This talk will demonstrate how understanding and addressing the social determinants of TB are critical in the struggle to eliminate TB and are the foundation of equitable healthcare delivery in communities.

Objectives:

1. Describe the history of the social determinants of health in TB program development.
2. Describe how a recognition of the importance of addressing social determinants of TB as part of a broader health equity agenda will lead to better health outcomes.
3. Describe how comprehensive TB care delivery can serve as a platform for care delivery for other diseases.
In 2021

ABOUT 1.6 MILLION PEOPLE DIED FROM TB
INCLUDING 190,000 PEOPLE WITH HIV

In 2021

ABOUT 0.5 MILLION PEOPLE FELL ILL WITH DRUG-RESISTANT TB
ONLY ONE IN THREE PEOPLE HAD ACCESS TO TREATMENT
OF THOSE TREATED, ONLY 60% WERE TREATED SUCCESSFULLY

~20% DR-TB patients cured

Decline of TB incidence is slow: We will not meet global goals

Drug-sensitive TB declined 1.3% per annum from 2006-2016 (age standardized)

MDR-TB declined 2.1% per annum from 2006-2016 (age standardized)

XDR-TB increased 7.9% per annum from 2006-2016 (age standardized)
Why are we in this situation?

Concern over cost led to an over-simplified global approach: the DOTS strategy

1. Political commitment
2. Diagnosis with sputum-smear microscopy
3. Standardized short-course chemotherapy
4. Regular supply of high-quality drugs
5. Standardized recording and reporting

Basic principles of epidemic control for TB

- Search actively for newly infected people among the contacts of current patients using a sensitive test (x-ray)
- Start therapy quickly for people with disease; give the safest, most effective multi-drug therapy in the shortest time
- Ensure adherence to therapy with supports
- Treat all contacts that do not yet have disease with post-exposure prophylaxis
- Ensure proper infection control

MISSING KEY COMPONENTS FOR CONTROL AND ELIMINATION

ill-suited for children
ill-suited for people with HIV
ill-suited for drug-resistance
Does not address poverty
Increasingly there is a consensus that TB rates will only be driven down through a comprehensive program that recognizes the biological and social dimensions of TB.
The situation of workers during the industrial revolution in England resulted in the push for the creation of a sanitary commission (1837), raising concern over the sanitary conditions of the laboring population (1842).

This was not, in the words of Rene Dubos, “built on scientific doctrine.” Rather, it arose from the understanding that “illness was, in large measure, the penalty of bad living and social injustice.”

• In *The Conditions of the Working-Class in England in 1844*, Friedrich Engels, the son of a Prussian textile mill owner who had been sent to Manchester England to supervise his father’s factory, outlined the following reasons for disease:
  – Poverty
  – Air pollution (which he believed caused “inflammation”)
  – Lack of sewerage
  – Lack of quality food with low nutrition (“food desert”)
  – Overcrowded living conditions
  – Lack of access to physicians
  – Child labor
  – “atomization” of society where people don’t help each other

• Later, similar ideas were raised by the great physician and father of the field of Social Medicine, Rudolph Virchow, on his *Report on the Typhus Epidemic in Upper Silesia*

• During this 19th century, the period of the Industrial revolution, rates of TB grew to very high levels – 200 to 500 per 100,000 people

• The disease was said to account for the death of 25% of the inhabitants of Europe, and a similar number of lives in Massachusetts and New York.

• While there was some understanding that it could be passed from person to person and within families – that there was some biological basis to the disease, from the earliest period it was clear that TB, like many other diseases had a strong social dimension: it was the interaction between the biological and the social that led to disease.

Sources:
Food/Nutrition

- Thomas McKeown suggested that the drop in rates of TB between the mid nineteenth and mid-20th century was due to improved living conditions, housing, food.

