TB epidemiology

http://www.who.int/tb/country/en/

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Tuberculosis Epidemiologist, WHO
Speaker: Howard Takiff
Global Epidemiology of Tuberculosis

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Huang Di Nei Jing

The Yellow Emperor’s inner cannon, the first written medical text in China around 2700 BC described as Xulao Bing – weak consumptive disease
Aristotle (384-322 BC) – “He who comes into contact with the [phthisis] sufferer inhales his corrupted breath and so himself becomes ill”

Delphi Classics, 2013
TB has been with us for a very long time

Robert Koch (1843-1910) – “one seventh of all human beings die of tuberculosis”

Nobel Lecture, 1905
Most of the Decline in Tuberculosis Mortality in the England and Wales Occurred Before Antibiotics were Discovered
Post-industrialization decline in TB (England and Wales)

- TB mortality
  -3%/year

- TB incidence
  -9.3%/year

Chemotherapy
Worsening of the TB epidemic during the industrial revolution in Japan

Chemotherapy

+5.5%/year

TB incidence

TB mortality
Case Fatality Ratio (CFR \approx \text{mortality / incidence})

England & Wales

Chemotherapy

40-50% → 5-10%
Global TB infection and disease, 2015

- **Susceptible**: 77% of the world population

- **Infected**: 23%

- **TB disease**: <0.2%

  - Lifetime risk: 5–15%
    - *Am J Epidemiol* 2000, 152, 3

- Transmission by contact

*Plos Med* 2016; DOI: 10.1371
The risk of TB disease is not the same for everyone

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Under-nutrition</td>
<td>3</td>
<td>734</td>
<td>1,900,000</td>
</tr>
<tr>
<td>HIV infection</td>
<td>20</td>
<td>36</td>
<td>880,000</td>
</tr>
<tr>
<td>Cigarette smoking</td>
<td>2</td>
<td>1,047</td>
<td>830,000</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3</td>
<td>460</td>
<td>790,000</td>
</tr>
<tr>
<td>Alcohol abuse</td>
<td>3</td>
<td>407</td>
<td>490,000</td>
</tr>
</tbody>
</table>

TB incidence rate worldwide (2017)
10 million new TB cases, 1.4% *M. bovis*
## Distribution of TB Cases by Region

<table>
<thead>
<tr>
<th>WHO Region</th>
<th>Population (billions)</th>
<th>HIV-negative TB mortality</th>
<th>HIV-positive TB incidence</th>
<th>Total TB incidence</th>
<th>HIV-positive TB incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMR</td>
<td>0.996</td>
<td>17,000 (16,100–17,900)</td>
<td>6,240 (5,570–6,940)</td>
<td>274,000 (255,000–294,000)</td>
<td>30,100 (27,700–32,700)</td>
</tr>
<tr>
<td>EMR</td>
<td>0.669</td>
<td>81,700 (69,100–95,400)</td>
<td>3,020 (1,810–4,530)</td>
<td>766,000 (573,000–985,000)</td>
<td>9,850 (5,930–14,800)</td>
</tr>
<tr>
<td>AFR</td>
<td>1.02</td>
<td>417,000 (351,000–488,000)</td>
<td>320,000 (272,000–372,000)</td>
<td>2,590,000 (2,310,000–2,900,000)</td>
<td>764,000 (660,000–876,000)</td>
</tr>
<tr>
<td>EUR</td>
<td>0.916</td>
<td>26,100 (25,500–26,800)</td>
<td>5,060 (3,910–6,360)</td>
<td>290,000 (251,000–333,000)</td>
<td>33,600 (26,200–41,800)</td>
</tr>
<tr>
<td>WPR</td>
<td>1.89</td>
<td>103,000 (84,600–123,000)</td>
<td>4,960 (3,040–7,340)</td>
<td>1,800,000 (1,500,000–2,130,000)</td>
<td>29,100 (23,100–35,800)</td>
</tr>
<tr>
<td>SEA</td>
<td>1.95</td>
<td>652,000 (542,000–772,000)</td>
<td>34,700 (24,800–46,200)</td>
<td>4,670,000 (3,190,000–6,440,000)</td>
<td>163,000 (120,000–211,000)</td>
</tr>
<tr>
<td>Global</td>
<td>7.44</td>
<td>1,300,000 (1,160,000–1,440,000)</td>
<td>374,000 (325,000–427,000)</td>
<td>10,400,000 (8,770,000–12,200,000)</td>
<td>1,030,000 (915,000–1,150,000)</td>
</tr>
</tbody>
</table>

*The six WHO Regions are as follows: AFR, Africa; AMR, the Americas; EMR, Eastern Mediterranean; EUR, Europe; WPR, Western Pacific. Countries in each region are listed in Global TB Report 2017.*

1. The six WHO Regions are as follows: AFR, Africa; AMR, the Americas; EMR, Eastern Mediterranean; EUR, Europe; WPR, Western Pacific. Countries in each region are listed in Global TB Report 2017.
Age Distribution of TB Patients - 2016

Global Distribution of estimated incident cases (black lines)
Shaded portions are the number of cases officially reported to the WHO in 2016
Blue (men) and Red (women)
TB is associated with poverty
The risk of TB is greater in malnourished people
Exposure to SO$_2$ increases risk of TB  
(Korean J Intern Med 2014; 29: 183–90.)

