Objectives

- To state the most important intervention to prevent transmission in health care facilities.
- To understand how (and why) to apply the 3 levels of TB Infection Control Measures described in the CDC Guidelines to protect health care workers, patients and visitors from airborne TB.
- To list three resources that are good references for information on preventing TB transmission in health care facilities.

Potential conflicts of interest - 1

- Patent pending on a device to facilitate use of the small membrane filter to improve the sensitivity of AFB microscopy
- Patent application submitted on a cough aerosol collection device
- Patent application submitted on a ‘Easy Breathing Medical Mask’ intended to prevent transmission from infectious patients
Potential conflicts of interest

- Co-investigator on NIH-NAID SBIR grant on Single Particle Aerosol Mass Spectroscopy to detect airborne TB
- Site P.I. for study of Arykace, an inhaled liposomal amikacin for nontuberculous mycobacterial infections (Insmed, Inc.)
  - Served on a Medical Advisory Board for Insmed, Inc.
- Serving on a Data Safety Monitoring Board for a clinical trial of an inhaled ciprofloxacin product

Miasmatic Theory of Contagion

"For when the morning breezes blow toward the town at sunrise, if they bring with them mist from marshes and, mingled with the mist, the poisonous breath of creatures of the marshes to be wafted into the bodies of the inhabitants, they will make the site unhealthy."

- Vitruvius on miasma, 1st Century AD

Riley experimental TB ward

- Slide courtesy of Sol Permutt, 2004
TB is transmitted by aerosols NOT by sputum


Cough Aerosol Sampling System, v.2

Size Distribution of \textit{Mtb} Cough Aerosols

Fennelly KP et al. AJRCCM 2012: 186:450
Variability of Infectious Aerosols in TB

Fennelly KP et al. AJRCCM 2012; 186:450

Cough Aerosols of M. tuberculosis Predict New Infection: A Household Contact Study
Jones-Lopez EC et al. AJRCCM 2013; 187:1007-15

- TST conversion 1
- TST conversion 2
- IGRA conversion
- TST and IGRA conversion
Changes in cough aerosols with treatment

![Graph showing changes in cough aerosols with treatment](image)

Fennelly KP et al. AJRCCM 2004; 169: 604

Are bacilli exposed to antibiotics more susceptible to the stresses of aerosolization than those in sputum?

![Graph showing relative infectivity of patients](image)

Fennelly KP et al. Am J Resp Crit Care Med 2004; 169; 604-9

Riley Ward – 2nd 2-year study

- included untreated patients

Relative infectivity of patients*:

- Susceptible TB
  - 61 Untreated (29 GPs) 100%
  - 29 Treated (1 GP) 2%
- Drug-resistant TB
  - 6 Untreated (14 GPs) 28%
  - 11 Treated (6 GPs) 5%

*all smear positive patients, relative to the amount of time on the ward

Slide kindly provided by Ed Nardell.
Staying Safe: Preventing TB Transmission in Health Care Facilities
Webinar
October 20, 2014

Air Stress on *M. smegmatis*

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<th>Time (min)</th>
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Relative humidity 32-34%
Temperature 24.3-27.2°C

Transmission of TB from Irrigation of a TB Abscess

Hutton MD et al. J Infect Dis 1990; 161:286-95

Wells-Riley Mathematical Model of Airborne Infection

Probability of MTB Infection:
Isolation Room with 6 ACH
Infectiousness and Duration of Exposure

Duration of Exposure (hours)

- 0.1
- 1
- 10
- 100
- 1000
TB Infection Control Measures are Synergistic: Relative Efficacy of PRP and Room Ventilation


Simple TB-IC measures are effective

- MDR-TB outbreak on HIV ward in Milan mitigated by simple measures of use of single rooms, doors closed, limiting transport
  - 26 of 90 (28%) of patients exposed prior to implementation developed MDR-TB
  - 0 of 44 HIV patients on ward after implementation

- While implementing the first pilot DOTS-Plus Program in Uganda to manage MDR-TB, we could not identify any transmission to HCWs or patients using only simple WHO TB-IC guidelines (unpublished)