- Papworth Village Settlement in England: social experiment 1918-1943; after being released from sanitorium people with TB disease were given employment, food, and medical care. They saw a dramatic decrease in TB incidence among children under five who were born in the settlement: zero cases in the intervention arm versus 1,217 cases (per 100,000 person years)

- During the WWII, rates of TB went up when there were food shortages

- Study of Russian and British POWs in Germany: British POWs received extra calories from the Red Cross (which included animal protein). Russian POWs had a 13-fold increased incidence of TB compared to British POWs

Undernourished individuals are also more likely to have greater severity of TB. In India patients who were severely undernourished had 11% more of their lungs affected on chest X-ray (95% CI: 4.0–13.3) and more lung cavitation (a rate of 4.6 times more; 95% CI, 1.5–14.1) compared to those with a normal BMI. (Hoyt et al, PLoS One, 14(3), 2019)

- A study in Latvia of 995 MDR-TB patients found that those who were underweight were significantly more likely to be both smear and culture positive compared to patients with a normal body weight (OR 2.2 for both). (Podewils et al. Epidemiol Inf, 139(1), 2010)

- Patients who are underweight at time of diagnosis (defined as being 10% or more below ideal body weight) had a 19.1% chance of relapse, compared to only a 4.8% likelihood of relapse among those who were not underweight when diagnosed with TB (p < 0.001). (Khan et al. Am J Respir Crit Care, 174(3), 2006)

- A South African study found that for every kg decrease in weight at the start of treatment, odds of survival decreased by 7.5% (P < 0.01) among those with extensively drug-resistant TB. (Kvasnovsky, Cegielski, Erasmus et al. J Acquired Immune Defic Syndromes, 57(2), 2011)
Housing

- Chalmers (1913) showed that in every age-group the rate of TB mortality in Glasgow was lower in bigger houses compared to smaller houses; Similarly, Peters (1933) showed that mortality was 340% greater in a one-apartment house than a four-apartment dwelling (not directly even linked to overcrowding vs volume). (Stein, L. Tubercle 35(8), 1954)

- Chapman and Dyerly found an association between the risk of tuberculin conversion in children living in the house of an infectious tuberculosis case and the number of cubic feet per person in the house (Stein L. Br J Soc Med, Vol 6, 1952)


- In the Bronx, New York, children less than age 5 years living in severely crowded areas were about five times more likely to develop tuberculosis (adjusted for HIV status) than children living in areas with limited or no crowding (Drucker E. et al. Lancet, Vol 343, 1994)

Race

- In a study of the employees of the New York City board of education, race was the strongest risk factor for tuberculosis infection in each age group, after control for SES (Reichman LB, O’Day R. Am Rev Respir Dis, Vol 117, 1978)

![TB Cases by Race/Ethnicity, United States, 2011–2020](https://www.loc.gov/resource/ds.06489/)
Poverty

• Retrospective study in Liverpool, England, that examined the notifications of all forms of tuberculosis by council ward over a six year period and correlating this with four indices of poverty found that the rate of tuberculosis was correlated with all measures of poverty. This link was independent of race or ethnicity. (Spence et al, BMJ, 1993)

Air quality

• Data on tuberculosis incidence, climate (i.e., precipitation, atmospheric pressure, relative humidity, temperature, and wind speed), and air quality (inhalable particulate matter, sulfur dioxide, and nitrogen dioxide concentrations) in Beijing from 2004 to 2016 were collected and systematically analyzed based on a structural equation model. The tuberculosis incidence was negatively correlated with the concentration of inhalable particulate matter, sulfur dioxide, or nitrogen dioxide.

• Meta analysis showed: Long-term exposure to PM$_{10}$, SO$_2$ or NO$_2$ is associated with increased odds of tuberculosis. (Zhang and Zhang, Annals of Epi, Volume 37, 2019)
TUBERCULOSIS PROGRAMS HAVE SHAPED THE PARADIGM FOR COMMUNITY-BASED CARE-DELIVERY

Photo: Partners In Health/Russia

SEARCH for people with TB disease and infection in the community

Photo: University of Washington Library
Active case finding using a sensitive diagnostic
Active case finding using a sensitive diagnostic (x-ray) was a critical tool for finding active cases and stopping transmission of TB

- Was used in Edinburgh, Scotland, in the early 20th century.
- It was used in the US and Europe extensively in the 1930s, 1940s, and 1950s to drive down rates of TB. Large numbers of close contacts and other contacts of TB patients were screen and many cases were found
- This not only contributed to finding new cases, but to decreased mortality (early case detection)

