61ST ANNUAL

Denver TB Course

(Hybrid Event)

APRIL 2-4, 2025

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Transmission of *M. tuberculosis* and Infection Control Workshop

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Objectives:

- How transmission of TB occurs and factors influencing transmission
- Learn the important elements of a TB control plan and how they are implemented
- Learn how environmental controls work to decrease transmission of infectious particles

Structure (3 parts, each with an activity):

- Part I: The Infectious Patient
- Part II: Preparedness
- Part III: The Environment

PART I (The Infectious Patient)

Figure 8. TB patients by age group: Colorado 2023

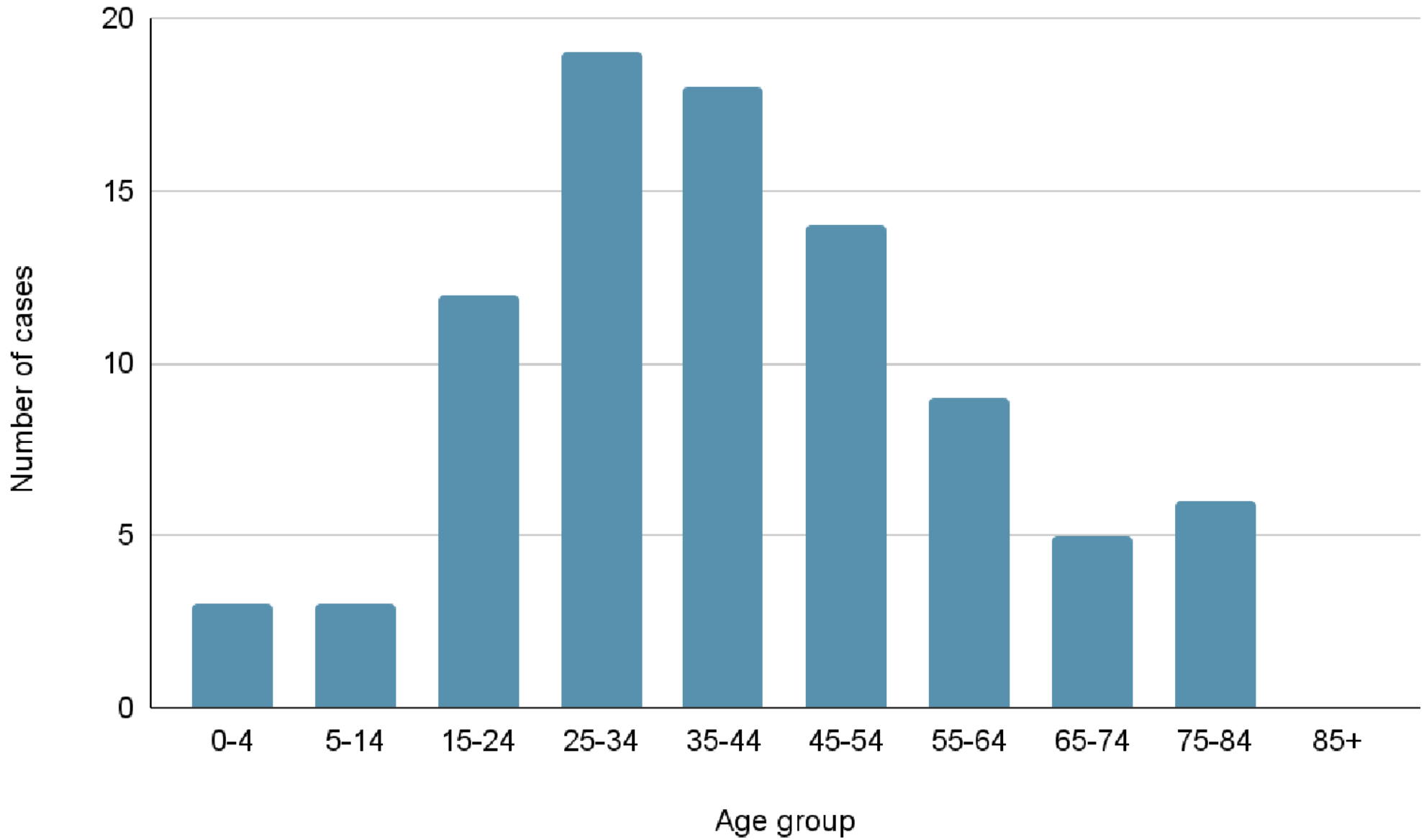
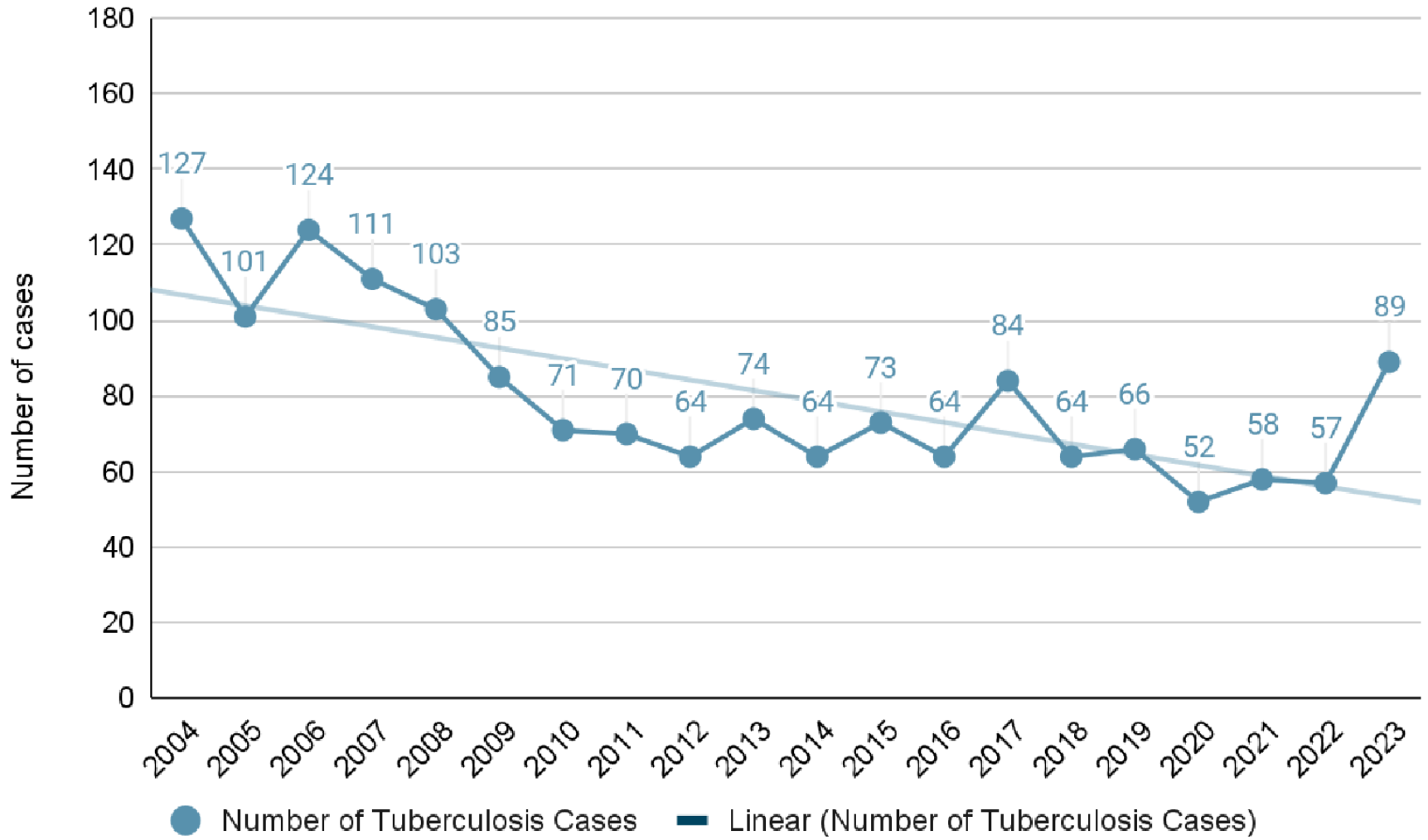


Figure 1. Number of TB patients and trend line: Colorado 2004-2023



Transmission via Aerosol

Infectious Particle for TB - Droplet Nucleus

- Microscopic droplets generated by coughing, sneezing, speech, singing
- Evaporate to droplet nuclei (1 to 3 microns)
- Capable of reaching alveolus
- Only particles with < 5 µM aerodynamic diameter (infectious droplet nuclei) containing 1-3 tubercle bacilli can initiate infection (larger particles captured by mucociliary defenses)
- Droplet nuclei remain suspended in the air for several hours in poorly ventilated areas
- Droplet nuclei disperse with the flow of air

Transmission of Tuberculosis
Generation of Droplet Nuclei

- One cough produces 500 droplets
- The average tuberculosis (TB) patient generates 75,000 droplets per day before therapy
- This drops to 25 infectious droplets per day within 2 weeks of effective therapy

Aerosolization of *Mycobaterium tuberculosis* by Tidal Breathing

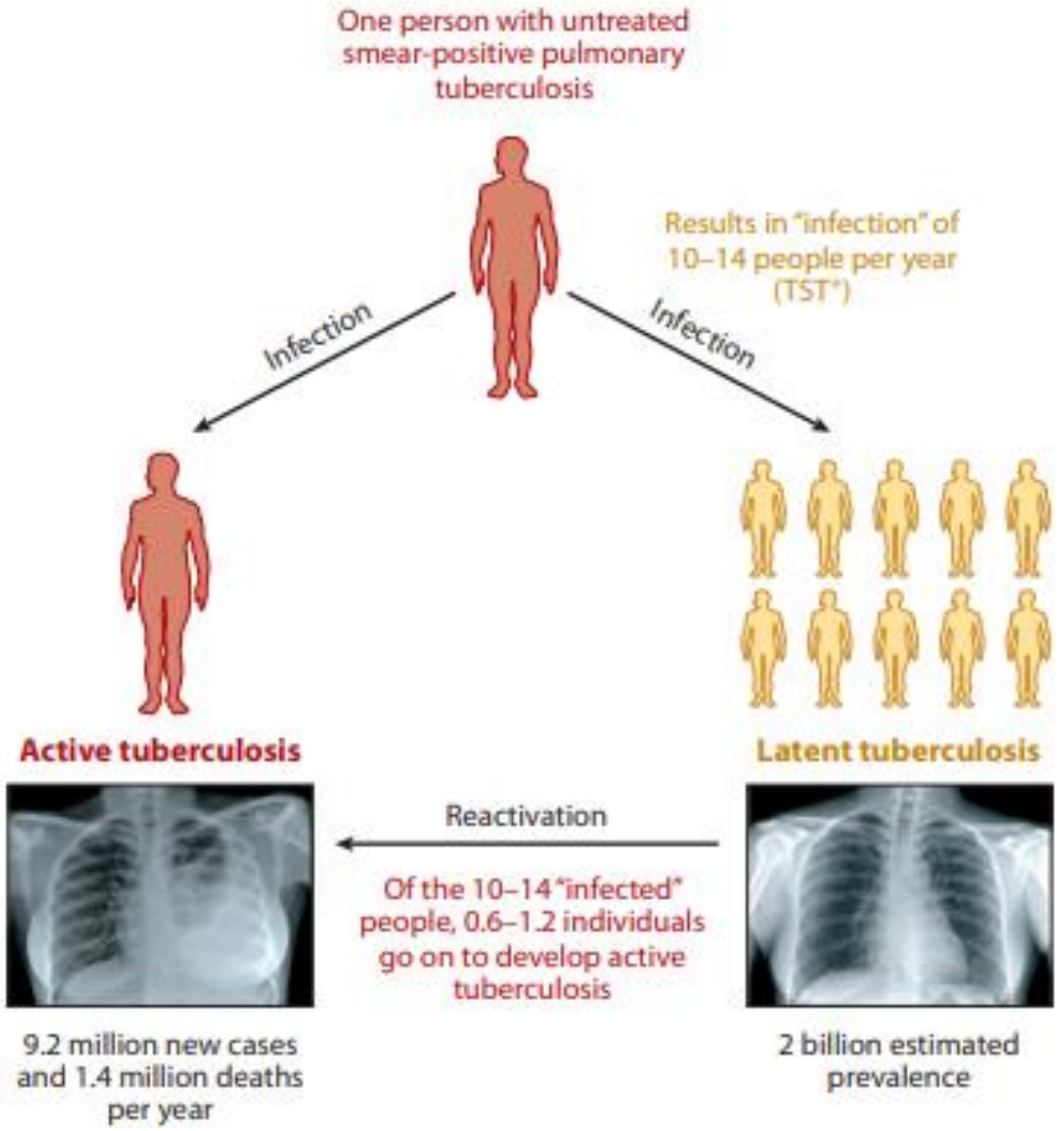
Dinkele R. et al. AJRCCM 2022, 206; 206.

- Bioaerosol sampling and *Mtb* enumeration by live-cell, fluorescence microscopy combined with real-time measurement of total particle counts from 38 patients with GeneXpert positive Mtb before treatment
- Cough, Tidal Breathing (TiB) and forced vital capacity (FVC) produced similar rates of positivity for Mtb (particle counts 4.8X greater for cough than TiB and FVC)
- TiB may contribute more than 90% of daily aerosolized Mtb among symptomatic TB patients and may be a significant contributor to TB transmission among active cases.

How infectious is TB?

