to double the number of vaccine specialists working on typhoid or should we broaden the team?

# The superiority of diverse teams in creative problem solving is widely supported in the academic literature

- Bantel, K.A. & Jackson, S.E. (1989). Top management and innovations in banking: does the composition of the top team make a difference? *Strategic Management Journal*, **10** (Special Issue), 107-124
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- Ghiselli, F.E. & Ledford, T.M. (1958). Patterns of managerial traits and group effectiveness. *Journal of Applied Psychology*, **43**, 101-107.
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- Pelz, S.M. & Hirschfeld, D. (1988). Creativity and group heterogeneity: a meta-analysis. *Administrative Science Quarterly*, **33**, 310-325.
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- Triandis, H.C., Hall, E.R. & Ewen, R.B. (1965). Member heterogeneity and dyadic creativity. *Human Relations*, **18**, 33-55.
- Willems, E.P. & Clark, R.D. III (1971). Shift toward risk and heterogeneity of groups. *Journal of Experimental and Social Psychology*, **7**, 302-312.
- Wood, W. (1987). Meta-analytic review of sex differences in group performance. *Psychological Bulletin*, **102**, 53-71.

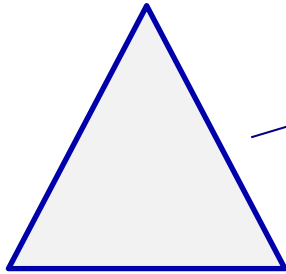
Why are the engineers who are conducting cutting edge work on water and sanitation systems in low income countries not a central part of our meeting discussing typhoid elimination?



# Research on new approaches to reduce exposure

## Consider alternatives between the central and household level

Municipal 24/7 supply



Community-level

Passive point of  
collection  
disinfection



Household treatment



# Point-of-collection (POC) disinfection



- Compatible with intermittent systems
- Ideal POC technology:
  - No user effort
  - Low-cost
  - No electricity
  - Handle varying flow rates
- Does not require strong municipal level governance