Source: Golub et al. 2005

TREAT TB disease correctly

USE THE CORRECT MEDICINES WITH LEAST SIDE EFFECTS OVER THE SHORTEST PERIOD OF TIME DELIVERED IN THE COMMUNITY
1943 — Streptomycin isolated in laboratory by Selman Waxman and Albert Schatz, the graduate student working with him

1944 — Given to the first human TB patient in November 1944

1948 — BMRC trials ➔ drug resistance to streptomycin observed

1955 — BMRC drug resistance survey in UK ➔ resistant strains transmitted

Multidrug regimens were needed

Rapid diagnosis of TB, determination of resistance, and correct treatment regimens are critical to prevent transmission

When patients were started on an effective treatment regimen, they were less infectious even after as little as 24 hours of treatment

Relative infectivity of patients*:

– Susceptible TB
  • 61 Untreated (29 GPs) 100%
  • 29 Treated (1 GP) 2%

*all smear positive patients (people coughing up bacteria)

(reprinted as “classic” Am J Epidemiol 1995; 142:3-14)

Early treatment with the correct regimen will stop transmission
Treatment at home is safe and led to good outcomes

When patients were started on an effective treatment regimen at home they had better outcomes

- 5 year study in Chennai (Madras) India showed that relapse rates of people treated at home was 7% versus 10% in the sanatorium.
- Also showed that the incidence of active tuberculosis and of tuberculous infections was no greater in the contacts of patients treated at home than in the contacts of patients treated in sanatorium, either in the first year or over the subsequent four years. The major risk to the contacts resulted from exposure to the patient before diagnosis.

Source:

Treatment at home/in the community is safe and effective

PREVENT
TB infection from becoming active disease

TREATING TB INFECTION IS AN ESSENTIAL PART OF STOPPING TRANSMISSION AND DISEASE
Preventive therapy and the decline in TB transmission in Alaska

Between 1950 and 1960, the US Public Health Service built health facilities, started active case finding, treatment of all forms of disease, and treatment of TB infection.


Today, it is estimated that ~20-30 million close contacts should receive treatment each year.

~8 to 10% of contacts will get TB during the first two years after exposure to an individual with active disease.

Eliminating TB: Alaska, USA

From 1953-56:
- Prevalence 2,000/100,000
- Mortality 282/100,000
- 1 in 4 infants infected in 1st year of life

Photo: http://bethel.akleg.gov/
Data: Kaplan, Fraser, and Comstock. 1972
Tackling TB in New York City (1988)

Community-based active case finding, treatment of all forms of TB, and treatment of TB infection (TB preventive treatment)

Basic principles of community-based TB epidemic control

1. Search actively for people with new infection or disease among the close contacts of current patients or in high-burden community settings (using a sensitive test like x-ray)

2. Start the correct therapy quickly for people with disease; give the safest, most effective multi-drug therapy in the shortest time; deliver care to people in the communities where they live and work

3. Ensure adherence to therapy with supports and food assistance

4. Screen and treat all infected contacts that do not yet have disease with post-exposure treatment

5. Ensure proper infection control
PATIENT-CENTERED COMMUNITY-BASED CARE DELIVERY IN WESTERN SIBERIA:
LINKING PRACTICE TO EQUITY

Tomsk Oblast
Population: 1,073,600
Area = 317,000 km²
TB Incidence per 100,000 – Civilian Sector

MDR-TB prevalence among all smear-positive new and re-treatment cases 2001, Tomsk Oblast (n=1303)
TB mortality in the Tomsk Penitentiary System (1999 – 2006; per 100,000 population)

MDR-TB Patient Treatment Outcomes
N=110

Source: Tomsk Oblast TB Services
Challenges faced by patients

• Poverty, poor living conditions, poor nutrition
• Alcohol and drug-use disorders
• Long distances between medical center and patients’ homes in both urban and rural places (lack of transport)
• Other priorities: children, job, family problems etc.
Programmatic Challenges