- One person with untreated smear-positive tuberculosis may lead to positive tuberculin skin testing in ***10-14 people per year***, of which 0.6-1.2 go on to develop active tuberculosis
  - *O'Garra et al. 2013 Ann Rev Immunol 31:475-527*

- Particular scenario: 1998 US sailor with smear-positive cavitary pulmonary tuberculosis led to ***over 700 latent infections*** and ***25 further cases of active tuberculosis***
  - *Zajdowski & Hankinson 2006 "Tuberculosis and military recruits" in DeKoning ed., Recruit Medicine*



Transmission and Pathogenesis of Tuberculosis

Exposure

No infection (70%)

Infection (30%)

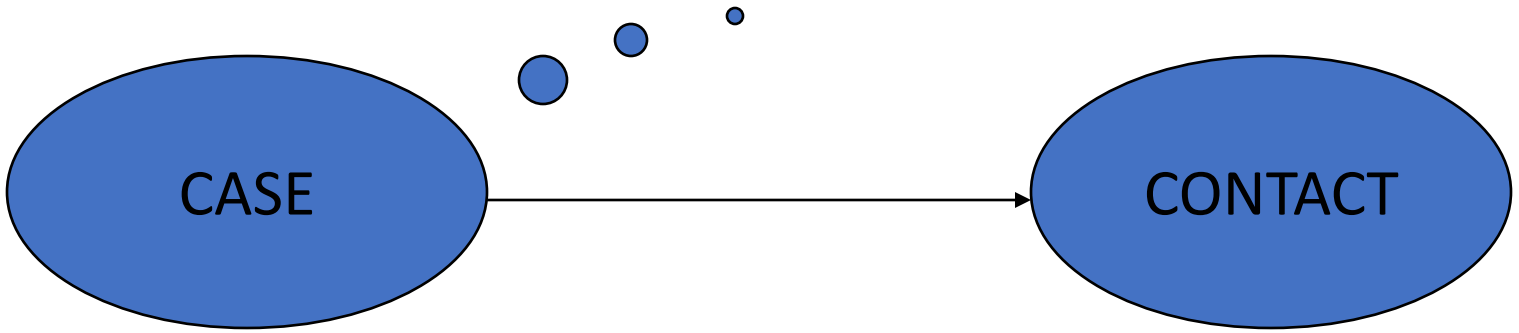
Early progression (5%)

Containment (95%)

Late progression (5%)

Continued containment (90%)

Transmission of Tuberculosis



Site of TB
Cough
Bacillary load
Treatment

Ventilation
Filtration
U.V. light

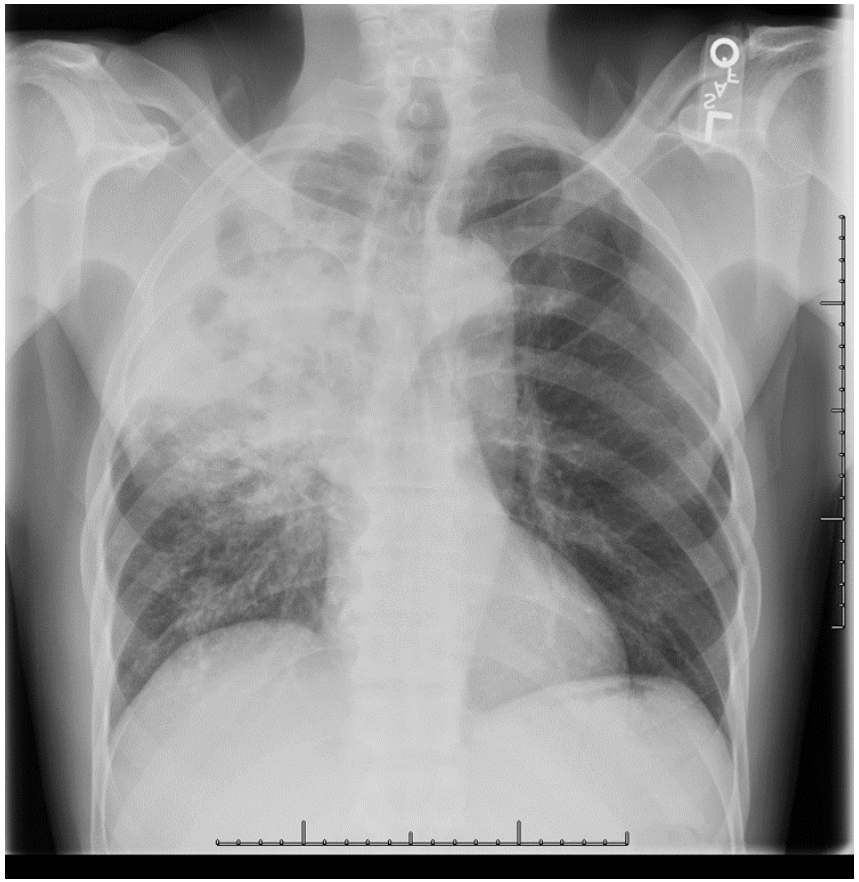
Closeness and
duration of contact
Immune status
Previous infection

Factors Associated with Transmission: TB Source Case

- Sputum AFB smear **+** : 10^3 – 10^4 bacilli/ml
  4- to 5-X as infectious
- Cavities : sputum volume up to > 100 ml/day
- Presence of cough - spontaneous or induced
- Laryngeal TB - usually with cavitary TB/cough; few AFB on vocal cords
- More virulent strains of TB - some markers found, but controversial

Case of a TB patient in the Emergency Department

- 43 year old man from Mexico, in US 2 years
- Chronic cough, weight loss
- Presented to NE Texas Community Hospital ED
- Treated as Community-Acquired Pneumonia with levofloxacin



Reasons a Diagnosis of TB is Missed or Delayed

- Patient is diagnosed as a community acquired pneumonia and responds to a fluoroquinolone (more than one course required for FQ resistance)
- Atypical clinical and radiographic picture
- Extrapulmonary disease
- Clinician does not consider TB as a diagnostic possibility (PCP, ED, specialist, radiologist)

FIRST ACTIVITY:

A man with months of cough and trace hemoptysis walks into the Emergency Department. He is from Central America and notes family members have had TB in the past. He is accompanied by his wife and children. As the new infection prevention officer at your institution, you are called by the ED attending asking for guidance on next steps.

- How should this patient be managed?
- What should his family do?
- What should staff do?
- Should he be admitted and if so, what are next steps? Next steps if not admitted?
- What should be done after he leaves the ED?

Identifying Patients with TB

Decision Instrument for the Isolation of Pneumonia Patients With Suspected Pulmonary Tuberculosis Admitted Through US EDs

Table 2. Factors associated with confirmed pulmonary TB among admitted pneumonia patients—derivation population.

Criterion	Relative Risk	TB Positive (%), n=112	TB Negative (%), n=2,432
Cavitation	8.8	30 (27)	72 (3.0)
Apical infiltrate	7.9	60 (54)	263 (10.8)
Immigrant	4.6	41 (37)	245 (10.1)
Weight loss	4.1	60 (54)	500 (20.6)
Positive TB history (includes previous positive tuberculin skin test result)	2.9	55 (49)	578 (23.8)
Homeless	1.6	21 (19)	307 (12.6)
Incarcerated	1.6	19 (17)	273 (11.2)

Moran et al. *Ann Emerg Med* 2008

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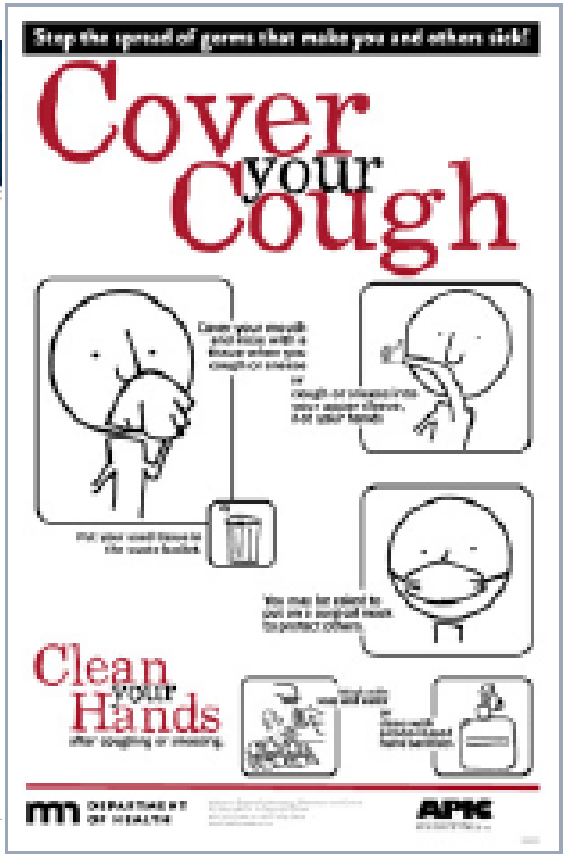
Educating patients and visitors

- Signage in waiting areas
- Respiratory etiquette/hygiene
- Further education by trained staff in certain areas (e.g., infectious diseases)
- Patient is to use a surgical mask around others if he/she is suspected to have TB



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Triage and Airborne Precautions Protocols

- Identify and isolate those with potential TB
  - Must have a suspicion for tuberculosis, providers must be knowledgeable
- Bed control and availability of airborne infection isolation rooms (AIIRs) under negative pressure; may need to move patients
- Respiratory protection with N95 masks or equivalent for staff
- Family members should be educated about TB transmission, reduce stigma

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Evaluating for Infectious TB and isolation discontinuation

- ***Sputum AFB smear & culture x3*** (at least one early morning) 8-24 hours apart
- ***2 rapid molecular diagnostics***, should include the ability to test for rifampin resistance, ideally other drugs like isoniazid and fluoroquinolones too
  - Nucleic acid amplification testing (NAAT) should not be used alone to rule out TB (may still be culture positive)
  - NAAT may have similar sensitivity and specificity to culture positivity if not better (one study sensitivity 87% vs. 76%)
  - Consider release from AII if 2 negative NAATs (regardless of AFB smear results – likely nontuberculous mycobacteria) ***UNLESS*** there is strong suspicion for TB
- ***Drug susceptibility testing (DST)*** for positive cultures

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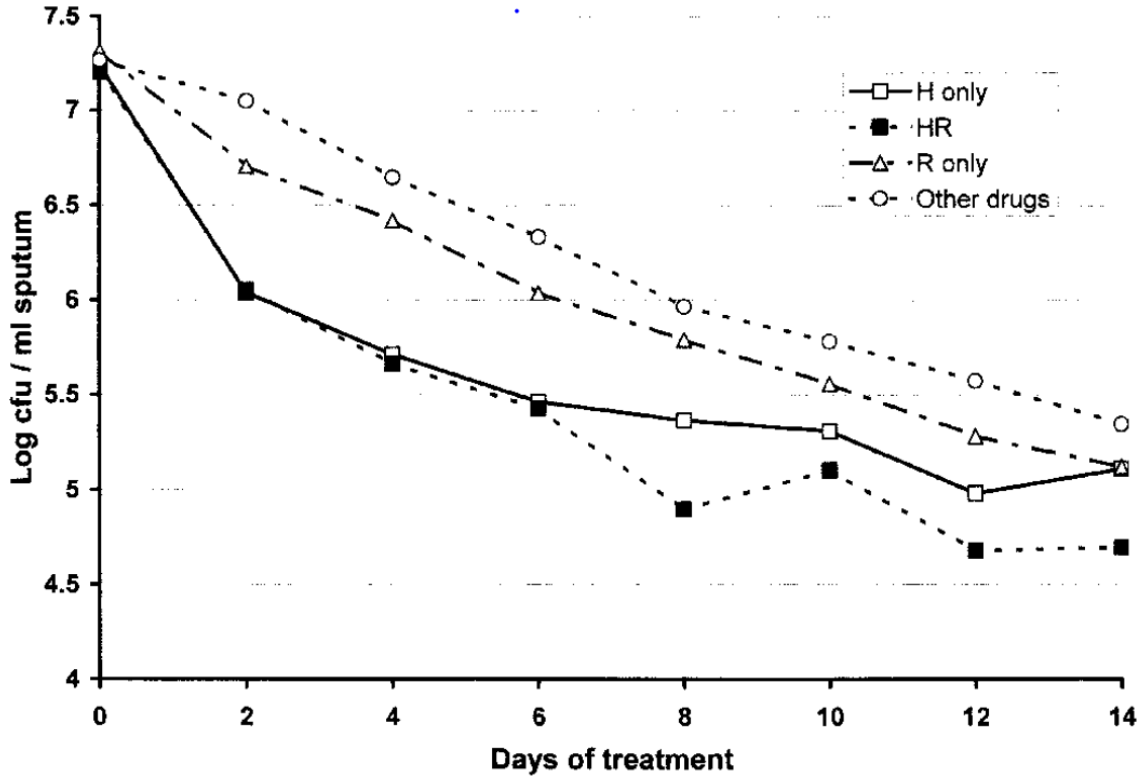
Probable Effect of therapy on TB transmission

- Very few studies on how therapy impacts transmission
  - Early bactericidal activity (EBA) studies
  - Animal model studies
  - Most indicate infectiously likely rapidly declines in 2-3 days of effective treatment
- Clinical trial in Chennai, India, in the 1950s
  - Randomized to start TB treatment under isolation or at home
    - No differences in TB infection/disease among household contacts
      - Could indicate majority of transmission is *prior* to treatment.

Bactericidal and Sterilizing Activities of Antituberculosis Drugs during the First 14 Days



Jindani, A et al. AJRCCM 2003
Shah M, et al. CID 2024

Infectivity of Tuberculosis Patients on Chemotherapy

- 21 patients with pulmonary TB discharged after about 2 weeks of chemotherapy (2-36 days).
  - 20/21 had positive sputum cultures on discharge, 16/21 had cavitary disease

- Of 72 household contacts initially tuberculin-negative, none converted their skin tests subsequently (23 of 72 treated with INH)

Conclusion: Tuberculosis patients on chemotherapy can be discharged safely without additional risk to contacts

Brooks, 1973

Discontinuation of Airborne Precautions (Confirmed TB)

Response to therapy:

- Clinical improvement (4-7 days)
- 3 consecutive, negative AFB smears or one negative rapid molecular test and two negative sputum smears
- Some favor at least 2 weeks of TB treatment for patients with positive AFB smears prior to discontinuation of isolation
- Continue until discharge for MDR-TB
- Additional caution for those who live in congregate settings

Curry Center, “Tuberculosis Infection Control”

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Discharge to Home: Smear Positive

- Public health follow-up and directly observed therapy (DOT)
- Household members
  - If previously exposed, will need to coordinate with public health
  - Ensure all have had the opportunity to be evaluated
- No new household members <4 years old or immunocompromised should be in same airspace with rare exceptions
- Patient will remain at home on isolation
  - Most patients can be released from isolation in 5 days