# Passive Chlorination; Novel Technology

shared water points  
minimizes behavior change

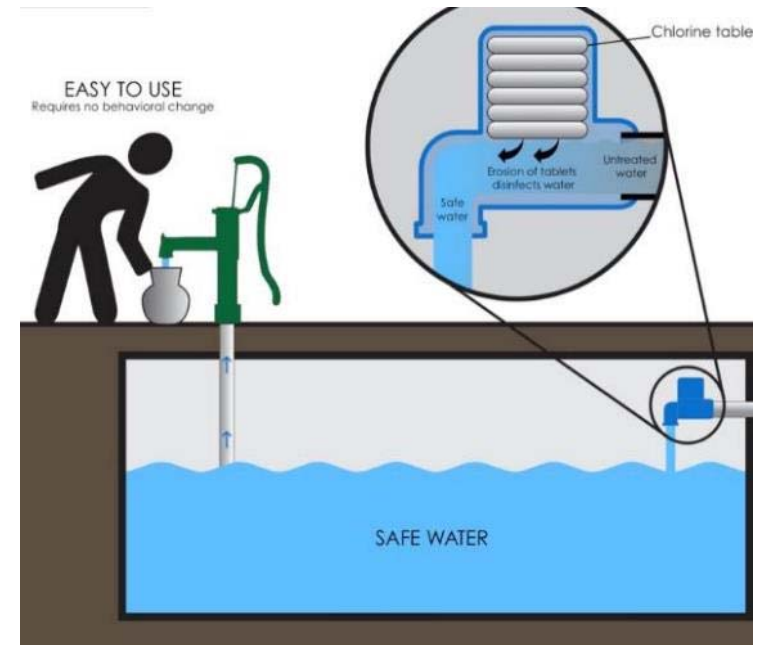


Lotus Water

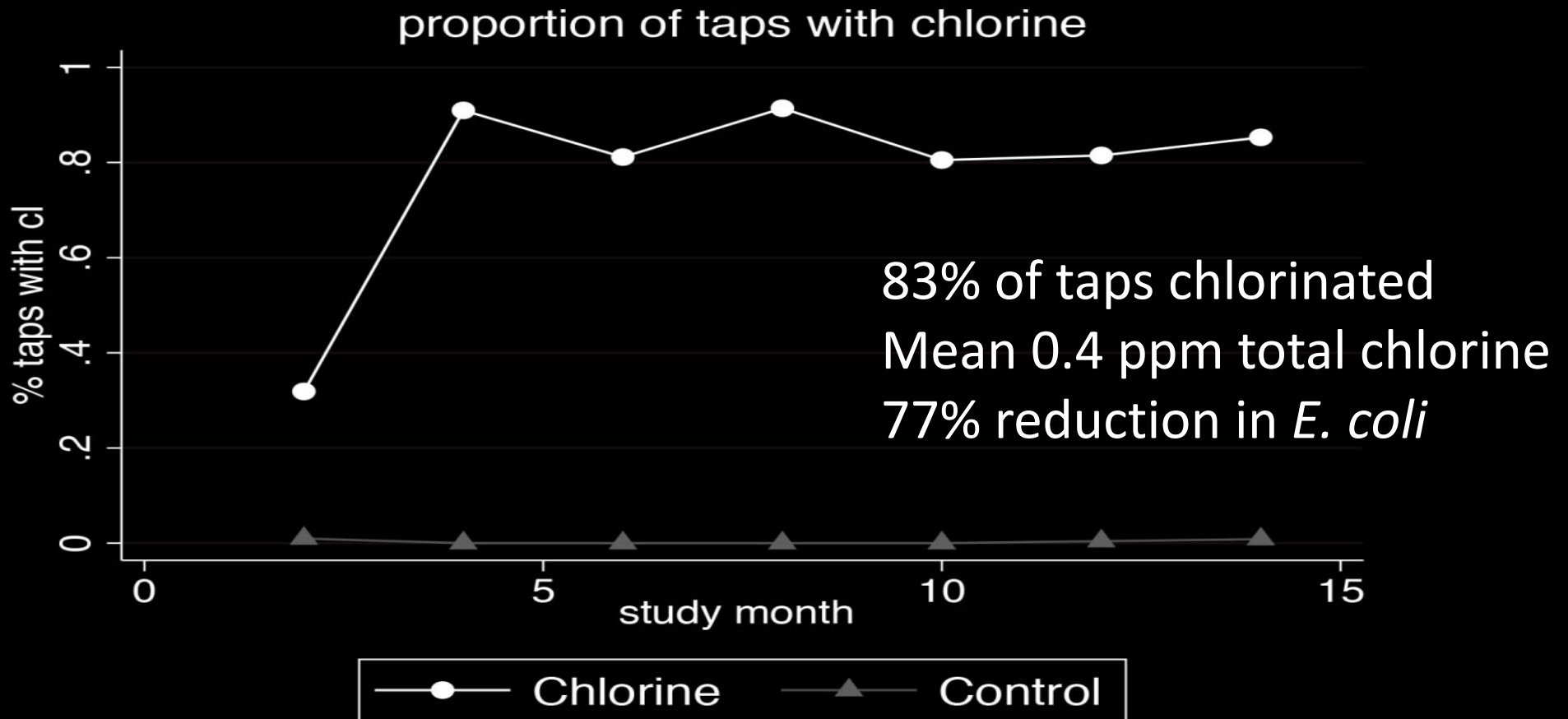


zimba

**Aquatabs Flo**  
Water Purification Unit



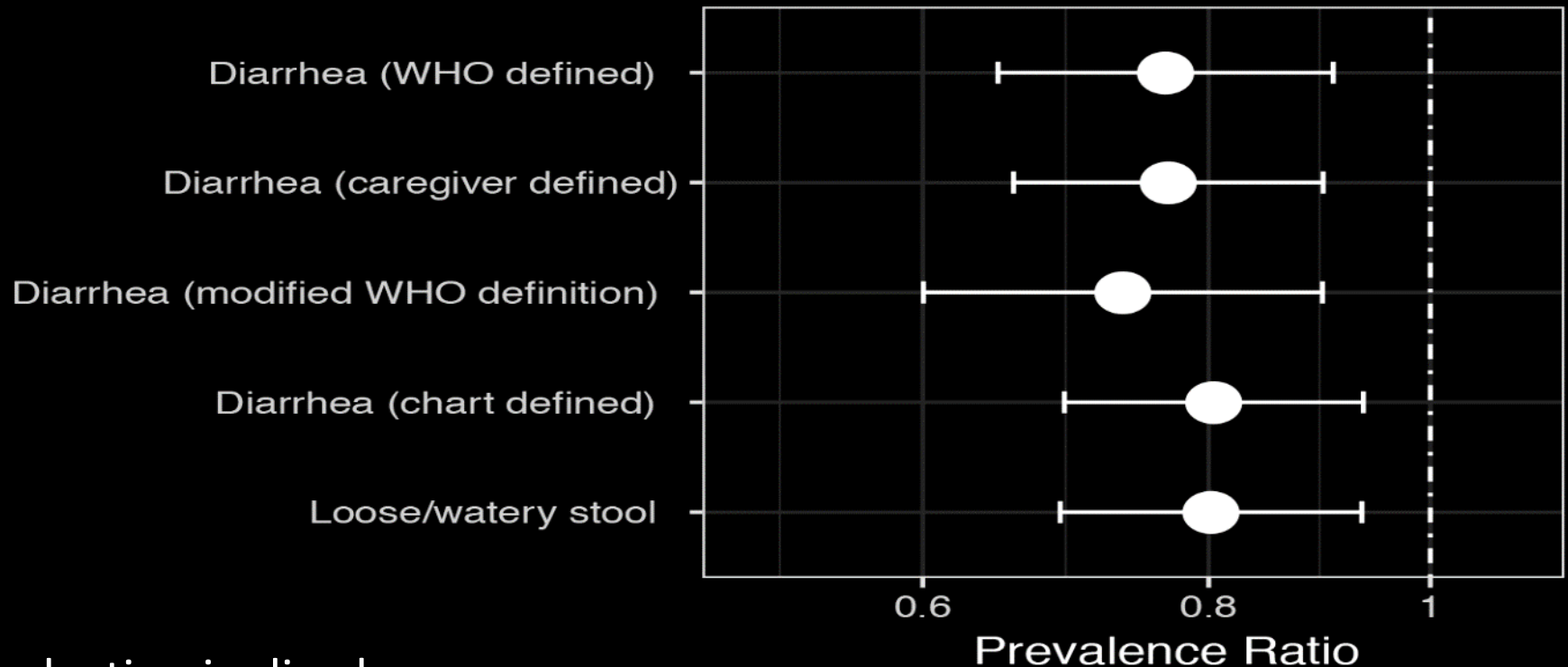
# Chlorine Dosing Performance



Slide: Amy Pickering



# Effect on Child Health



23% reduction in diarrhea

11% reduction in health care costs

30% less likely to seek treatment for gastrointestinal illness

Reduced antibiotic consumption in past 2 months

Slide: Amy Pickering

# Steve's Typhoid Elimination Forecast



[solopracticeuniversity.com](http://solopracticeuniversity.com)

- If we assume neither unanticipated breakthroughs nor chaotic shock
  - Count in decades, not years
  - Track record suggests >3 decades
- If low case fatality holds up, time to elimination will lengthen
- If XDR typhi results in mortality among elites, we could see dramatic action

# Call to action

Take an engineer to lunch

