Curry International TB Center

Issues in TB Infection Control

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TB Intensive, October 2015

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

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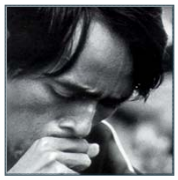
The Issue: Transmission of TB



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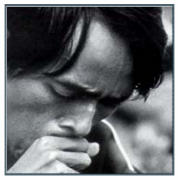
The Issue: Transmission of TB



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The Issue: Transmission of TB

Droplet nuclei

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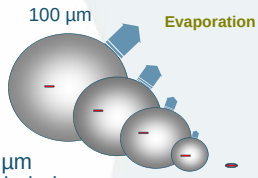
Fate of *M.tb* Aerosols

- 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 remain airborne indefinitely



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Generation of Droplet Nuclei

- One cough produces 500 droplets
- The average TB patient generates 75,000 droplets per day before therapy

- This falls to 25 infectious droplets per day within two weeks of effective therapy

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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

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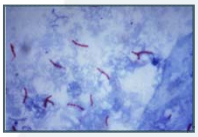
Stopping Transmission of TB

- **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

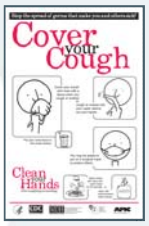
- Policies and practices to reduce risk of exposure, infection, and disease
- Develop strategies to promptly:
  - Identify and separate/isolate potentially infectious cases (triage)
  - Control spread of pathogen
  - Minimize time in health care settings

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



CDC poster

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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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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

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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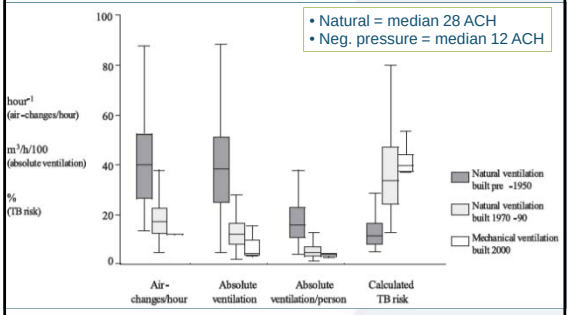
Natural vs. Mechanical ventilation

8 hospitals in Peru: "Old" better than "new"



Escombe, PLoS Medicine, 2007

Variables that effect natural vent.

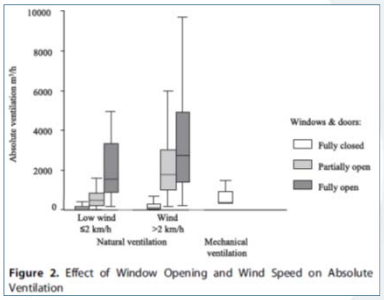


Figure 2. Effect of Window Opening and Wind Speed on Absolute Ventilation

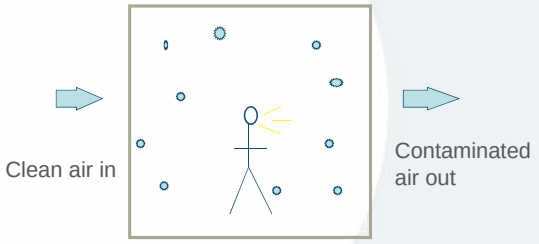
Ventilation improved:

- Windows fully open
- Higher winds

Escombe, PLoS Medicine, 2007

The Engineering Model (P. McArdle)

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



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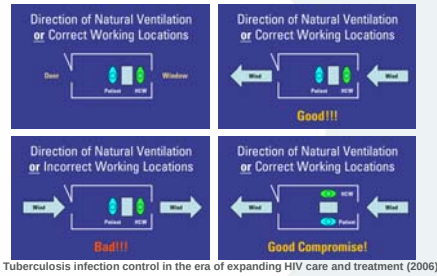
Dilution Ventilation

- 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)

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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

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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 6-12 air changes per hour (ACH)
- Negative pressure systems

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Ultraviolet Germicidal Irradiation

Photo credit: P. Jensen

- 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

UVGI Inside Ducts and Air Cleaners

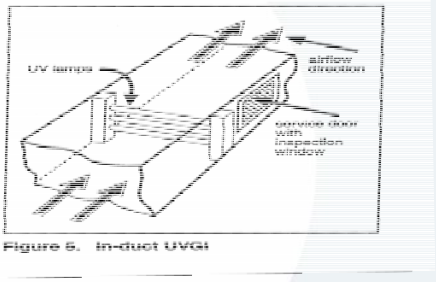

Figure 6. In-duct UVGI

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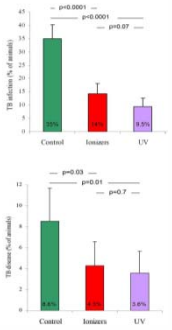
Evidence: UVGI ↓ transmission



- 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)

Escombe PLoS Medicine 2009

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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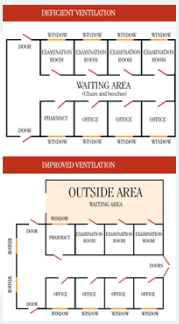
Structural Design for IC

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



Tuberculosis Infection Control in Health Care Facilities: Training Module, Peru/Partners TB Control/CDC
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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

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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)

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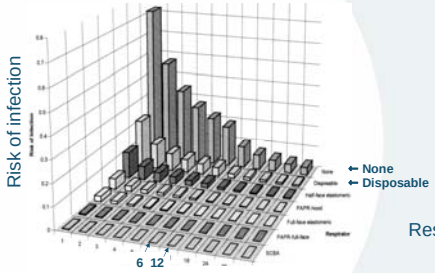
Evidence: Combining methods

Mathematical Modeling: Contribution of ventilation vs. PPE



Fennelly 1998

Evidence: Systematic Review

The efficacy of engineering and personal protective interventions for TB infection control: A systematic review

(Ling DI, 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: ↓ TB disease and bacterial concentration with UVGI
- Modeling studies:
  - ↓ 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

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IC Resources: US-based

- CDC: Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care settings 2005 MMWR 2005
- Tuberculosis Infection Control: A practical manual for preventing TB
  Francis J. Curry National TB Center, 2007
  - Practical information on specific environmental control measures
  - IC for clinics, sputum induction, isolation rooms, emergency department, homeless shelters

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Because you may be wondering…

Criteria for Discontinuing AII 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]

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

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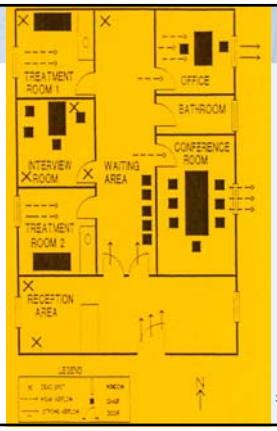
Case Study

TB/HIV Clinic



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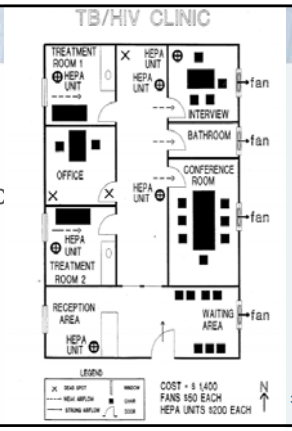

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