CDC 2005
Shah, CID 2024

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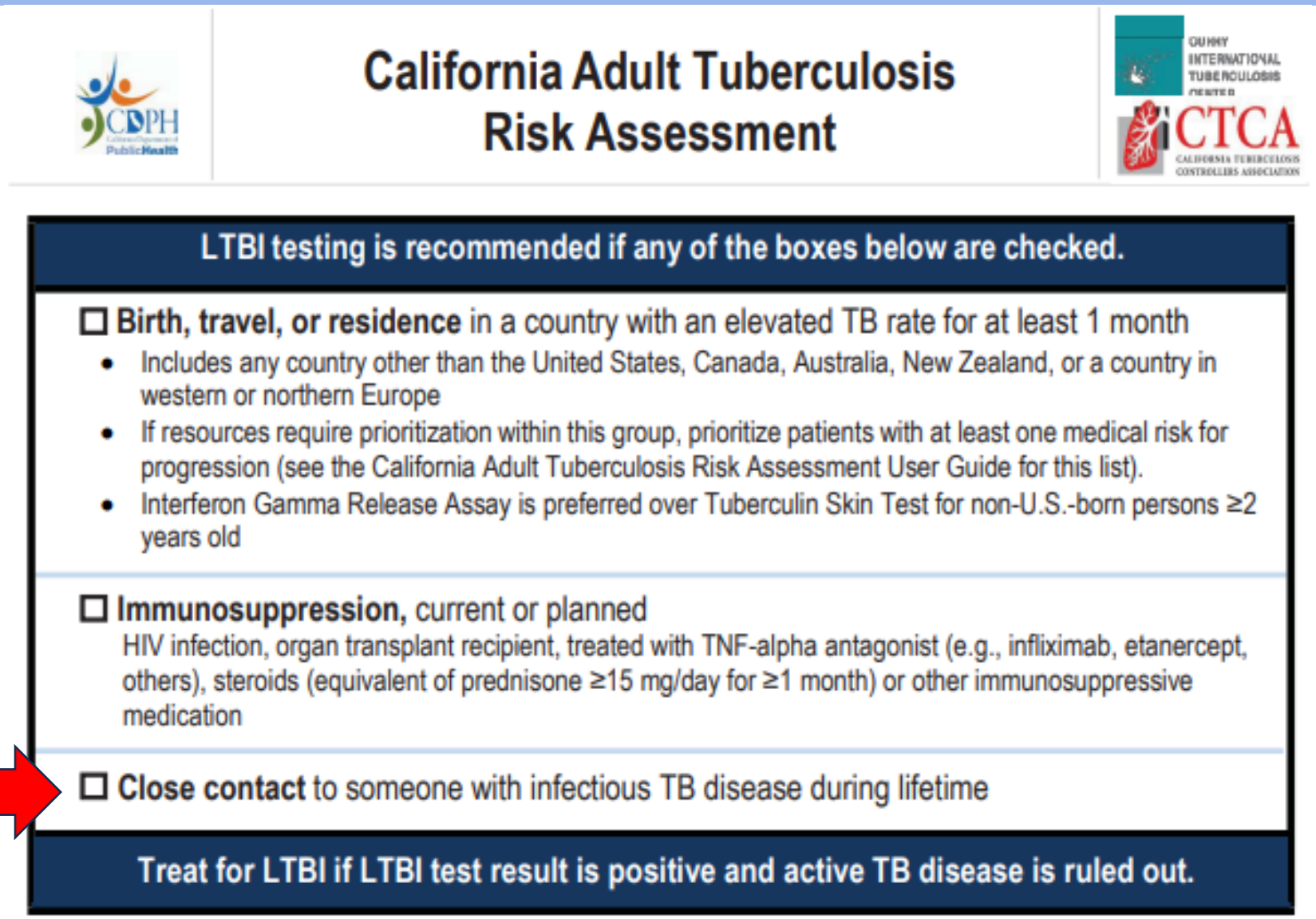
Shah et al. 2024: the vast majority can be released from isolation after 5 days of treatment

Table 3. Integrated Schematic and Decision Aid to Support Community-Based Respiratory Isolation and Restriction Recommendations for Individuals With Pulmonary Tuberculosis

Recommendation 3: Determining Infectiousness			Recommendation 4: Determining RIR	Recommendation 5: Level of RIR	Notes
ATT status	Pretreatment respiratory bacterial burden[a]	Assessment of individual infectiousness[a,b]	Is RIR indicated?[c]	What level of RIR to choose? (Rec 2; Table 2)	Specific recommendations should balance community and patient risks and benefits (Rec 1)
Pretreatment	High	Highest (Rec 3.1)	Yes (Rec 4.3)	Extensive	Support should be provided to mitigate harm to PWTB (Rec 5.3)
	Low	Moderate (Rec 3.1)	Yes (Rec 4.3)	Extensive or moderate (Rec 5.1)	
Treatment ≤5 d	High	Moderate (Rec 3.2)	Yes (Rec 4.3)	Moderate (Rec 5.1)	
	Low	Moderate/low (Rec 3.2)	Yes (Rec 4.3)	Moderate (Rec 5.1)	
Treatment >5 d	High	Low (Rec 3.3)[b]	Not indicated in most situations (Rec 4.2)[d]	None	Individual exceptions to continue RIR may be considered (Rec 5.2)[d]
	Low	Lowest (Rec 3.3)		None	

Shah et al. 2024 *Clin Infect Dis*. Apr 18:ciae199

Who should be tested for LTBI?



www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/TBCB-CA-TB-Risk-Assessment-and-Fact-Sheet.pdf
(accessed 3/31/2024)

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PART II (Preparedness)

TB Outbreak Among HCW in a Community Hospital

Griffith DE et al. AJRCCM 1995, 152:808

- 22 year old woman from Mexico
- Per family: 2 months of productive cough, fever, weight loss (cachectic), no medical problems or HIV risk factors
- Cardiorespiratory arrest at home
- Intubated in ED, unresponsive, hypotensive
- Initial CXR c/w ARDS
- In the ER 2 hours, transferred to MICU, placed on ventilator

TB Outbreak Among HCW in a Community Hospital

Griffith DE et al. AJRCCM 1995, 152:808

- She survived an additional 10 hours in the MICU
- She had a cardiorespiratory arrest and could not be resuscitate in the MICU, no autopsy
- Tracheal suction specimens were 4+ AFB smear positive and grew drug susceptible Mtb
- While in the ED and MICU
  - All HCW in contact with patient wore surgical masks
  - ED and MICU without negative pressure rooms, frequent or rapid air exchanges, filters for recirculated air, or ultraviolet lights

TB Outbreak Among HCW in a Community Hospital

Griffith DE et al. AJRCCM 1995, 152:808

- 29 HCW exposed to patient in ED and MICU in a Community Hospital in Orange County, CA
- Evaluated by TST
- 11 unevaluable: 4 BCG, 5 prior + TST, 2 LTFU,
- 4 without conversion: 2 Environmental services, 1 Central supply, 1 Security
- 3 TST converters who developed active TB: 1 ICU physician, 1 ED nurse and 1 respiratory therapist
- 11 other TST converters including: 2 MICU nurses, 1 ED nurses, 1 ER clerk, 1 floor nurse, 1 Nursing Supervisor, 2 Respiratory Therapists, 2 Environmental Services, 1 lab tech

SECOND ACTIVITY:

You realize that your facility was underprepared to handle the ED patient as you were not up to date and lacking a TB control plan.

What considerations should your TB plan address?

Where in the facility is the risk for spread of TB greatest?

Apart from your infection prevention team who else needs to be involved?

Keep in mind principles of TB infection prevention:

1) Reduce the concentration of infectious droplet nuclei in the air

2) Reduce the exposure of susceptible individuals to aerosols

A Comprehensive Approach

- Measures to prevent/minimize the transmission of airborne microbes from an infectious person to patients, visitors, staff
- Hierarchy of controls (I. most important then II. then III.)

I. **Administrative controls**

- reduce the risk of exposure to potential TB cases by managing ***people, policies***

II. **Environmental controls**

- reduce the spread of infectious aerosols by managing ***the air***

III. **Respiratory controls/personal protective equipment (PPE)**

- proper use of ***personal protective equipment*** in certain scenarios

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3-level Hierarchy of TB Infection Prevention

Administrative controls	**Triage** of people with TB signs and symptoms, or with TB disease
	Respiratory separation
	Prompt **initiation of effective TB treatment** of people with TB disease
	Respiratory hygiene
Environmental controls	**Ventilation systems**
	Upper-room germicidal ultraviolet (**GUV**) systems
Respiratory protection	**Particulate respirators**, within the framework of a **respiratory protection programme**

WHO Consolidated Guidelines on Tuberculosis: Module 1: Prevention (accessed 3/31/2024)

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Administrative Controls

Curry Center: “the most important, least expensive, and often the most difficult measures to implement.”

- Have a plan:
  - TB IPC plan, overseen by infection prevention staff
  - Conduct TB Risk Assessment
  - Education for wider staff
- Evaluate staff:
  - Baseline and periodic evaluation of employees and volunteers
- Clinical: separate, diagnose/”rule-out,” +/- treat:
  - For whom to initiate isolation and when to discontinue isolation
  - Proper diagnostics, including rapid molecular testing
  - Prompt treatment when warranted, tailored by drug susceptibility testing (DST)
  - Coordinating with public health
- Cleaning, disinfection, sterilization of equipment
- Organizational measures to ensure environmental controls and PPE

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The TB Infection Control Plan (IPC)

- ***Leadership***: a single program leader with the authority and resources to administer the IPC, knowledgeable in TB
- ***Implementation***: nurse(s) or other infection preventionist(s) with time allocated for TB infection control duties
- ***Infection Control Committee*** to bring together a multidisciplinary group (MD, RN, facilities, occupational health, microbiology)
- ***TB Risk Assessment***: vulnerable populations for TB progression (HIV, children, immunocompromised)

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TB Risk Classifications

	LOW	MEDIUM	Potential Ongoing Transmission
Inpatient >= 200 bed Inpatient <200 beds	<6 TB patients per year <3 TB patients per year	>=6 TB patients per year >= 3 TB patients per year	Evidence of ongoing transmission regardless of setting
Outpatient	<3 TB patients per year	>= 3 TB patients per year	Evidence of ongoing transmission regardless of setting
Nontraditional facility-based settings (long-term care, EMS, correctional, etc.)	Only treat patients with LTBI System to detect TB symptoms No cough-inducing procedures	Settings where TB patients are expected to be encountered	Evidence of ongoing transmission regardless of setting

Low risk: unlikely to encounter TB disease

Medium risk: might be exposed to TB disease

CDC 2005

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Conducting a TB IPC Facility Risk Assessment

- At least annually, may be more frequent
  - (e.g., new patient areas, suspicion for TB transmission within the facility)
- Review community incidence
- Review utilization of spaces, crowding/flow of people, location of TB patients with regards to vulnerable populations
- Types of environmental and personal respiratory protections required by specific people in specific areas
- Routine checks on control measures for high-risk procedures like sputum induction

CDC has a TB risk assessment worksheet, Appendix B of "Guidelines for preventing the transmission of Myobacterium tuberculosis in health-care settings, 2005 MMWR) https://www.cdc.gov/tb-healthcare-settings/media/pdfs/Tuberculosis_Risk_Assessment_Worksheet_for_Facilities.pdf

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Baseline TB screening/evaluation of employees

- Before employment:
  - Test healthcare personnel (HCP) for TB infection without documented evidence of prior LTBI or TB disease
  - ***Individual risk assessment*** and symptom evaluation (>=1 month in TB-endemic country, current/planned immunosuppression, close contact with a person with active TB)
- 2019 CDC MMWR : no more routine serial screening of HCP
  - ***Certain groups*** might undergo routine serial TB screening (e.g., respiratory therapists, pulmonologists) or in settings where transmission has occurred in the past
- Annual TB education for HCP
- Encourage LTBI treatment in untreated HCP with TB infection
  - Annual symptom screening for HCP with untreated LTBI

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MMWR 2019 Sosa et al. 68 (19): 439-443

Evaluation of employees (2 of 2)

If TB exposure (i.e., without adequate PPE):

- Timely symptom evaluation and additional testing if indicated
- Perform TST or IGRA if no prior documented LTBI/TB and retest in 8-10 weeks if first test is negative
- New positive test: clinical evaluation and chest X-ray
- If prior LTBI/TB, then further evaluation if concern for TB exists

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Training and Education of Employees

Regular concise training for all personnel (including non-clinical) on:

- TB bacillus and the difference between latent infection and disease
- Airborne transmission of TB and infectiousness vs. other pathogens
- Signs and symptoms of TB disease
- Management of crowding and other environmental factors
- How and when to use appropriate respiratory PPE
- The availability and effectiveness of treatment regimens!

https://www.cdc.gov/tb/education/tb_coe/default.htm

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Personal Protective Equipment (PPE)

- **Respirators** are needed for aerosol particles **<5 micrometers in diameter**, small enough to be deposited deep in the lungs
  - Prevent inhalation of particles (*not for source control*)
- Not generally recommended for those with pulmonary TB (increased work of breathing vs. a surgical mask)
- Respiratory authenticity check: https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/default.html
- Require **fit testing**, frequency depends (e.g., change in facial features), usually annual, may need PAPR if inadequate seal

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Personal Protective Equipment (PPE)

Four Major Types of Respiratory:

- Filtering facepiece respirators (FFR) including N95
- Powered air-purifying respiratory (PAPR)
- Elastomeric half mask respirators
- Elastomeric full facepiece respirators

FIGURE 3. **Examples of N95 respirators**

Sources: CDC https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/free-n95-manufacturers.html and jocic/Shutterstock.com

Powered Air-Purifying Respirators (PAPR)

Source: CDC https://phil.cdc.gov/Details.aspx?pid=23209 and 3M

Half-mask elastomeric respirator

Source: anmbph/Shutterstock.com

Curry Center, "Tuberculosis Infection Control…" 2022 Updates, "PPE"

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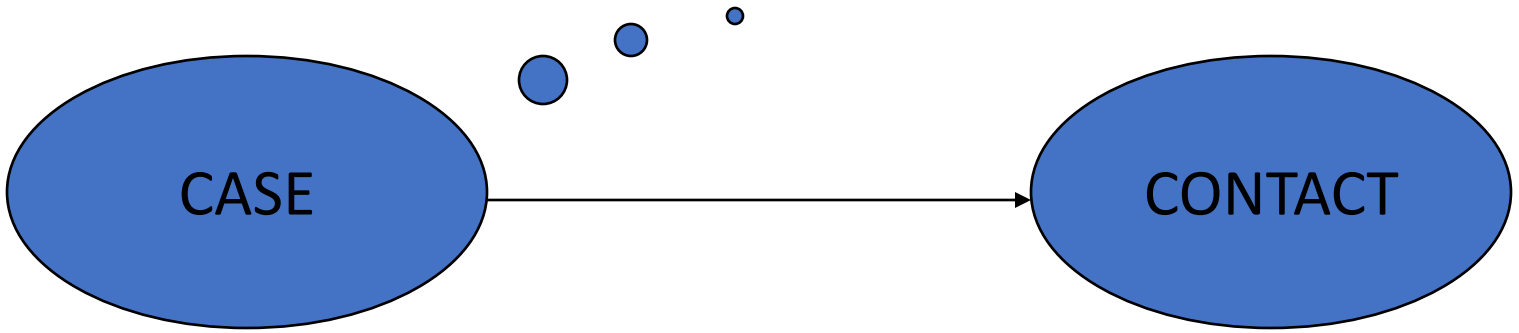
PART III (The Environment)

