TB Transmission in Resource-limited Settings

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Why focus on TB Transmission?
- >33% of the global population infected with the TB bacillus
- HIV burden → synergy for more TB infection
- Airborne infectious disease caused by *Mycobacterium tuberculosis*
- Preventable and curable
- People ill with TB bacteria in their lungs can infect others when they cough, talk, spit, sneeze

- Someone is infected with TB during every second (3,600 new TB infections during this lecture or >300,000 during this course)
- Left untreated, each person with active TB disease will infect between 10 - 15 people every year.
- If detected early and fully treated, people quickly become non-infectious and eventually cured.
- Major challenges incl. multidrug-resistant TB (MDR-TB) and extensively drug-resistant TB (XDR-TB), HIV-associated TB, and weak health systems.

Where does TB transmission occur?

“It may seem a strange principal to enunciate as the very first requirement of a hospital is that it should do the sick no harm.”

- Florence Nightingale. Notes on Hospitals, 1863
How is TB transmitted?
**Airborne vs. droplet transmission**

**Airborne**
- Small droplet nuclei <5 microns diameter
- Stay suspended in air
- When inhaled, can reach the alveoli and cause infection

**Droplet**
- Large droplets > 5 microns in diameter.
- Do not remain suspended in the air, so no special air handling or ventilation is required
- If inhaled, do not reach alveoli

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Number and size of organisms

**Number of organisms released**
- Talking: 0-200
- Coughing: 0-3,500
- Sneezing: 4,500-1,000,000

**Size of the droplets (function of air velocity)**
- Sneeze ~3-10 m/s
- 75% are ~10 μm
- < 25% are droplet nuclei (1-5 μm-droplet nuclei -> responsible for transmitting infection)

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Fate of droplet nuclei vs. droplets

**Droplet nuclei (airborne transmission)**
- A 1.0 μm droplet nucleus will settle at a rate of 0.0035 cm/sec (or 3 m in 24 hours)
- > these droplet nuclei will stay suspended for a long time thereby increasing likelihood of causing infection

**Large droplets (droplet transmission)**
- Fall to ground or other horizontal surface relatively fast

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TB stages and risk factors

1. Infectious cases of TB in the community
2. Exposure time, proximity and concentration
3. Endogenous factors, such as HIV
4. Severity of disease, delay in diagnosis, age

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A Sneeze

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Number of Droplets produced by Different Aerosol Producing Maneuvers

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Risk factors for TB infection

- Concentration of infectious droplet nuclei
  - How contagious is the TB patient?
- Duration of exposure
  - How long did the exposure last?
- Proximity to source
  - How close was the person to the TB patient?

*Most exposed persons do not become infected*

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**TB Pathogenesis (1)**

**Latent TB Infection**

- Once inhaled, bacteria travel to lung alveoli and establish infection
- 2–12 wks after infection, immune response limits activity; infection is detectable
- Some bacteria survive and remain dormant but viable for years (latent TB infection, or LTBI)

- NB. Persons with LTBI are
  - Asymptomatic
  - Not infectious

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**TB infection vs TB disease**

**TB Infection**

- TB not replicating
- Well
- CXR usually normal
- Negative bacteriology
- PPD usually positive
- Not infectious
- Not a TB case

**TB Disease**

- Bacilli replicating
- Sick
- CXR usually abnormal*
- Positive smear, culture*
- PPD usually positive
- May be infectious
- A case of TB

* May not be true in patients with extrapulmonary TB and/or compromised immune systems

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**Factors affecting the risk of transmission**

- Patient
  - source of infection
- Recipient
  - Other patients, visitors, staff etc
- Bacterial
- Institutional
  - Clinics, prisons, hospitals

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**Patient factors**

- Infectiousness: sputum smear positivity, cavitation, force and frequency of cough*, TB of lung or larynx
- Cough-inducing or aerosol generating procedures
- Treatment (time since start of correct treatment, treatment adherence)*
- Understanding of TB, cough etiquette*-failing to cover the cough, and adherence to IC practices
- General health status (immune status,* nutrition, co-morbidities, e.g. diabetes)

*Influence the number of infectious bacilli released

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**When is a TB patient less infectious?**

- Completed at least 2 weeks of appropriate therapy, preferably with direct observation
- Has become smear negative
- Has improvement in symptoms
Patients at risk of progression to TB disease compared to general population

