Issues in TB Infection Control

Lisa Chen, MD

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Curry International TB Center

Stopping transmission of TB

TB Infection Control

- A combination of measures aimed at minimizing the risk of TB transmission within populations

The Issue: Transmission of TB

Droplet nuclei
Fate of *M.tb* Aerosols

- Large droplets settle to the ground quickly
- Droplets <100 µm fall <1 meter before evaporating to 1-10 µm size
- Smaller droplets form "droplet nuclei" of 1-5 µm diameter and can be inhaled and deposited in the distal airspaces
- Droplet nuclei may remain airborne indefinitely

<table>
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<tr>
<th>Generation of Droplet Nuclei</th>
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<td>One cough produces 500 droplets</td>
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<td>The average TB patient generates 75,000 droplets per day before therapy</td>
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<tr>
<td>This falls to 25 infectious droplets per day within two weeks of effective therapy</td>
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Transmission Factors

The likelihood of transmission relates directly to:

- The bacillary burden of the index case
- Environmental factors
- Amount of time exposed as contact
**Stopping Transmission of TB**

- Key elements to ↓ TB Transmission:
  - Early identification of TB suspects and rapid evaluation for TB
  - Proper management with adequate treatment

What are the other measures can we take?

**Infection Control: Basic components**

- Administrative Controls
- Environmental Controls
- Personal Protection

**Administrative Controls**

- Policies and practices to reduce risk of exposure, infection, and disease
- Develop strategies to promptly:
  - Identify and separate/isolate potentially infectious cases (triage)
  - Control spread of pathogen
  - Minimize time in health care settings

Priority – good evidence that administrative measures reduce TB transmission
Administrative Controls

Examples: **Education**
- “Cover your cough” campaign targeting both patients and staff
- Ongoing staff education around IC and safety

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Environmental Controls

- Equipment or practices to reduce the concentration of infectious bacilli in air in areas where contamination of air is likely
  - Natural ventilation
  - Mechanical ventilation
  - Ultraviolet germicidal irradiation (UVGI) fixtures
  - Health facility design, construction, renovation and use

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Administrative Controls

- **Examples: Plan and adjust patient flow**
- Triage and “Fast-track” patients to minimize time at facility
- Separate waiting areas
- Isolate/Cohort potential TB cases
- Policies to enhance rapid identification and treatment
- Policies/plans to protect vulnerable populations

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Ventilation: Natural vs. Mechanical

**Natural ventilation**
- Good: With right conditions can have very high ventilation rates
- Issues: Difficult to control amount and direction (dependent on wind, temperature), location dependent (warm climate)

**Mechanical ventilation**
- Can control direction and enhance air mixing

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**Natural vs. Mechanical ventilation**

8 hospitals in Peru: “Old” better than “new”

- Natural = median 28 ACH
- Neg. pressure = median 12 ACH

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Variables that effect natural vent.

Ventilation improved:
- Windows fully open
- Higher winds

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The Engineering Model (P. McArdle)

- Source emits infectious droplets which float in the air indefinitely unless removed or killed

Clean air in ↔ Contaminated air out

Dilution Ventilation

1. Maximize air changes
   - One air change removes 63% of droplets in the room air
   - Optimize room air mixing
   - Direct flow of "clean" air
     - Over staff
     - Across patient
     - Then exhaust

Ventilation

Example: Using directional airflow

WHO: Tuberculosis infection control in the era of expanding HIV care and treatment (2006)

ISTC Training Modules 2020
Optimizing Room Air Mixing

- Consider the temperature of supply air
- Avoid short circuiting between supply air and exhaust terminals
- Design of the supply air diffuser (supply impacts mixing > exhaust)
  - Throw
  - Flow pattern

Isolation Rooms

- Isolates infectious patient
- Environmental control measures to reduce concentration of infectious particles (ideally removes contagion away from corridors/shared patient areas/staff)
- Minimum 12 air changes per hour (ACH)
- Negative pressure systems

Ultraviolet Germicidal Irradiation

- Well designed UVGI system can disinfect at level equal to 1-20 ACH
- Safety concerns/issues
- Guidelines prioritize ventilation – but consider UVGI a good complementary intervention
Evidence: UVGI ↓ transmission