Transmission of Tuberculosis

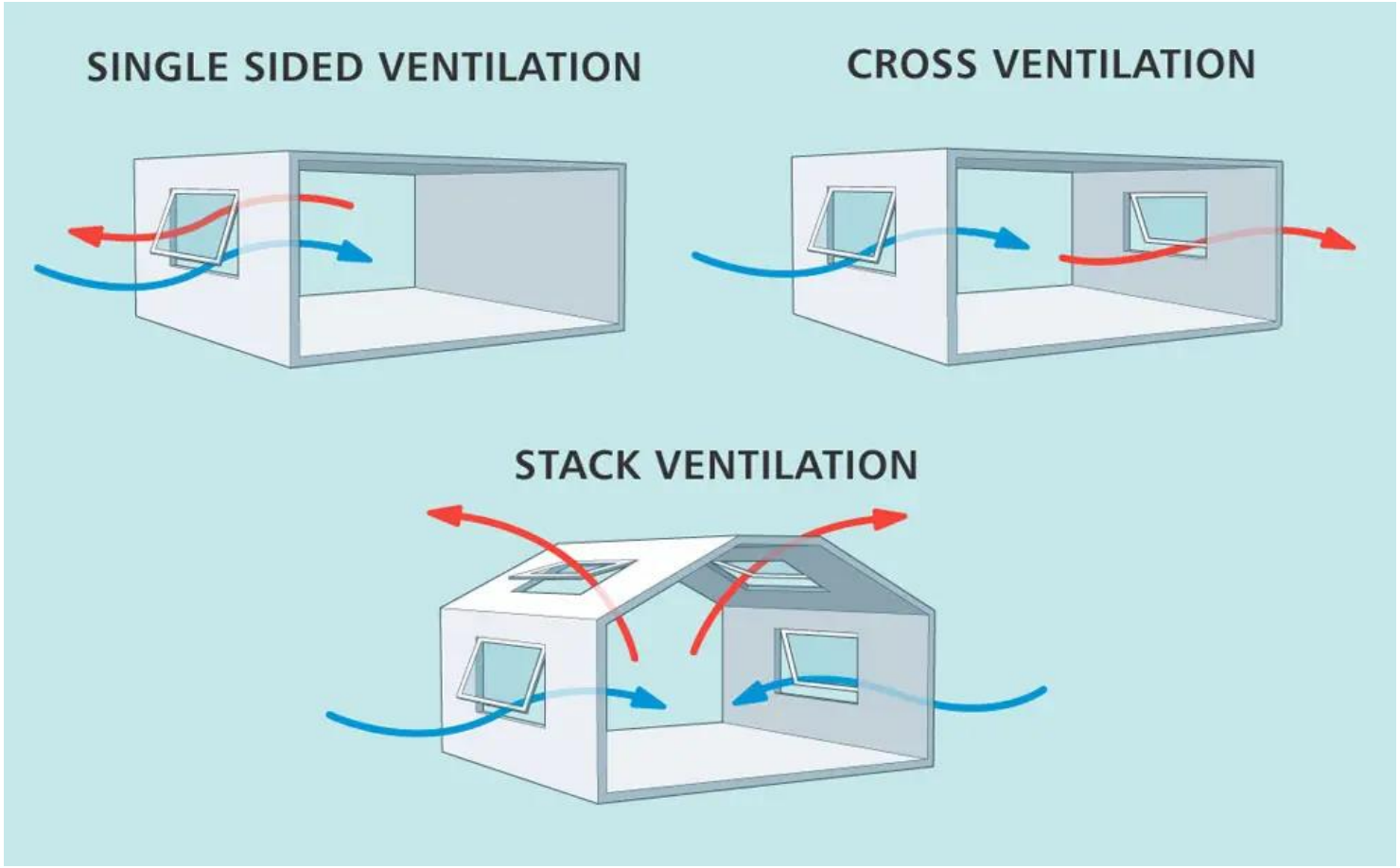


Site of TB
Cough
Bacillary load
Treatment

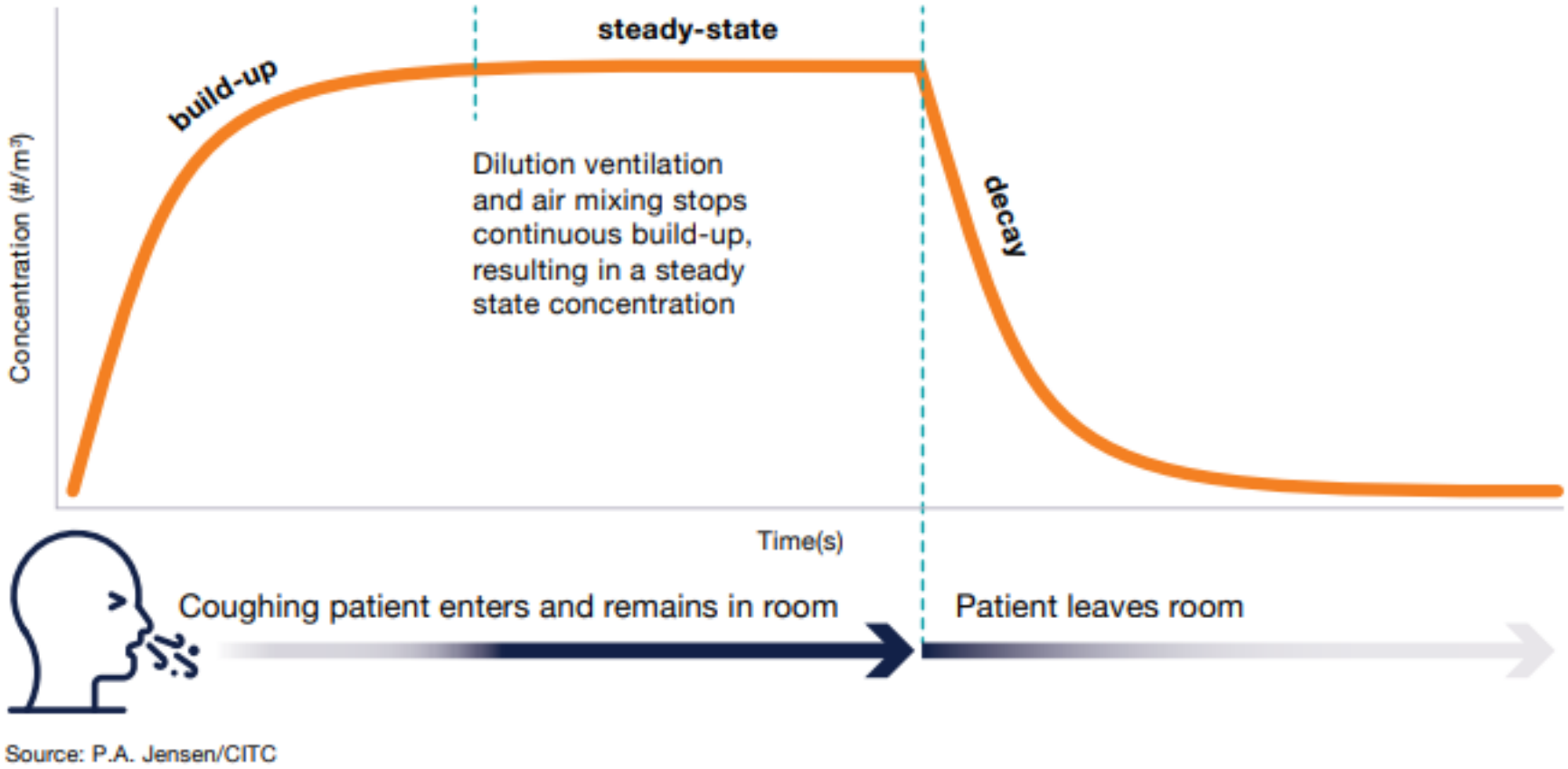
Ventilation
Filtration
U.V. light

Closeness and
duration of contact
Immune status
Previous infection

Natural Ventilation (warm air rises, buoyancy forces) Dilution, Displacement



Dilution Ventilation to Clear Particles



Source: P.A. Jensen/CITC

Curry Center, "Tuberculosis Infection Control…" 2023

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Assessing and increasing Ventilation

Windows and doors open: mean ACH 5.5
Windows, doors, and skylights open: mean ACH 15
ACH = air changes per hour

- The movement of air in a building and replacement of inside air with air from the outside (dilutes & removes particles)
- **Natural Ventilation**: open doors and windows, fans may assist
- **Mechanical Ventilation**: Air-moving system to circulate air
- Contaminated air is either removed outside (***exhausted***) or filtered or irradiated and returned (***recirculated***)
- Air outlets: diffusers (entry), grilles/registers (exit)
- Smoke test for ventilation

Types of Environmental Controls

ENVIRONMENTAL CONTROLS FOR TB INCLUDE:		
Ventilation		**Ultraviolet C-Band (UVC)**

MECHANICAL & NATURAL VENTILATION
Mechanical ventilation: heating, ventilating, air-conditioning (HVAC) systems
• Dilution ventilation
• Unidirectional ventilation
• Single-pass ventilation
• Recirculating ventilation
  • No filtration
  • Filtration: low, medium, or high; high efficiency particulate air (HEPA)
  • In-duct UVC (UVGI)
Mixed-mode ventilation
Natural ventilation
	ROOM AIR CLEANERS (RACs)
	• HEPA filtration
	• Minimum efficiency reporting value (MERV) 11-14 filtration
	• UVC
		• Upper-room UVC
		• Whole-room UVC
		• In-duct UVC
		• RACs with UVC

Curry Center, "Tuberculosis Infection Control…" 2023

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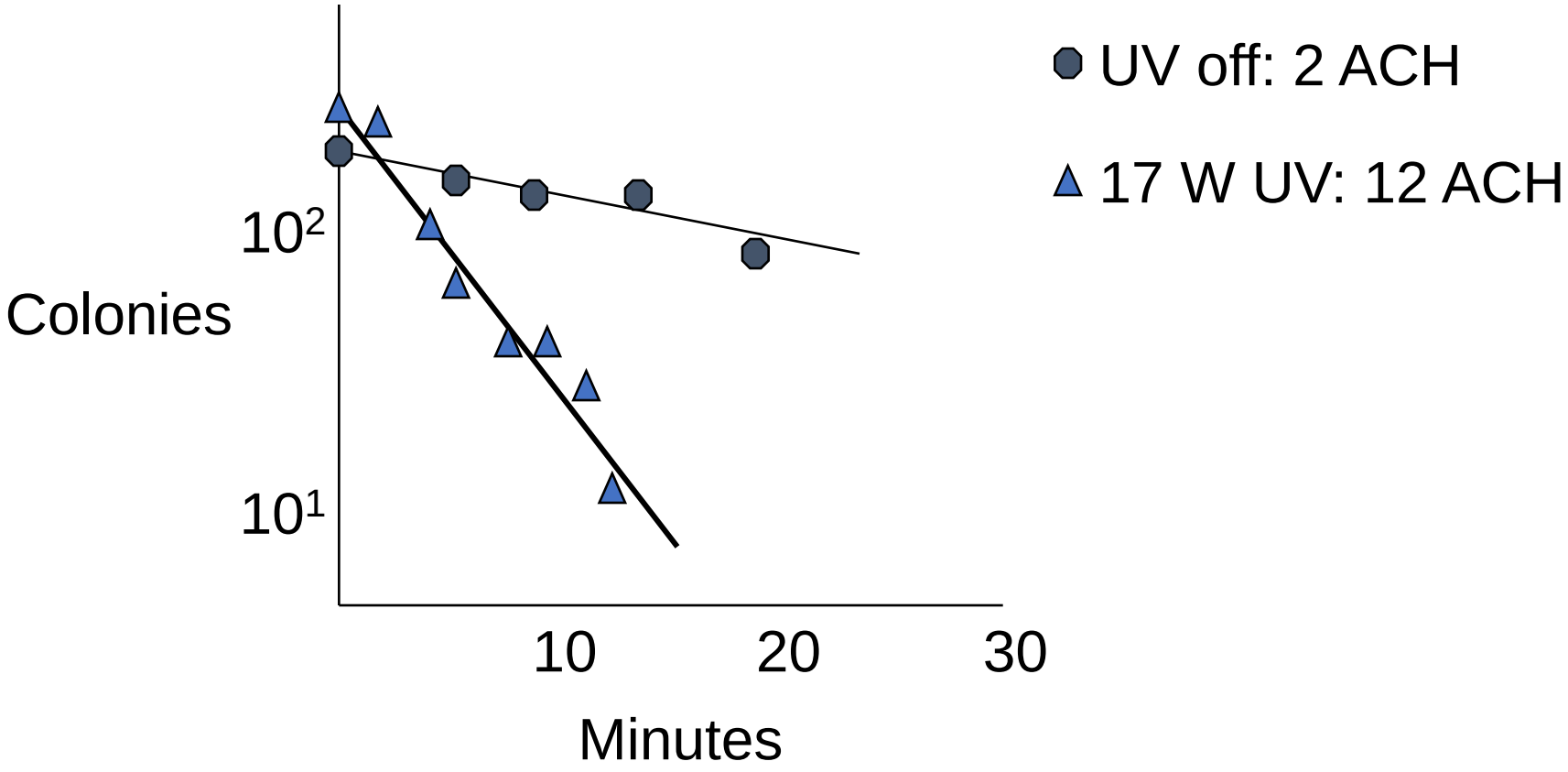
UVGI (Removal of Aerosolized BCG by UVGI)



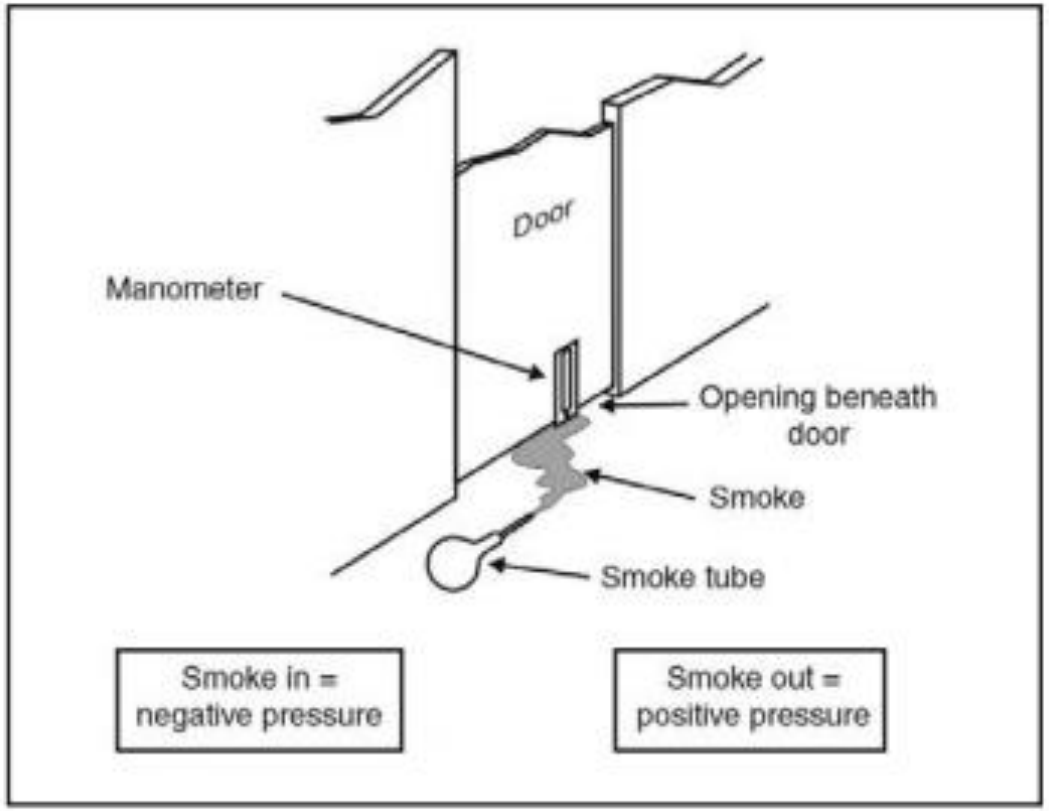
Adapted from Riley, et al. ARRD 1976;113:417