<table>
<thead>
<tr>
<th>Model</th>
<th>Male RR$^a$ (95% CrI)</th>
<th>Female RR$^a$ (95% CrI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{10}$, μg/m$^3$</td>
<td>0.98 (0.94–1.02)</td>
<td>1.01 (0.97–1.06)</td>
</tr>
<tr>
<td>O$_3$, ppb</td>
<td>0.99 (0.94–1.03)</td>
<td>1.01 (0.97–1.05)</td>
</tr>
<tr>
<td>CO, ppb</td>
<td>0.99 (0.95–1.03)</td>
<td>1.01 (0.98–1.04)</td>
</tr>
<tr>
<td>NO$_2$, ppb</td>
<td>1.00 (0.96–1.05)</td>
<td>1.01 (0.98–1.05)</td>
</tr>
<tr>
<td>SO$_2$, ppb</td>
<td><strong>1.07 (1.03–1.12)</strong></td>
<td>1.02 (0.98–1.07)</td>
</tr>
</tbody>
</table>

Impact of an interquartile increase in pollutant concentration on the incidence of tuberculosis
9 out of 10 people worldwide breathe polluted air

#AirPollution
Impact of the HIV epidemic on TB

HIV prevalence in 15–49 year-old in Kenya

7-year lag time

TB incidence in Kenya

Incidence rate

Case notification rate
0.92 million HIV+ TB cases in 2017

9% of TB cases
Global TB and HIV, 2017

- **0.92 million** new TB cases HIV+
- **36.9 million** HIV+ people
- Incidence of TB = 0.92/36.9 = **2.5% person-yr**

- **9.1 million** new TB cases HIV-
- **7.49 billion** HIV- people
- Incidence of TB = 9.1/7.49/10 = **0.12% person-yr**

**TB incidence rate ratio** = 2.5 / 0.12 = **20.4**
## TB mortality (2017)

<table>
<thead>
<tr>
<th></th>
<th>HIV-</th>
<th>HIV+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident cases</td>
<td>9.1m</td>
<td>0.92m</td>
</tr>
<tr>
<td>TB deaths</td>
<td>1.27m</td>
<td>0.3m</td>
</tr>
<tr>
<td>Case Fatality Ratio (CFR)</td>
<td>$\frac{1.27}{9.1} = 14%$</td>
<td>$\frac{0.3}{0.92} = 33%$</td>
</tr>
</tbody>
</table>
Estimates of the TB case fatality ratio, including HIV-negative and HIV-positive patients, 2016
TB first cause of death among infectious diseases

Top causes of death, 2016

TB and HIV Mortality, 2017

In grey: TB/HIV deaths

Funding and Research
HIV >>> TB
TB incidence rate declining 2%/year

*Why is the decline so slow?*

1. Global aging, large infection pool (1.7 billion people)
2. Rise of diabetes, pollution, crowding, urban population in slums, poverty
3. Low case detection and cure, drug resistance, HIV
Global trends in TB burden

10 million new cases (2017)

1.6 million TB deaths (2017)
6.4 million notified/treated cases, but 10 million incident cases estimated.
Slow death of the TB epidemic in Japan

1 case per 1000 elderly people
= 100/100,000

The Large Reservoir of Latent TB

2 orders of magnitude

1 case per 100,000 children
transmission nearly stopped
Worsening of the TB epidemic during the industrial revolution in Japan

Graph showing the rate per 100,000/year of TB incidence and TB mortality from 1900 to 2000. The TB incidence and mortality rates increase sharply around 1950 with a +5.5%/year increase, which is labeled as 'Chemotherapy' on the graph.
Demographic transition in Japan

- High prevalence of infection in nearly all age groups
- High prevalence of infection in 30+ year old
- High incidence of disease in 60+ year old
TB drug resistance (2017)

MDR/RR-TB: 558,000 new cases per year (82% MDR)

8.5% of people reported with MDR/RR-TB have XDR-TB
RR-TB in **new cases** (2017)

3.5 (2.5 - 4.7)%

RR-TB in **retreatment cases** (2017)

18 (6.3 - 34)%
RR-TB care cascade

Incident RR-TB

- 29% detected and reported
- 87% treated
- 55% cured
TB/HIV: Anti-retroviral coverage gap

Estimated HIV+ incident TB cases

Notified HIV+ TB patients

HIV+TB patients on ART
Principles of TB control

- Detect, treat and cure
- Isolation, infection control
- Prophylactic treatment, Post-exposure vaccine, Action on determinants
- BCG (limited efficacy)
Ending the global TB epidemic

- Business as usual
- Universal access to care
- Post-exposure vaccine ± safe PT

"End the global TB epidemic"