A Timeline for Typhoid Elimination

Leland Stanford, Jr.
(1868 – 1884)

Steve Luby, MD
11th International Conference on Typhoid and Other Invasive Salmonelloses
Hanoi
28 March 2019
“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

2020 goals

- At least 2 effective TCVs achieve WHO PQ by 2020
- Generate vaccine performance data to support WHO SAGE recommendations, Gavi funding decision, and country adoption
- Proof-of-concept demonstrated for next generation of broadly cross-protective salmonella vaccines
- Define and validate a toolkit of cost-effective interventions to reach our impact goal
- Build the case for adoption of a global typhoid control goal
- Assess the feasibility of typhoid elimination

Pathway to impact

By 2020, as the result of our work, the world will be well-poised to scale up an appropriate toolkit on a pathway to sustained reduction by 2035

- Multi-sectoral toolkit capable of meeting 2035 goal defined
- Maximize effective coverage of interventions

Beyond 2020 timeframe

Sustained reduced incidence

Slide: Anita Zaidi
The planning fallacy

Planning based on best case scenario

Ignores experience of similar projects
– “This won’t happen to us.”

Kahneman, D. *Thinking, Fast and Slow*, 2011
Planning Fallacy Examples

• 1997 New Scottish parliament building in Edinburgh could be constructed for <£40 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

• Scottish parliament building completed in 2004 for £431 million.

• 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

Kahneman, D. Thinking, Fast and Slow, 2011
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

Data from Sedgwick WT, MacNutt JS, J Inf Dis. 1910;7(4):490-564.
Typhoid Fever Deaths
New York State exclusive of New York City

Case fatality rate: 11.9%

“As a result of improvement in environmental sanitation.”

Antibiotics available

Ames, WR. Amer J Pub Health 1943;33:221-230
Singapore typhoid incidence 1980 - 1989

Sarawak State, Borneo, Malaysia

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


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

Per capita water availability

Renewable water resources 1000 m$^3$ per capita

World Bank

http://www.plastemart.com
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
Will there be any breaks in the pipe?
Estimated losses from urban water networks

- Germany (1999)
- Denmark (1997)
- Finland (1999)
- Sweden (2000)
- Spain (1999)
- United Kingdom (2000)
- France (1997)
- Italy (2001)
- Romania (1999)
- Ireland (2000)
- Hungary (1995)
- Slovenia (1999)
- Bulgaria (1996)

% of water supply

EEA, Indicator Fact Sheet, WQ-6, Oct 2003
Water on
Water off

Intermittent water supply = contaminated drinking water
Average supply hours per day

- < 10
- 10 – 15
- 15 – 20
- 20 – < 24
- 24
- No data

Kumpel E. Environmental Sci Technol 2015
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 19th century ≭ US cities in the early 20th century ≭ 21st century low income country cities

- Need new approaches
- Need new framing

19th century approaches are not fit for purpose for 21st 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.


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
- Household treatment
- Passive point of collection disinfection
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

Slide: Amy Pickering
Passive Chlorination; Novel Technology

shared water points
minimizes behavior change

Lotus Water

Aquatabs Flo
Water Purification Unit

zimba

EASY TO USE
Requires no behavioral change

SAFE WATER
Chlorine Dosing Performance

83% of taps chlorinated
Mean 0.4 ppm total chlorine
77% reduction in E. coli

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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

• 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