Negative Pressure

- Higher to lower pressure
- Airflow into room
- 10% flow differential (85 m3/h minimum)
- Pressure differential
- Doors and windows should be closed
- Proper direction & no stagnation on smoke tube testing

CDC 2005

FIGURE 5. Smoke tube testing and manometer placement to determine the direction of airflow into and out of a room



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Airborne Infection Isolation Rooms (AIIR)

- CDC 2005 recommendations: ***minimum of 12 air changes per hour (ACH)***, 2 ACH from outdoor air
- Minimum pressure differential relative to surrounding area of at leat 0.01 inches of water gauge (“w.g.) (2.5 Pa); in practice, usually set at 0.05 “w.g. (12.5 Pa)
- Minimum airflow differential (exhaust vs. supply) at least 10% or 100 CFM (>170 m3/h)

TABLE 1. **How to quantify negative pressure and airflow differential**

PARAMETER	UNITS OF MEASUREMENT	MEASURING DEVICE
Pressure differential	• inches of water gauge (“w.g.) • Pascals (Pa)	Manometer
Speed of air under the door	• feet per minute (FPM) • meters per second (m/s)	Velometer
Exhaust airflow differential	• cubic feet per minute (CFM) • cubic meters per hour (m^3/hr)	Air capture hood

Curry Center, “Tuberculosis Infection Control…” 2023

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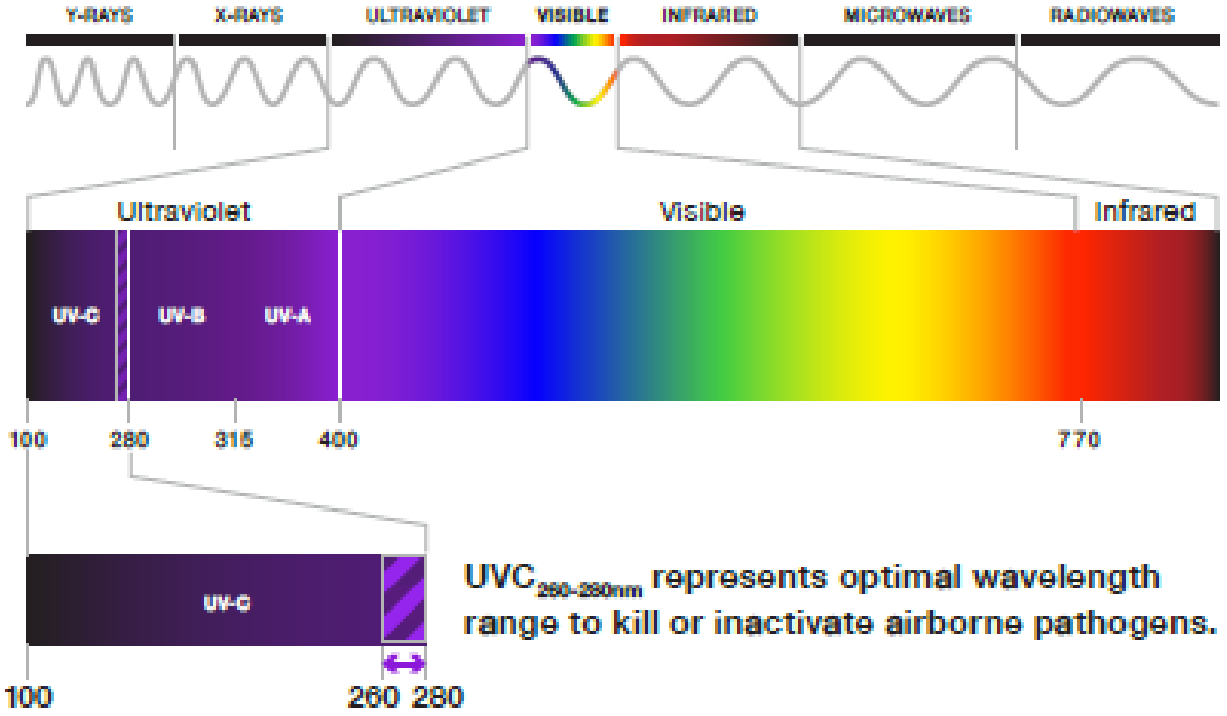
Environmental Controls: UVC



Curry Center, "Tuberculosis Infection Control…" 2022 Updates, "Environmental Controls: UVC"

- Ultraviolet radiation in the C subregion (100-280 nm) or **UVC** used in Ultraviolet Germicidal Irradiation (**UVGI**), aka Germicidal Ultraviolet (**GUV**)
- **UVC_{254}** is the specific wavelength often used (260-280 optimal), better safety profile?
- Sunlight UVC is not sufficient to kill TB in a reasonable amount of time (filtered by atmosphere)

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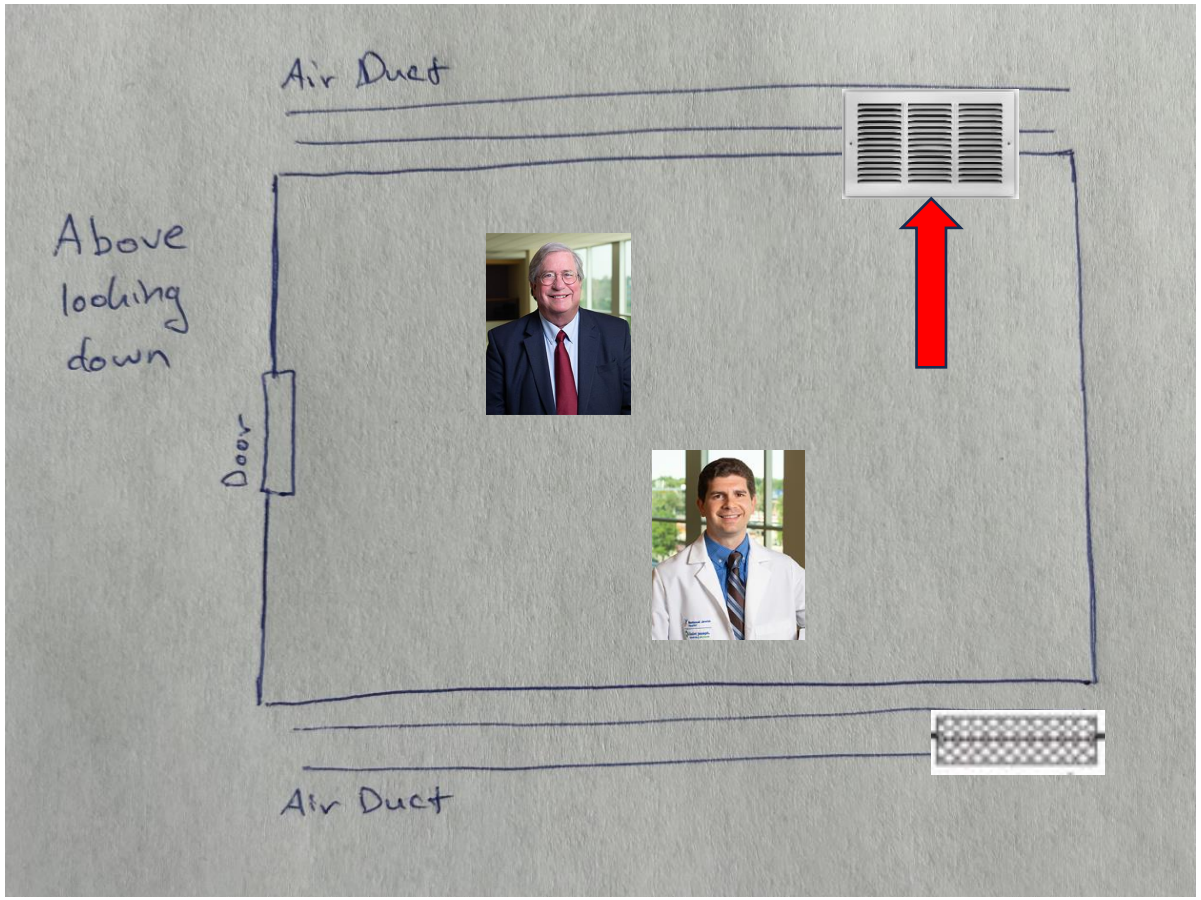
THIRD ACTIVITY:

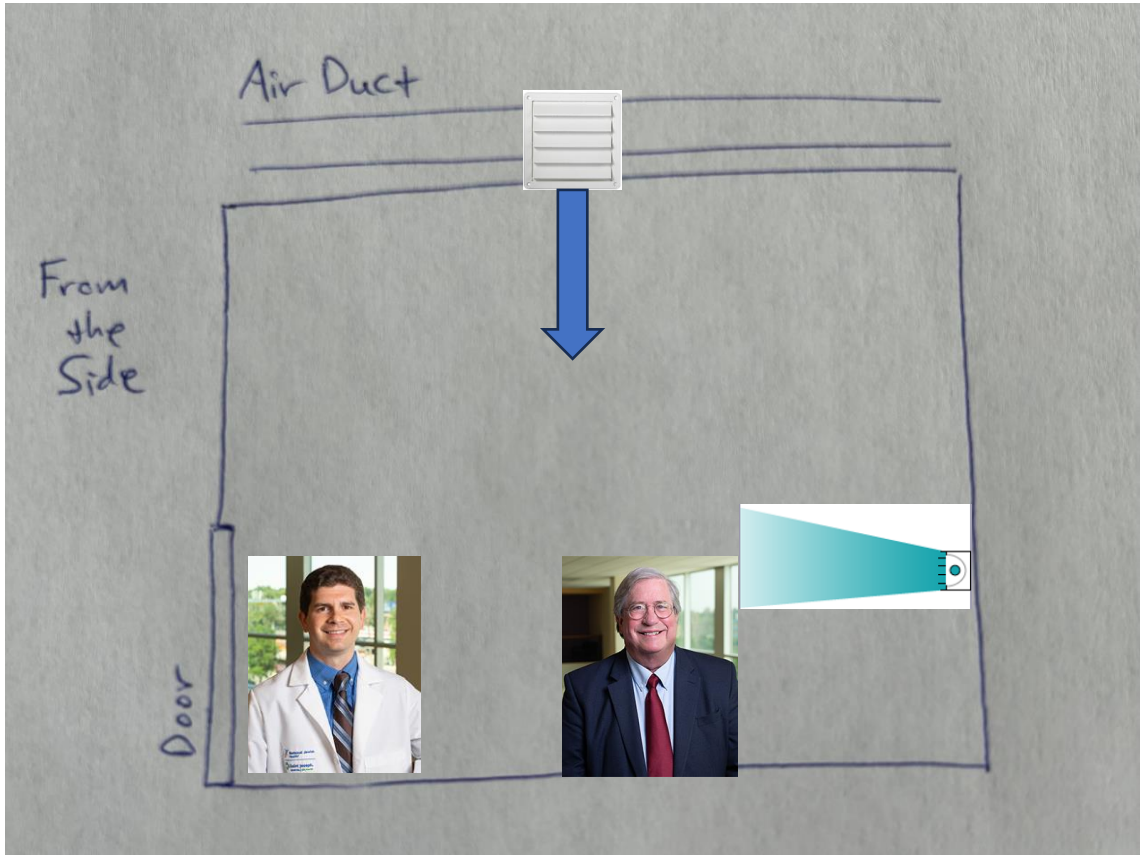
Your hospital is building a new wing and would like your input on room layout that best prevents the spread of respiratory infections.