• 18-24 month-long course of treatment
• Twice-daily drug intake of 4-7 medications
• Side effects common: almost all patients experience side effects, and about 10% of patients experience severe side effects
• Some patients have severe comorbidities (e.g. diabetes and alcoholism), which worsen the tolerance of the medications
PROGRAMMATIC SOLUTIONS

- Improvement of facilities AND choice of treatment site
- Food assistance for patients
PROGRAMMATIC SOLUTIONS

- Improvement of facilities AND choice of treatment site
- Food assistance for patients
- Transportation assistance for patients and health workers
- Food assistance for patients
- Improved adverse events management (provision of ancillary medications)
- Improvement of working hours at medical facilities to make it more convenient for patients
- Engagement of volunteers, enablers and incentives to support treatment
- Rapid search patients unable to take their medicines
TREATMENT OUTCOMES OF FIRST COHORT (N=244)
TOMSK, RUSSIA

- Cure: 77.0%
- Failure: 6.6%
- Default: 11.5%
- Death: 4.9%

Source: Shin et al., IJTL 2006

Treatment Outcomes, Civilian Sector
Tomsk Oblast, Russian Federation

Source: Tomsk Oblast TB Services, Analysis by Dr. D Taran, PIH Moscow
TREATMENT DELIVERY

THE WAR ON TUBERCULOSIS: DOTS IN NEWARK, NJ, USA

Am J Nursing, July 2010

When patients are the center of all of our efforts—when our attentions and resources revolve, like satellites, around them—we succeed, even though our treatments are imperfect.

— Dr. Paul Farmer, PIH Reports 2014
Accompaniment: “Sputnik” program

• Some patients require assistance to finish treatment

• Need a system of accompaniment to help overcome barriers to treatment (this is different from DOT)
  — Social supports
  — Nutritional supports
  — Family support

• One Sputnik will look after five to seven patients

• Changes the onus of responsibility for adherence from the patient (“non-compliant”) to the program (programmatic gap)

53 non-adherent patients were enrolled on Sputnik program from December 17, 2006 to November 30, 2008

2 patients refused to participate

51 patients stayed on Sputnik program

5 patients restarted new treatment course with 83% adherence
  [baseline adherence 0%]

46 patients continued previous treatment. Adherence increased from 52% before enrolment on the program to 81% while on Sputnik, p<0.0001
Note: No deaths were due to TB; most were due to violent crimes
"Default" includes the 2 patients who refused to participate in the program

Source: Gelmanova et al., IJTLD 2011
In Tomsk, Russia, a comprehensive strategy was used to rapidly reduce TB incidence.

Can the TB care delivery platform be a model for equitable care delivery for other diseases?
Community-based care delivery for TB and DR-TB

Community-based health delivery platform
- Links the clinic with patients in the communities where they live
- Essential to finding cases early or even before infected people progress to disease

BUILDING A PLATFORM FOR COMMUNITY-BASED CARE DELIVERY

Community-based care delivery for TB

Community-based care delivery for diseases

HIV
Hepatitis C
Diabetes
Heart Disease
Hypertension
Mental health disorders
Autism
Cancer
Post-operative care
We have an opportunity to shift the global TB care delivery paradigm in a way that will simultaneously strengthen health systems

<table>
<thead>
<tr>
<th>Tuberculosis</th>
<th>Health systems strengthening/Biosecurity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SEARCH</strong></td>
<td>Find people sick with TB or exposed to TB using effective tests (e.g. mobile x-ray; genetic tests).</td>
</tr>
<tr>
<td><strong>TREAT</strong></td>
<td>Rapid deployment of the correct medicine and support the sick. This requires testing of strains, access to medicines, and a system for community-based care delivery and adverse events monitoring.</td>
</tr>
<tr>
<td><strong>PREVENT</strong></td>
<td>Prevent people from being exposed to TB and treating people who have been exposed so that they do not become sick with TB. Providing supports that prevent disease and support treatment.</td>
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**EXAMPLE:**

**CAN THE TB PLATFORM BE USED TO DELIVER CARE FOR DIABETES?**
Rising rates of diabetes are a concern for health systems

Number of adults (20–79 years) with diabetes worldwide

**WORLD**
- 2020: 700 million
- 2030: 578 million
- 2050: 463 million

**Europe**
- 2020: 68 million
- 2030: 66 million
- 2050: 59 million

- 1 in 6 live births are affected by hyperglycaemia in pregnancy
- The Region has the highest number of children and adolescents (0–19 years) with type 1 diabetes – 26,000 in total