<table>
<thead>
<tr>
<th>Risk Group</th>
<th>Relative Risk of TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV positive</td>
<td>40-50</td>
</tr>
<tr>
<td>Silicosis</td>
<td>30</td>
</tr>
<tr>
<td>Fibrotic lesions on chest x-ray</td>
<td>4-26</td>
</tr>
<tr>
<td>Cancer (head or neck)</td>
<td>16</td>
</tr>
<tr>
<td>Immunosuppressive treatment</td>
<td>12</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>10-15</td>
</tr>
<tr>
<td>PPD conversion &lt;1 yr</td>
<td>10</td>
</tr>
</tbody>
</table>

Transmission Risk by site of tuberculosis

- **Pulmonary tuberculosis:**
  - Tuberculosis affects the lungs in 80% of cases.
  - Pulmonary tuberculosis in adults is often *sputum smear-positive* and therefore *highly infectious*.
  - Other pulmonary cases, which are only *sputum culture-positive* or *culture negative* are 7 to 10 times less *infectious* (*sputum negativity now higher due to HIV prevalence*).
- **Extra-pulmonary tuberculosis:**
  - Affects various organs, patients with extra-pulmonary tuberculosis hardly ever spread the disease to other persons.

Recipient factors

- Closeness, duration and frequency of contact*
- Risk of TB infection (prior treatment, age, homelessness, contact of known case, etc.)
- Adherence to IC practices*
- Susceptibility either intrinsic or acquired (i.e. immune status, general health, other diseases, nutrition, age)

*B*Influence dose of inhaled bacilli

Bacterial factors

- Intrinsic virulence of MDR-TB bacilli may not be greater than drug susceptible bacilli
- However, patients with MDR-TB may infect more people due to their prolonged period of infectiousness
- Previously treated cases (treatment failure, default, relapse) have increased levels of MDR-TB

Institutional factors (1)

Risk of transmission in facilities varies by
- TB prevalence in health-care setting
- TB prevalence in community
- Patient population served
- Health-care worker occupational group
- Effectiveness of infection control measures

Transmission in health facilities

- Mainly from patients
  - Undiagnosed TB
  - Untreated TB
  - or severely drug-resistant TB
- High-risk procedures
- High-risk departments
  - Admissions, medical wards, surgical wards, laboratories
Institutional factors influencing risk of transmission (2)

- Exposure in small, enclosed spaces
- Lack of adequate ventilation
- Re-circulation of contaminated air
- Fixed characteristics (type, location, structure)
- Variable characteristics (temperature, humidity, rain)
- Type and number of people served by institution (crowding)
- Policies and practices governing patient movement and housing
- Time lag between detection of disease or drug resistance (reporting and proper treatment)
- In patient vs outpatient
- Diagnosed TB cases vs. undetected TB

Health-care–Associated Transmission of *M. tuberculosis* (3)

When are you most at risk?

Linked to close contact with infectious TB patients during procedures generating aerosols
- Bronchoscopy
- Endotracheal intubation or suctioning
- Open abscess irrigation
- Autopsy
- Sputum induction
- Aerosol treatments

Overburdened health services

![Image of healthcare workers]

Institutional factors (4):

Path of the patient and of specimens

 Patients
- In-patients versus out-patients
- Diagnosed TB cases vs. undetected
- Intake, triage, registration
- Waiting area
- Laboratory, radiology, pharmacy
- High risk procedures

Infectious Specimens
- From collection to disposal

Where are the TB transmission risks

Incidence of TB infection and disease in health workers

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Settings</th>
<th>Risk ratio*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB infection</td>
<td>Low income</td>
<td>6</td>
</tr>
<tr>
<td>TB</td>
<td>High income</td>
<td>10</td>
</tr>
<tr>
<td>TB</td>
<td>Low income</td>
<td>6</td>
</tr>
<tr>
<td>TB</td>
<td>High income</td>
<td>2</td>
</tr>
</tbody>
</table>

*compared to general population

Source: WHO, 2009

HCW’s had 5 and 6 times the rate of hospital admission for MDR & XDR TB than non-HCW’s
Summary

- TB is spread through droplet nuclei that stay airborne for prolonged periods, and can be inhaled
- Patient, recipient, bacterial and institutional factors influence the risk of TB transmission
- Infection control policies need to be adopted in TB and HIV programs

Questions

- What is the mechanisms of TB transmission
- What are the factors affecting the risk of TB transmission (patient, recipient, bacterial and institutional factors)
- List at least 2 policies that need to be adopted by TB and HIV programs to improve TB control