You will need to draw up some diagrams incorporating how your rooms will manage the following:

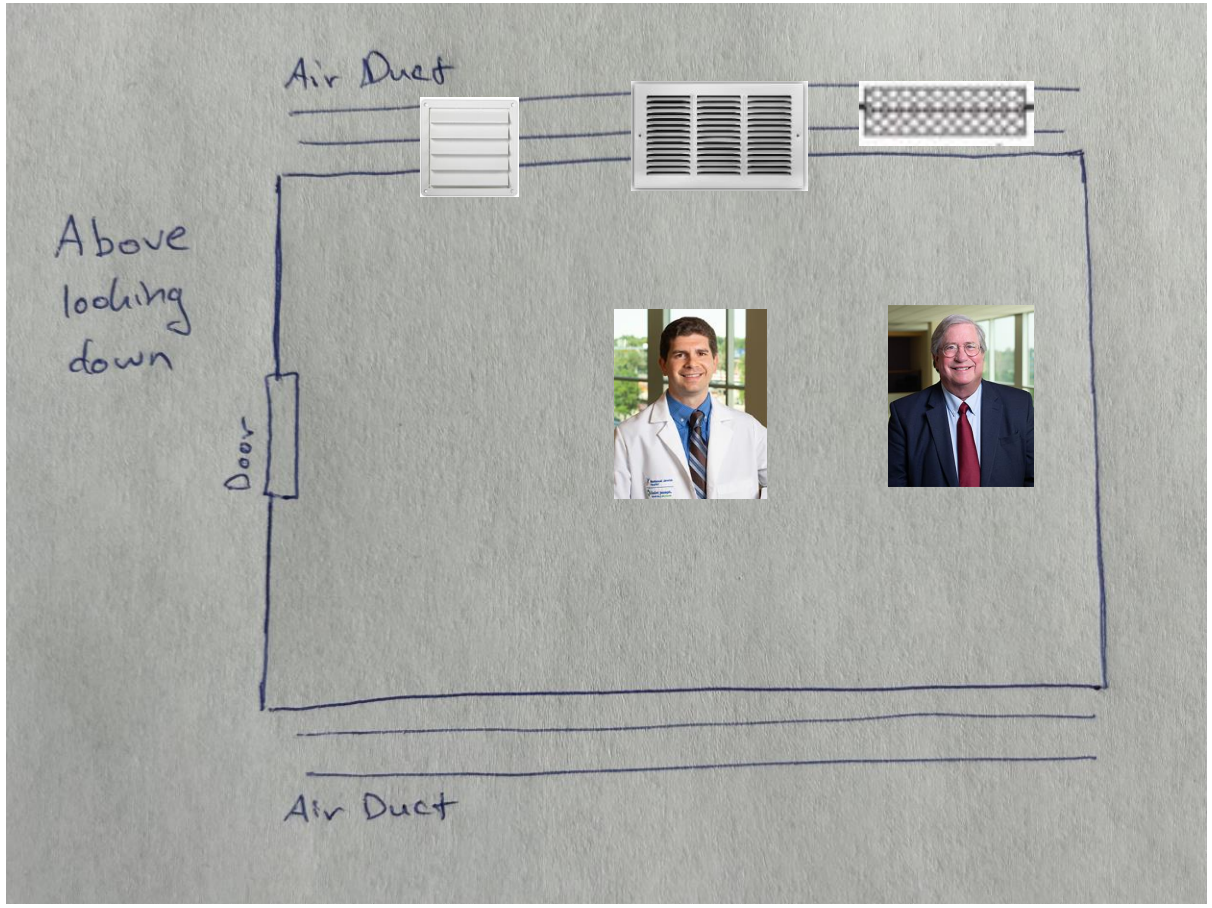
- Positioning of a patient (e.g., Dave)  and a provider (e.g., Dr. Eddy) 
- Positioning of intake (diffuser)  and exhaust (grille, register)  ports for air flow
- Location of HEPA filtration systems 
- Location of UVGI 