- UVGI with air mixing resulted in fewer TB infections (PPD+) and TB disease in guinea pigs breathing air from TB/HIV ward
  - Infection: controls 35% (106/304) vs. UV 9.5% (29/307)
  - Disease: controls 8.6 (26/304) vs. UV 3.6% (11/307)

Model for testing IC interventions
Filtration Devices

**HEPA (high efficiency particulate air) filter**
- Removes particles >0.3 micrometers (99.97%)
- Provides air cleaning, dilution, mixing
- Range: small units (portable), large units (can produce negative pressure for small room, exhaust to outside), may be built into recirculating ventilation systems.
- Requires maintenance – not always practical

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Structural Design for IC

**Example: Improve IC with structural changes**
- Poor design: Shared indoor waiting area with all interior doors
- Better design: Separate waiting area with exam room doors leading to outside

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Personal Protection Interventions

- Equipment and interventions to protect personnel who must work in environments with contaminated air
  - Particulate respirators
- Prevention and care for health care workers, including:
  - HIV prevention
  - ART (anti-retroviral therapy) and isoniazid preventive therapy (IPT) for HIV+ health care workers
Respirators vs. Masks

- Particulate respirators offer protection against inhalation of infectious particles (masks do not)
  - Example: N95 (95% efficiency, 0.3 µm) or FFP2 respirators
  - (Other respirators: Powered air purifier respirators, PAPR)
- Masks (facemasks, surgical masks) prevent expelling large droplets into the air
  - >50% reduction in transmission (Dharmadhikari, AJRCCM 2012)

Evidence: Combining methods

Mathematical Modeling: Contribution of ventilation vs. PPE

Evidence: Systematic Review

The efficacy of engineering and personal protective interventions for TB infection control: A systematic review (Ling DL, Pai M, et al; Am J Respir Crit Care Med 2009)

- Epi studies: No added benefits of UVGI and respirators, but lower ventilation associated with higher TST conversion
- Animal/lab studies: Increased TB disease and bacterial concentration with UVGI
- Modeling studies:
  - Increased TB risk with UVGI and ventilation
  - Fewer XDR cases with ventilation and respirator use

Review suggests combination of controls best; reduces transmission in health-care facilities
Because you may be wondering…

Criteria for Discontinuing All Precautions

- Infectious TB is unlikely and another diagnosis is made that explains the syndrome
- Or
- If initially +smear, now has 3 consecutive negative AFB sputum smear results, and
- Patient has received standard anti-TB treatment (minimum of 2 weeks), and
- Patient has demonstrated clinical improvement

[CA for release TB mod/high smear: suspect to congregate setting: 3 negative smears + 5 days TB Rx; MDR requires culture conversion to negative]

New: Xpert MTB/RIF for All release (4/2016)

NTCA/APHL Consensus Statement

- Algorithm: 2 neg. Xpert tests to release from airborne infection isolation
- Emphasize NOT same as decision for diagnosis and/or empiric treatment – still must use clinical skills (diagnosis talk: smear + vs smear- performance)
- ONLY for Xpert (FDA approval 2015); not other NAAT
- Collection/quality of sputum is critical
- 1 neg. Xpert predicted absence of smear pos. TB with NPV 99.7%, two gave NPV 100% (TBTC Study 34, Luetkemeyer CID 3/2016)
Discharge to Home

Patient can be discharged without 3 negative sputum smears if:

• Follow-up plan made with local TB program
• Patient is on standard treatment and directly observed therapy (DOT) is arranged
• No person in home <4 yrs old or immunocompromised
• All in household previously exposed
• Patient willing to stay home until sputum results negative
• Do not release if high-risk persons will be exposed

Tuberculosis Infection Control

Summary

• A package of infection control measures reduces TB transmission and safeguards the health of healthcare workers, patients, and the community
• A sound infection control strategy uses a combination of measures, especially with strong administrative controls, to reduce facility disease transmission
• Everyone has a role

Case Study

TB/HIV Clinic