Surgical Masks on Patients Reduce TB Transmission

56% reduction in transmission to guinea pigs

- Dharmadhikari AS et al. AJRCCM 2012; 185: 1104
### Preventing TB Transmission

<table>
<thead>
<tr>
<th>TB patient Environment</th>
<th>Exposed Susceptibles</th>
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<tbody>
<tr>
<td><strong>Rapid diagnosis &amp; treatment</strong></td>
<td>Optimal dilution ventilation (&gt; 6 ACH)</td>
</tr>
<tr>
<td><strong>Appropriate treatment (r/o drug resistance)</strong></td>
<td>De-crowding</td>
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<tr>
<td><strong>Mask on patient (e.g., for transport)</strong></td>
<td>Airborne isolation (negative pressure)</td>
</tr>
<tr>
<td><strong>Cough suppression ?</strong></td>
<td>UVGI</td>
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<td><strong>Macromodulatory Agents?</strong></td>
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<tr>
<td><strong>Inhaled antibiotics?</strong></td>
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### Arguments for ‘Early’ Removal from Isolation

- Retrospective study of HHCs of TB patients
  - Group A: 86 cx + (52 sm +) pts discharged ‘early’
  - Group B: 69 pts both cx- and sm- at discharge
  - No differences in infection of HHC
  - BUT…median hospital days 38 (A) and 36 (B)

- 21 (20 sm +) patients discharged after mean of 15 days; no conversions among 72 TST-neg HHCs.

- Limitations: Studies based on discharge after 2 or more weeks of in patient treatment.
  - Madras (India) study similarly negative, limited by high background
  - Those most susceptible or exposed were probably already infected
    - i.e., epidemiological ‘harvesting’

### Arguments Against ‘Early’ Removal from Isolation

- Guinea pigs injected SQ with isolates from sputa of 21 treated patients
  - 17/25 (68%) smear + sputa produced infections

- GP’s inoculated with bacilli from sputa from 7 patients during treatment.
  - + infections after treatment for 3-7 weeks in all 7

- Limitations: Animal experiments used direct inoculation versus aerogenic exposures.
  - Only 1-16% Mtb bacilli survive aerosolization
    - Rocchi HL, Am. J. Hg. 1952;50:56-68.

- Data from cough aerosol studies and guinea pig infections from patients data suggests rapid decrease of viable airborne bacilli from patients during treatment.
  - Fennelly KP et al. AJRRCM 2004; 169:604-9
  - ARRD 1962; 85:511-525
Discharge to Home

- Patient can be discharged **without** 3 negative sputa smears if:
  - Follow-up plan has been made with local TB program
  - Patient is on standard treatment and directly observed therapy (DOT) is arranged
  - And clinically improving with microbiological response (e.g., sputa AFB 4+ to 2+); MDR-TB ruled out - KF
  - No person in home <4 years old or immunocompromised *Recommend home visit!* - KF
  - All in household previously exposed
  - Patient willing to stay home until sputum results negative

Dispelling TB Infection Control Myths

- The AFB smear has never been shown to be a useful indicator of infectiousness once patients are on treatment.
- The AFB smear is a risk factor that is positively associated with infectiousness, but it is NOT the sine qua non of infectiousness.
- Not all sputum smear-positive TB patients are infectious.
- About 15% of (untreated) sputum smear-negative patients are infectious.
- Most (untreated) TB patients are not infectious, but some are VERY infectious, i.e., superspreaders.
- The ‘2-week rule’ espoused by some is a fair but imperfect guess.

Summary

- The most important TB infection control measure is rapid and appropriate treatment
  - Requires high degree of clinical suspicion for TB.
  - Optimally aided by rapid molecular diagnostics for drug resistance.
- Use TB infection control measures synergistically:
  - Administrative (rapid diagnosis, isolation, treatment)
  - Engineering (remove/destroy infectious aerosols)
  - Personal Respiratory Protection (back up/close contact)
- Good resources are available.
  - Know who to call.
Resources for TB Infection Control

- CDC Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Settings, 2005; 54(RR17):1-141.

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