Examples of positioning icons on diagrams

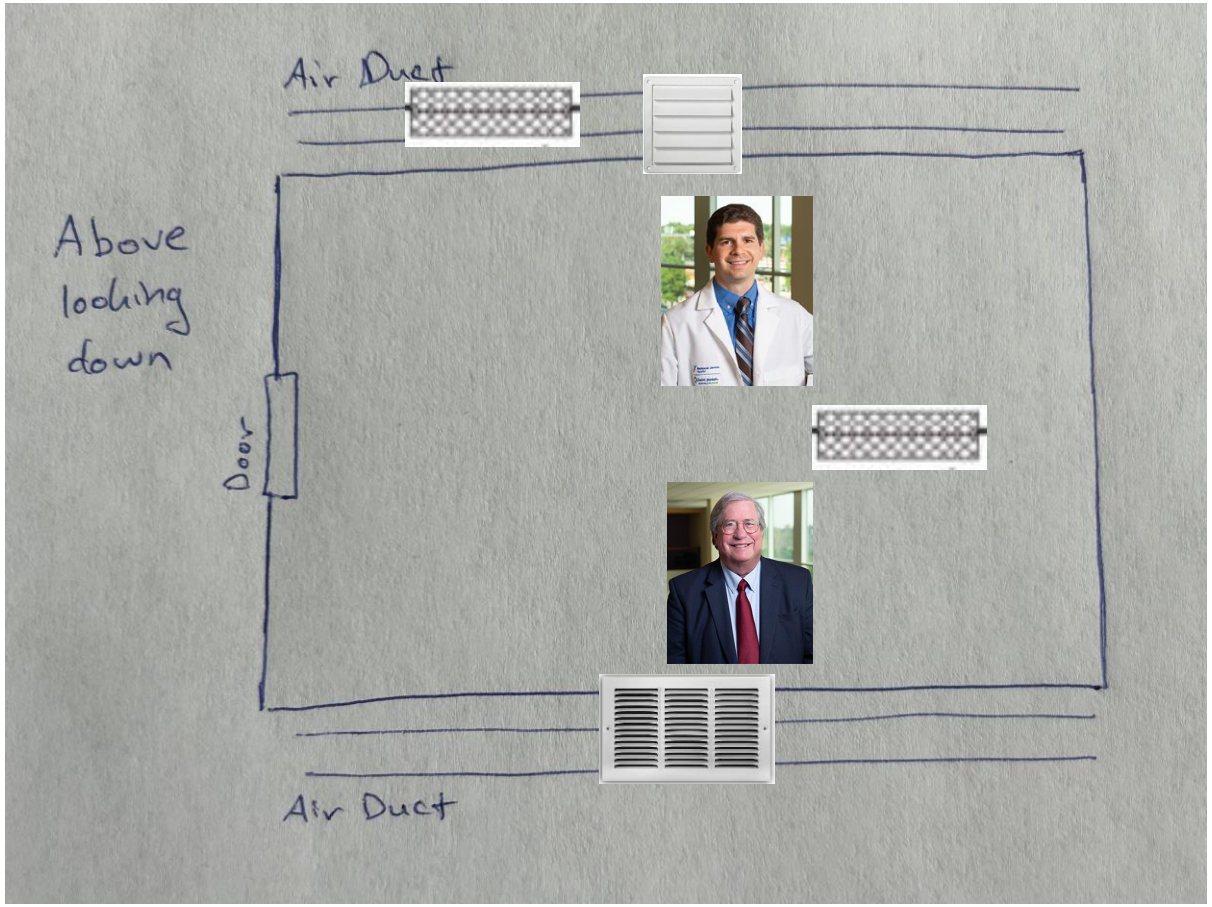




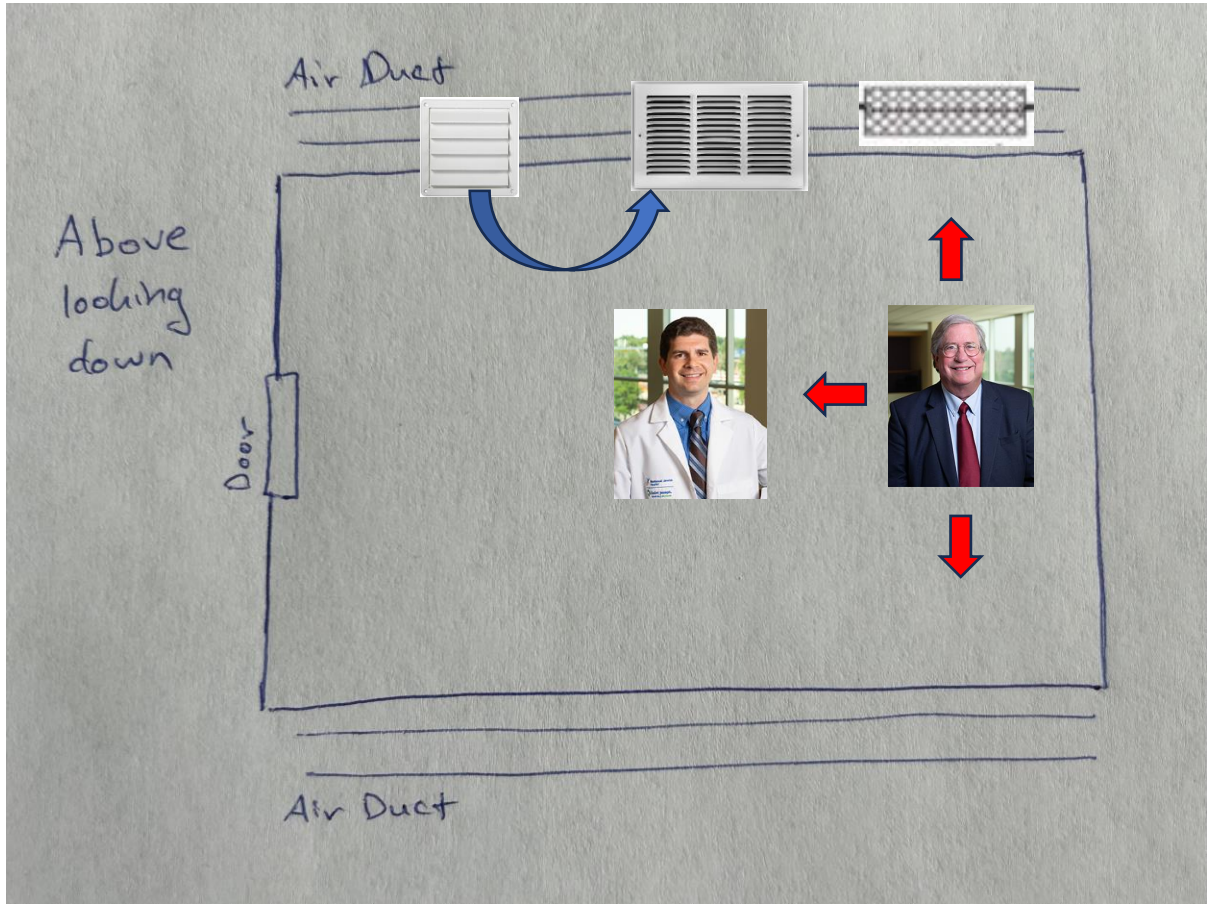
Scenario 1



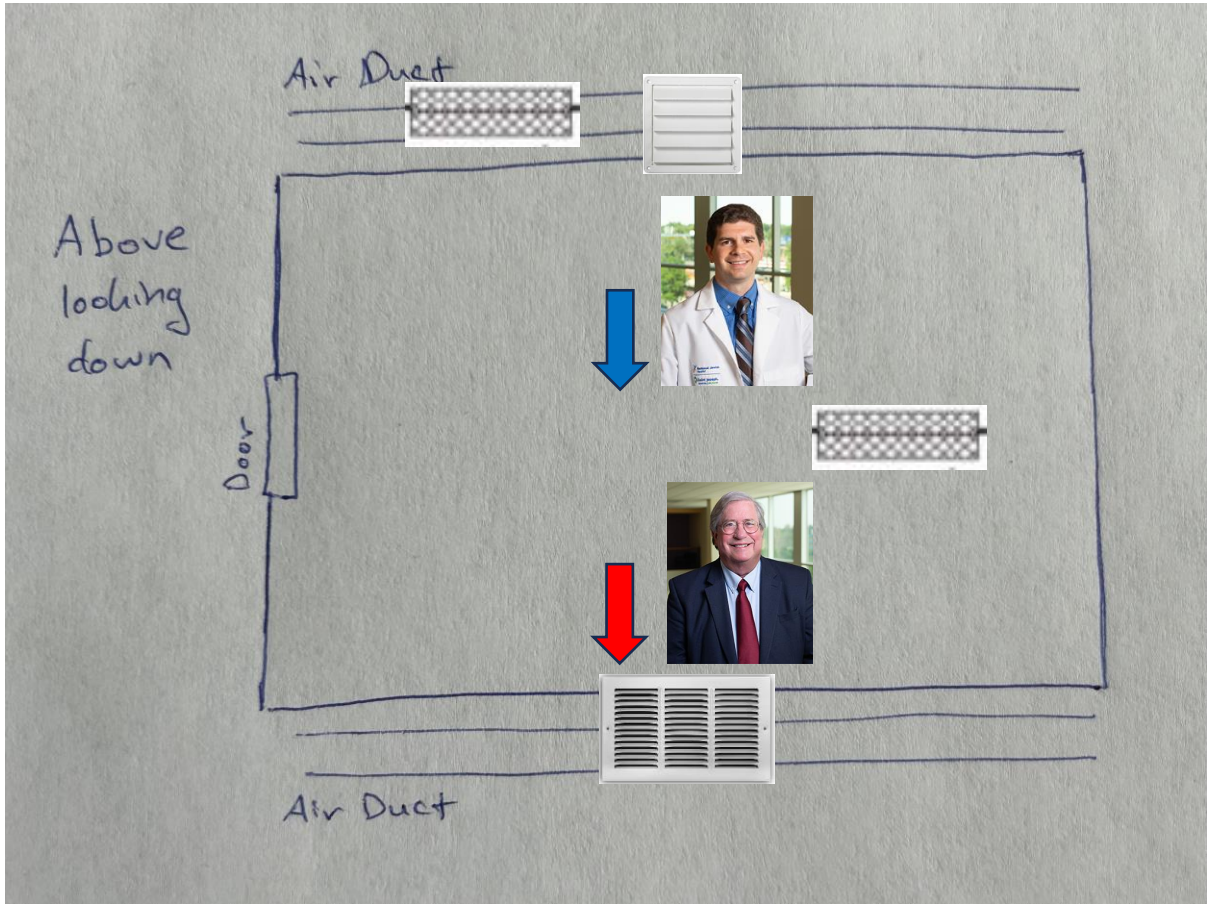
Scenario 2



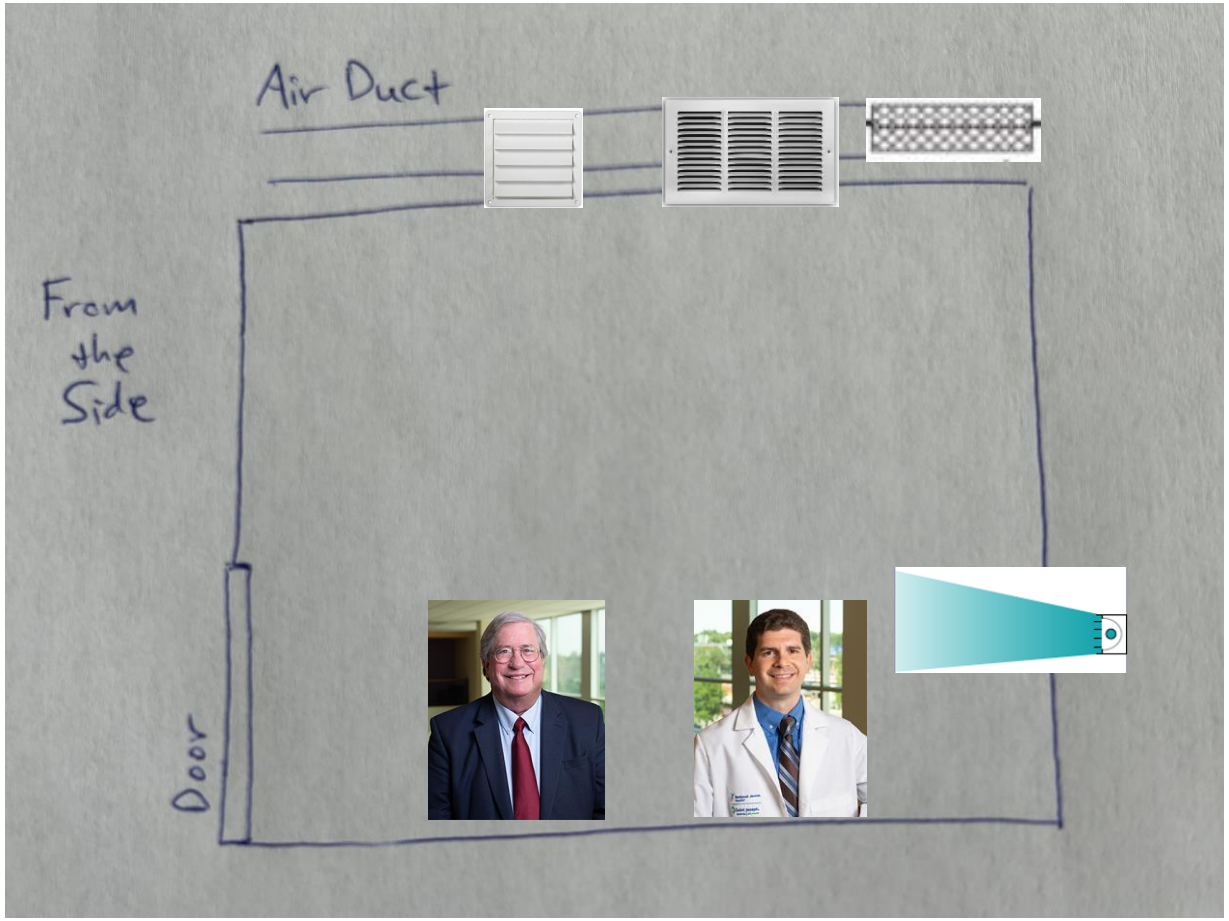
WRONG: Short-Circuiting and Stagnation



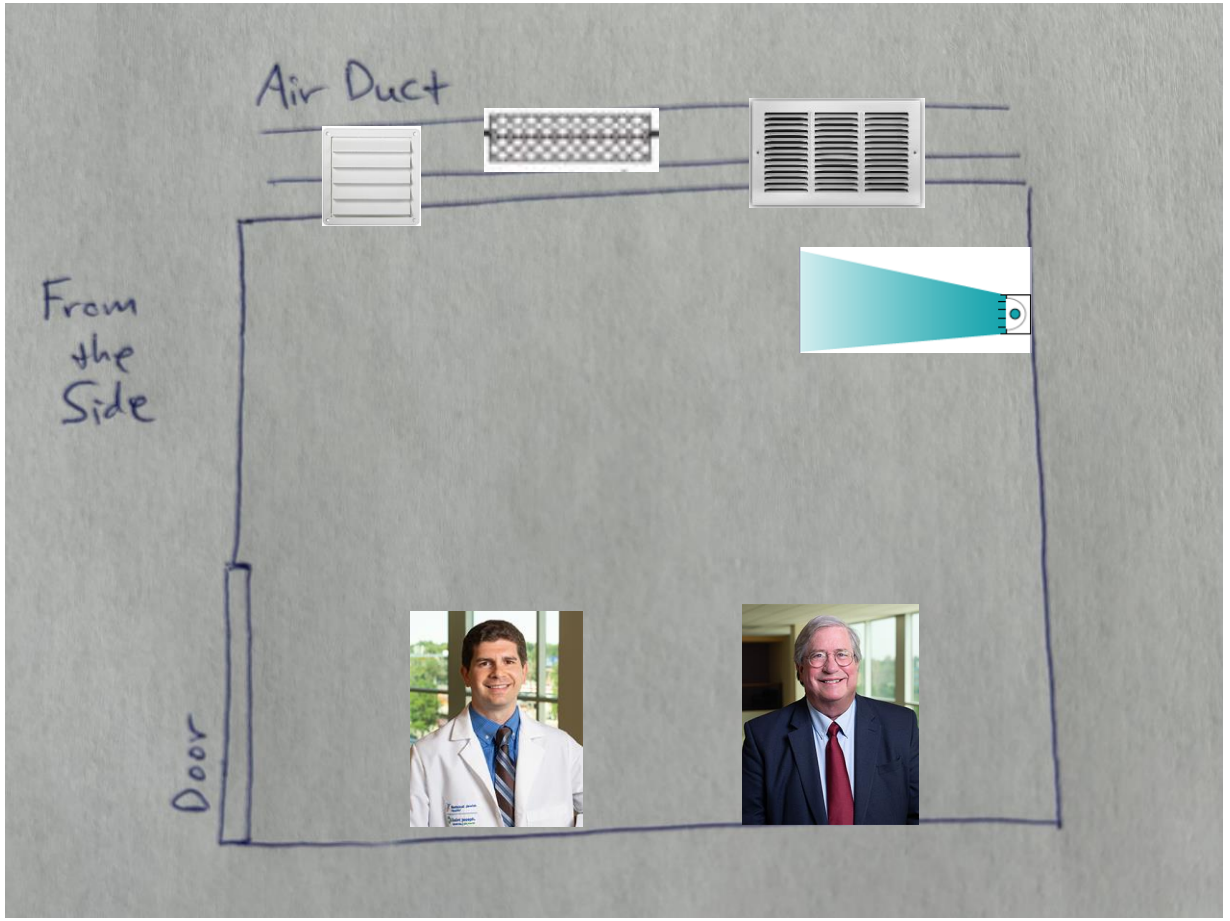
CORRECT: separation of intake & exhaust, correct directional air flow



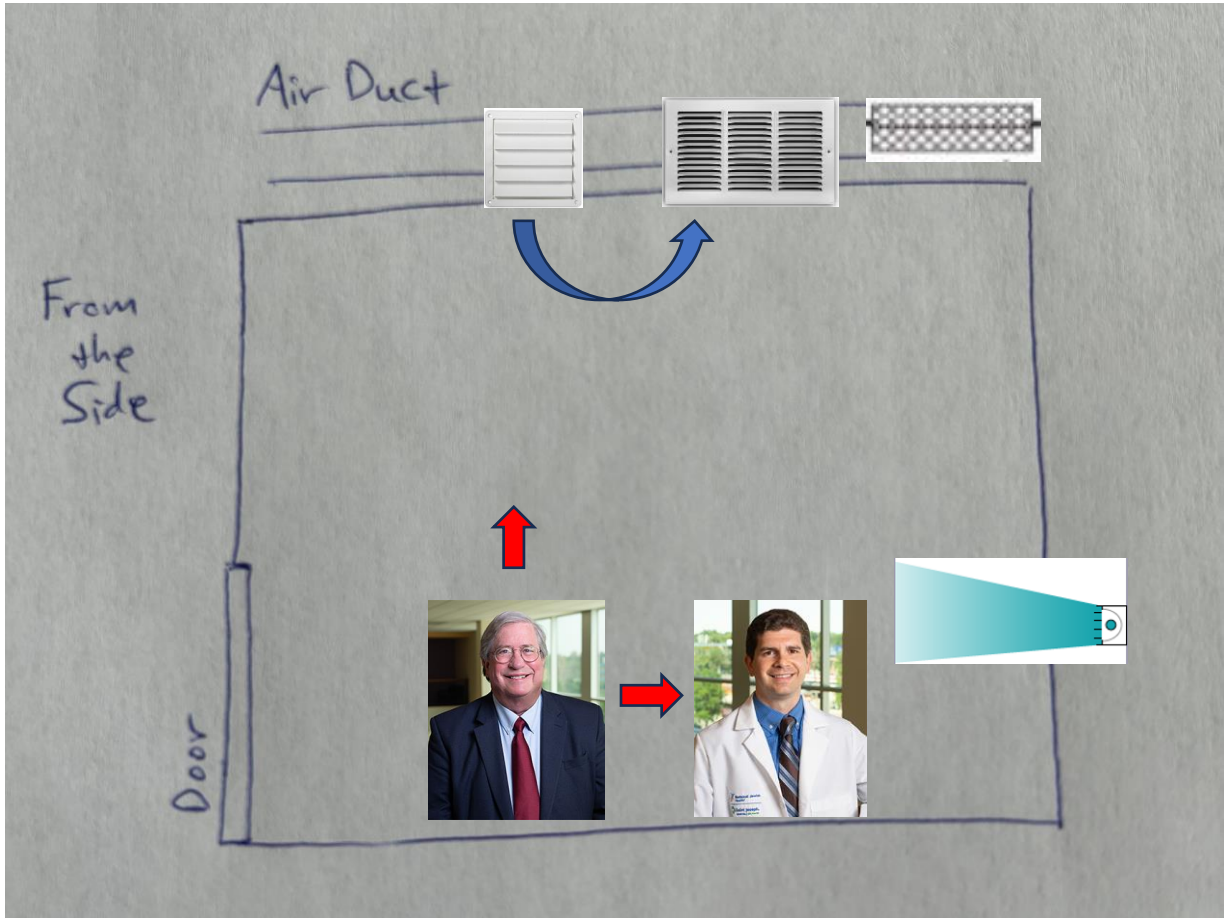
Scenario 3



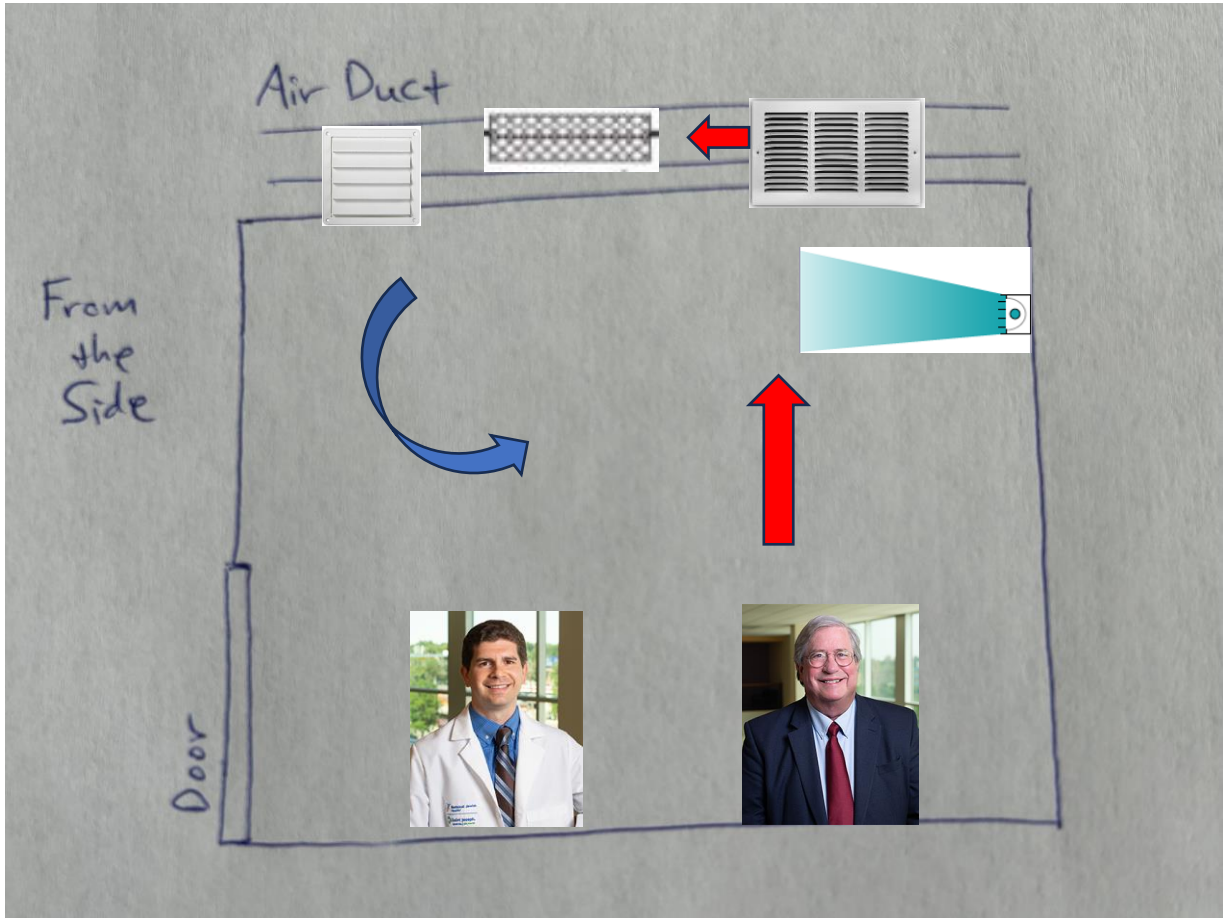
Scenario 4



WRONG: Short-Circuiting and Stagnation



CORRECT: separation of intake & exhaust, correct directional air flow



Poor Ventilation

- **Stagnation**: part of the room does not benefit from fresh air supply, or has no ventilation
- **Short-circuiting**: clear air is removed before it has mixed well with room air (e.g., exhaust located right next to supply)
- **Stratification**: warm air (during winter/heating season) diffused near the ceiling does not mix with lower air

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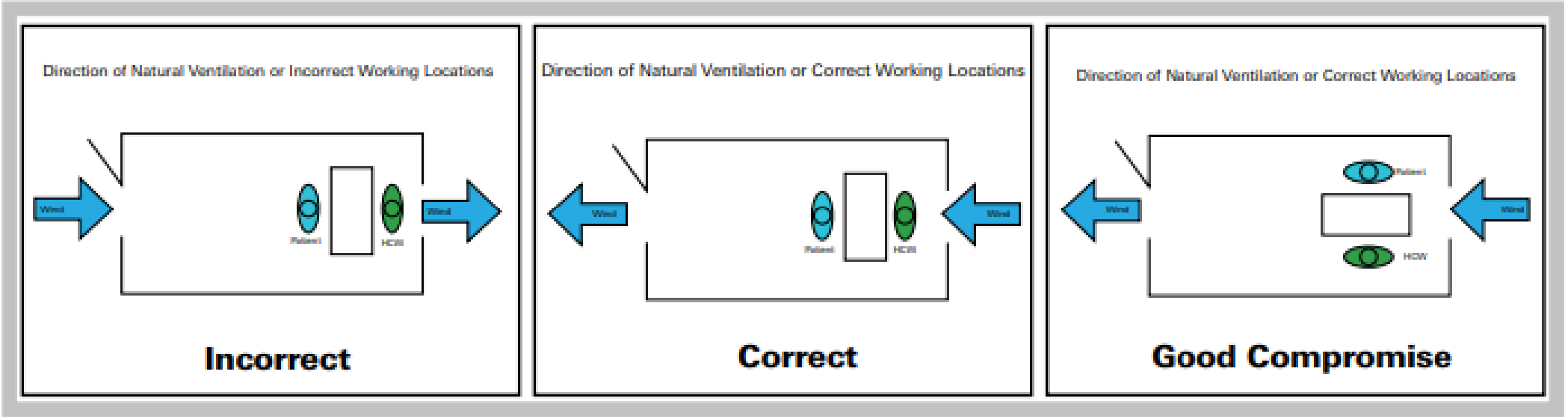
Directional Air Flow

- Locate people to be protected by the supply and infectious people by the exhaust