**North America & Caribbean**
- 2020: 63 million
- 2030: 56 million
- 2050: 48 million
- 1 in 6 adults in this Region is at risk of type 2 diabetes
- 43% of global diabetes-related health expenditure occurs in this Region

**South & Central America**
- 2020: 49 million
- 2030: 40 million
- 2050: 32 million
- 2 in 5 people with diabetes were undiagnosed
- Only 9% of global diabetes-related health expenditure for diabetes is spent in this Region

**Africa**
- 2020: 47 million
- 2030: 29 million
- 2050: 19 million
- 3 in 5 people with diabetes are undiagnosed
- 3 in 4 deaths due to diabetes were in people under the age of 60

**Middle East & North Africa**
- 2020: 108 million
- 2030: 76 million
- 2050: 55 million
- 1 in 8 people have diabetes
- 1 in 2 deaths due to diabetes were in people under the age of 60

**South-East Asia**
- 2020: 155 million
- 2030: 115 million
- 2050: 88 million
- 1 in 5 adults with diabetes lives in this Region
- 1 in 4 live births are affected by hyperglycaemia in pregnancy

**Western Pacific**
- 2020: 212 million
- 2030: 197 million
- 2050: 165 million
- 1 in 3 adults with diabetes live in this Region
- 1 in 3 deaths due to diabetes occur in this Region


The cost of inaction:

- Eye complications
- Foot complications
- Nephropathy
- Neuropathy

DIABETES IN THE U.S
A SNAPSHOT

DIABETES

37 Million
37 million people have diabetes
That’s about 1 in every 10 people
1 in 5 people don’t know they have it

PREDIABETES

96 Million
96 million American adults—more than 1 in 3—have prediabetes
More than 8 in 10 adults with prediabetes don’t know they have it

COST

$327 Billion
Total medical costs & lost work & wages for people with diagnosed diabetes

Medical costs for people with diabetes are more than twice as high as for people without diabetes

RISKS

People who have diabetes are at higher risk of serious health complications:

- Blindness
- Kidney failure
- Heart disease
- Stroke
- Loss of toes, feet, or legs
Data from Taiwan (2000-2005)

– Compared with their middle-income counterparts, the adjusted odds ratio (OR) for the poor population incidentally identified as having diabetes through hospitalization was 2.2 ($P < 0.001$).

– Poor persons with diabetes were less likely to visit any diabetes clinic (OR, 0.4; $P < 0.001$).

– The ORs for the poor population with diabetes to receive tests for glycated hemoglobin, low-density lipoprotein cholesterol, triglycerides, and retinopathy were 0.6 (0.4–0.9), 0.4 (0.2–0.7), 0.5 (0.4–0.8), and 0.4 (0.2–0.9), respectively.

– Poverty is associated not only with higher diabetes incidence but also with inequality of diabetes care in a northeast Asian population, despite universal health coverage.

Source: Hsu et al. Diabetes Care, Vol 35(11), 2012
Age distribution by sex, race, and ethnicity among patients with type 2 diabetes among 576,306 unique patients aged 10 to 100 years who had visited an emergency department at least once from 2011 through 2015 in New York City.

Data source: New York State Department of Health Statewide Planning and Research Cooperative System

1/5th of the global burden of type 2 diabetes is attributable to PM$_{2.5}$ pollution.

Diabetes Screening in Chennai, India (2020-2022)
Delivering care across a spectrum for chronic diseases will require changing the systems we use for care-delivery.

Summary of key ideas

1. Systems designed to address TB have been shaped around the social determinants of disease and the recognition that TB and many other diseases are bio-social phenomena. This means that medicines alone are often not enough to stop morbidity and mortality.

2. Successful TB programs are designed around the patients and addressing their social needs. This not only supports equity in access and treatment, but leads to better health outcomes.

3. TB care delivery – with its focus on search-treat-prevent – can serve as a platform for care delivery for other diseases.
Thank you