TBCTA/CDC/USAID IMPLEMENTING the WHO Policy on TB Infection Control

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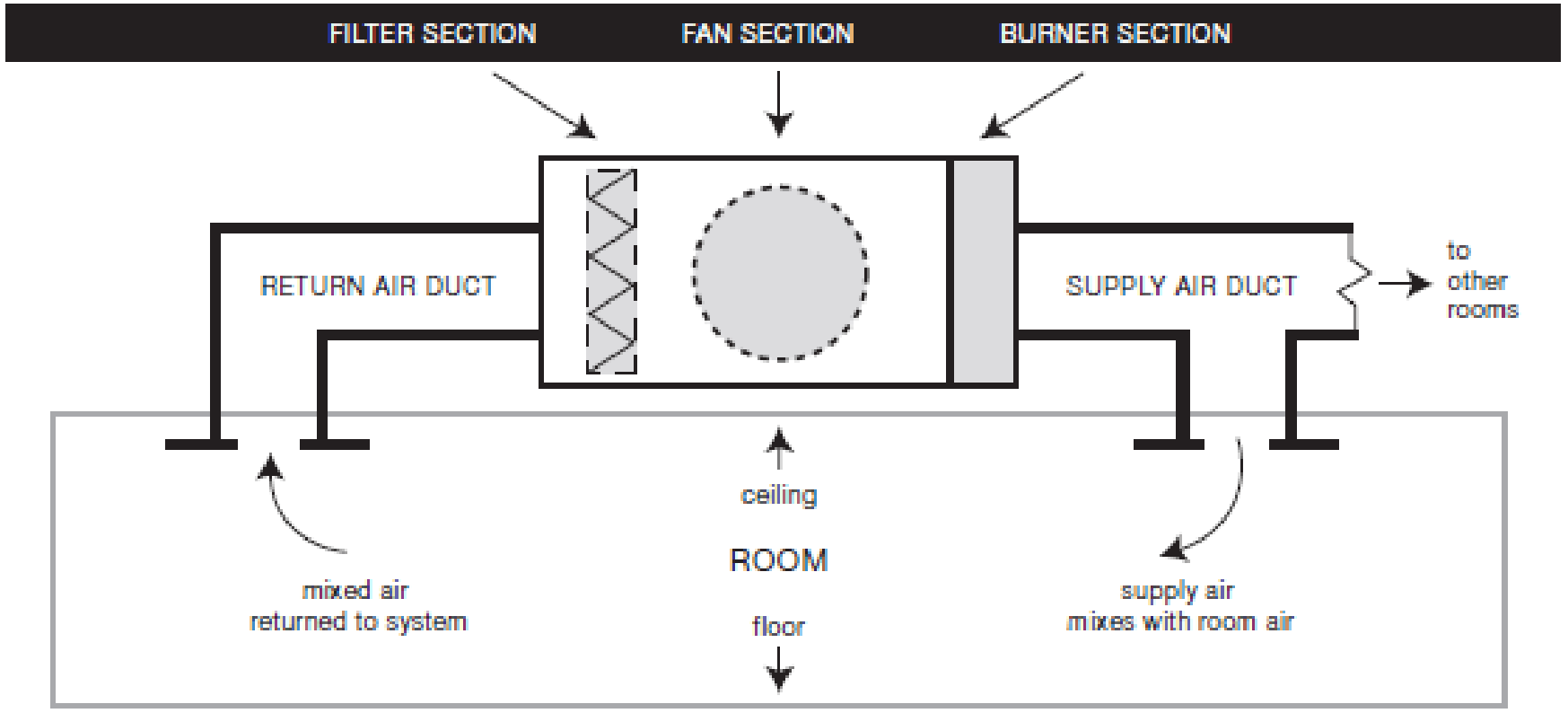
Recirculating Central Ventilation Unit

FIGURE 2.

Recirculating Central Ventilation Unit



Curry Center, "Tuberculosis Infection Control…" 2011

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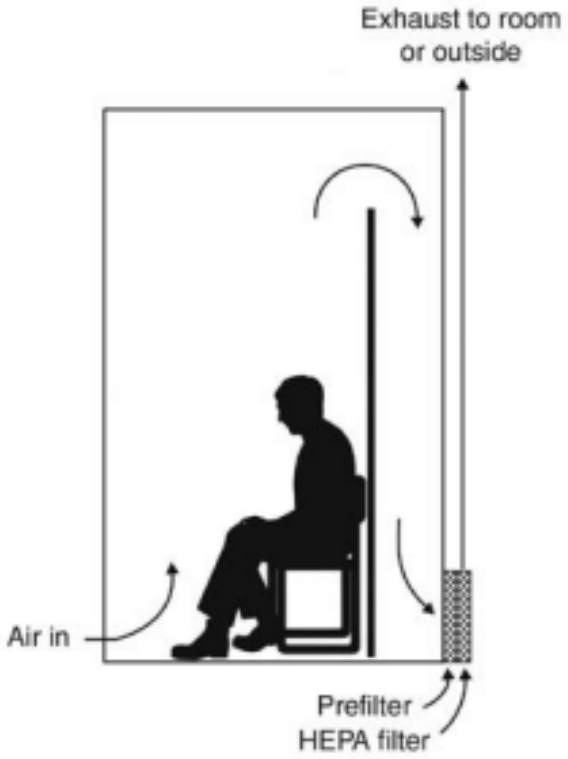
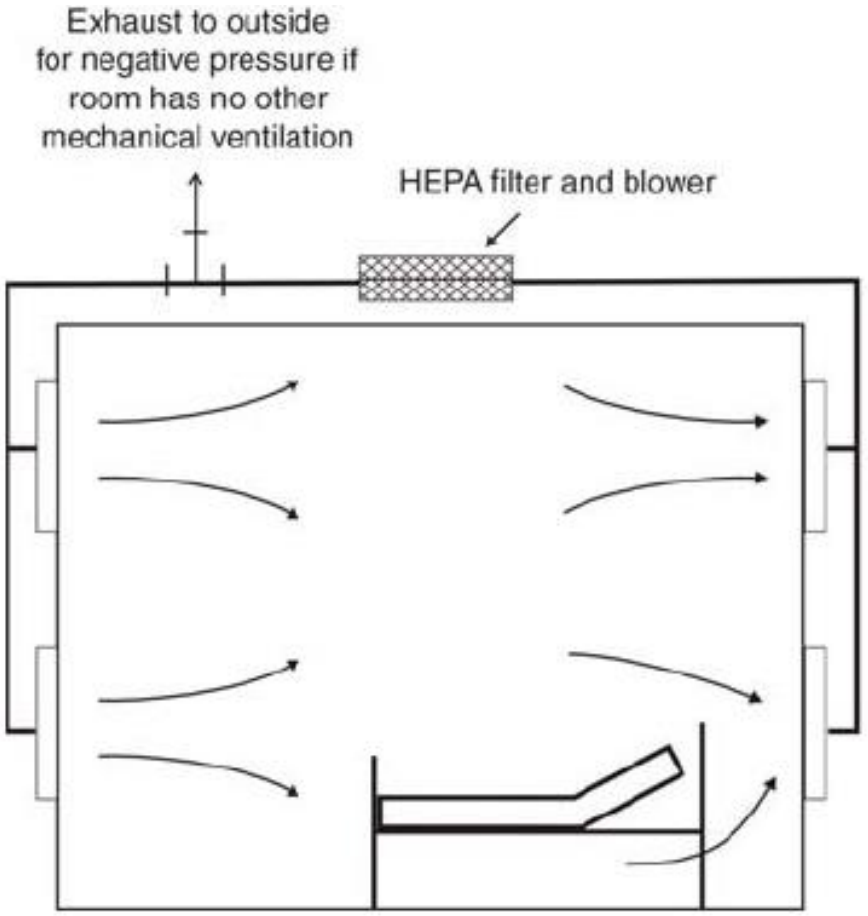
HEPA Filters

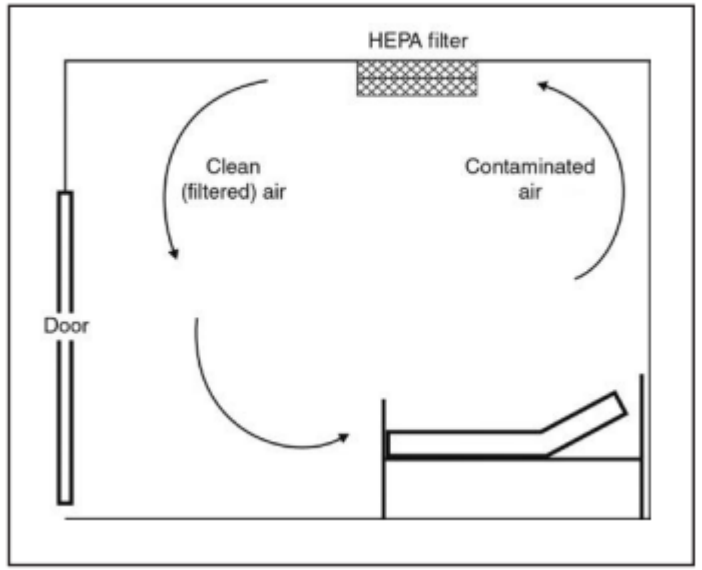




CDC 2005

- Reduce the concentration of *M. tuberculosis* droplet nuclei

FIGURE 8. Fixed ceiling-mounted room-air recirculation system using a high efficiency particulate air (HEPA) filter



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Upper-room and In-duct UVC_{254} System

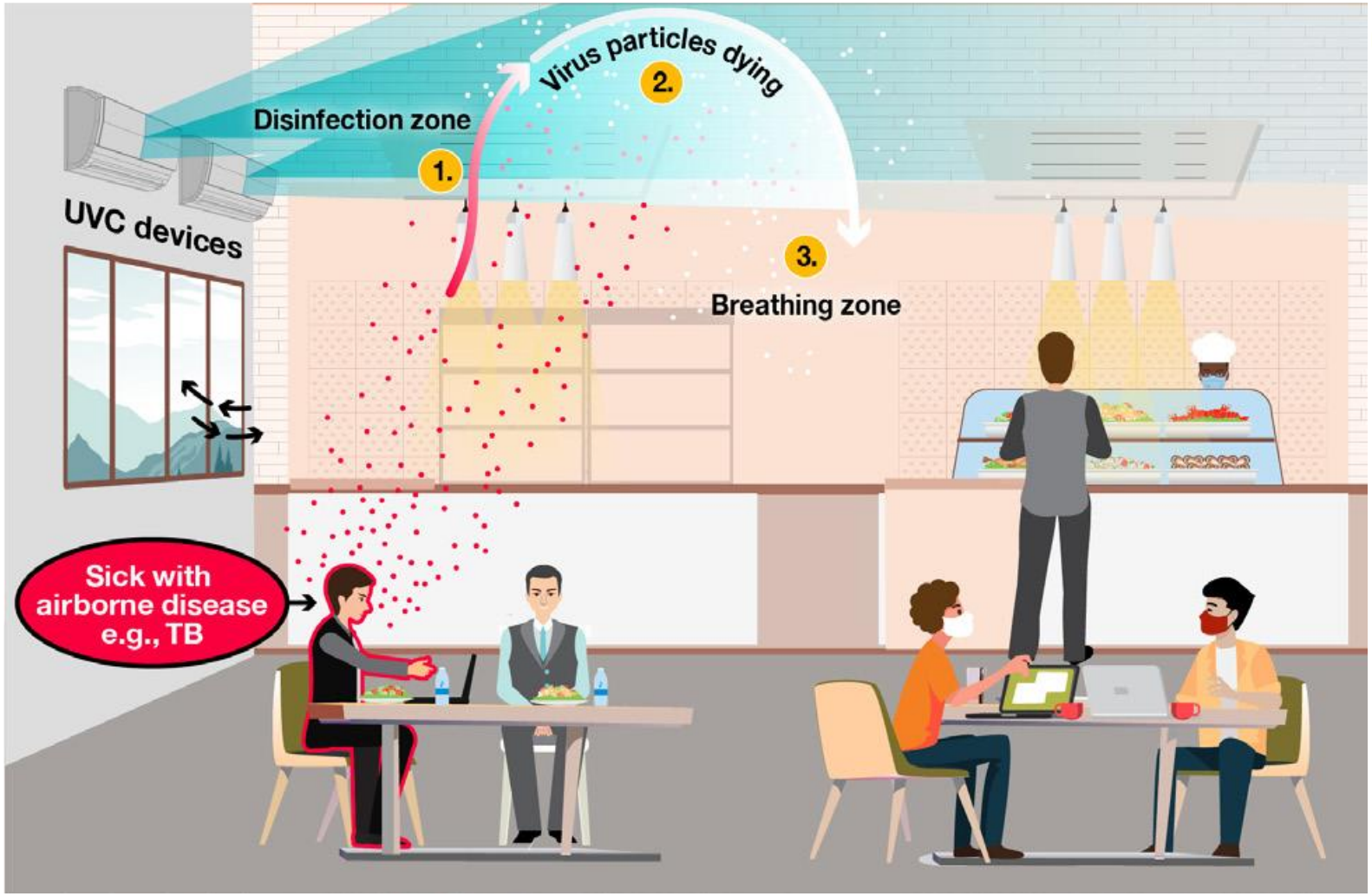
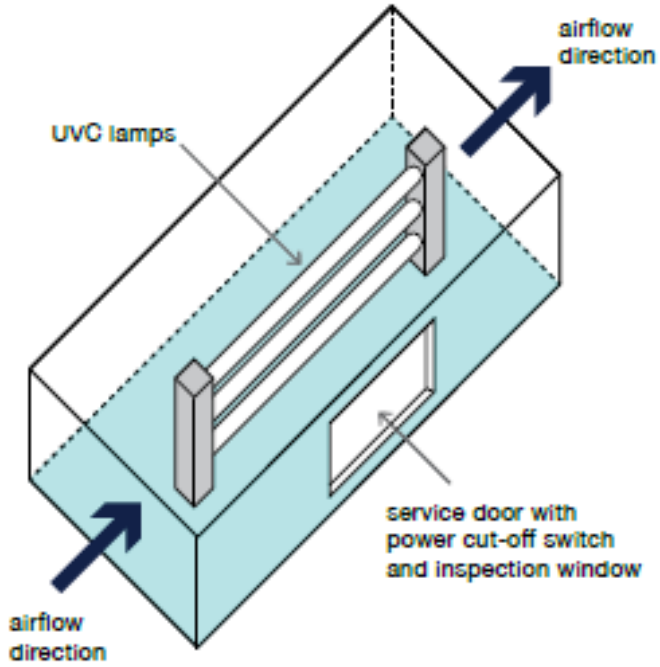


FIGURE 5. Schematic of in-duct UVC_{254} system



Curry Center, "Tuberculosis Infection Control…" 2022 Updates, "Environmental Controls: UVC"

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