Session II – HAP Training Institute Exposure Assessment

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AGENDA

- Presentation – Principles of Exposure Assessment
- Equipment demonstration
  - Station 1 – Real-time particulate matter sampling
  - Station 2 - Integrated particulate matter sampling
  - Station 3 – Carbon monoxide sampling and carboxyhemoglobin assessment
  - Station 4 – Particulate matter composition assessment

Faculty

- Johns Hopkins University Bloomberg School of Public Health
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Principles of Exposure Assessment

Exposure Assessment Concepts

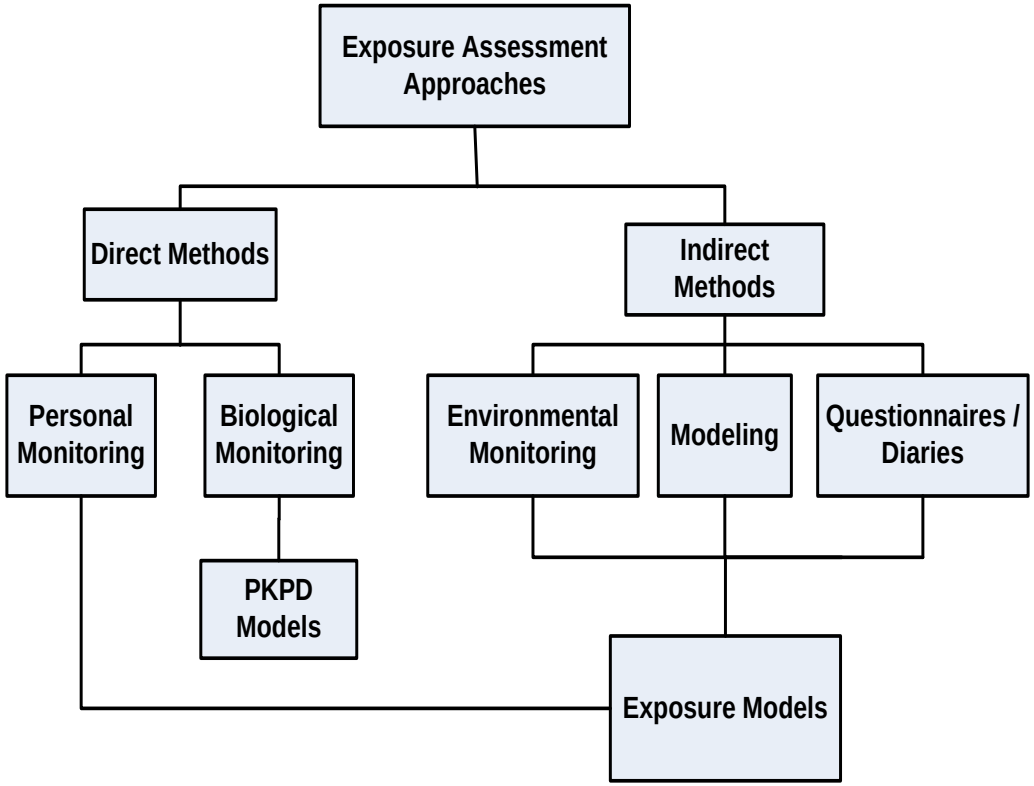
- Exposure
  - Contact between an agent and a target (person)
- Exposure Assessment
  - The process of estimating or measuring the magnitude, frequency and duration of exposure to an agent
  - The number and characteristics of the population
  - Describes the sources, pathways, routes, and the uncertainties in the assessment

Concepts

Exposure → Intake/Uptake → Dose

- Exposure
  - Contact between an agent and a person
- Intake/Uptake
  - Physically moving the chemical in question through an opening in the outer boundary (usually the mouth or nose) – i.e. inhalation
- Dose (absorbed dose)
  - Amount of material that is taken up into the body
    - Mass or mass per unit body weight (ug/kg)

Exposure Assessment Approaches



- Direct methods
  - More accurate
  - More expensive and time consuming
  - More burdensome
- Indirect methods
  - Inexpensive
  - Easy to implement for large studies
  - Can be either qualitative, semi-quantitative, or quantitative
- Exposure models
  - Hybrid approach

Types of Samples

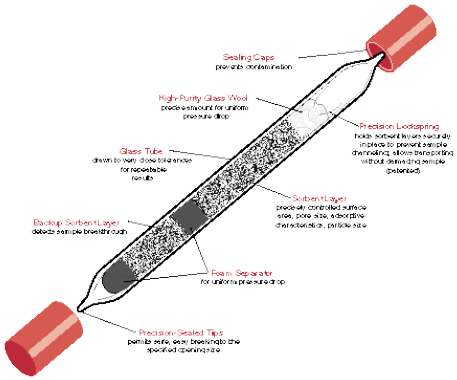
- Personal Sampling
  - Worn by the person
  - Integrates exposure over time and space as the person moves
  - Equipment needs to be small, lightweight, battery operated
- Area or fixed location sampling
  - Integrates exposure over time in a single location
  - Does not need to be as small and lightweight as personal samplers
  - Does not need to be battery operated

Active Sampling

- Pump + collection media
- Determine average exposure over the collection time
- Requires measurement of mass of contaminant collected and the volume of air it came from

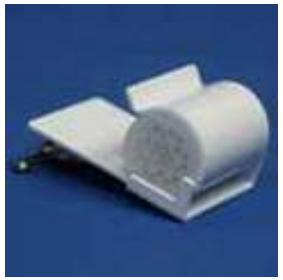
Particulate matter filter-based sampling
gravimetric or chemical analysis

Gas and vapor
sorbent tube sampling with chemical analysis



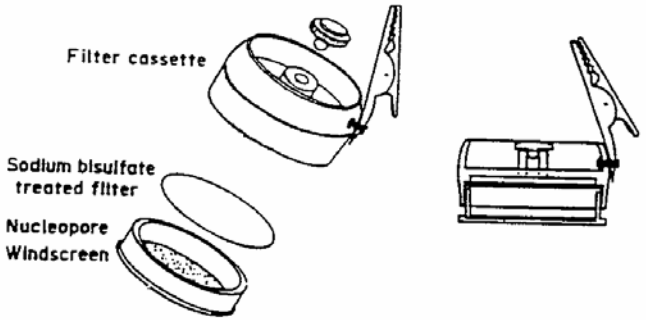
Passive Sampling

- Relies on diffusion (no pump)
- Used mostly for gases and vapors
- Requires chemical analysis



NO_2, O_3

Organic vapors



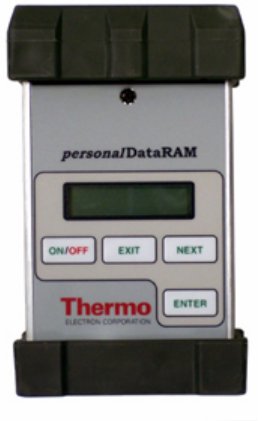
Nicotine

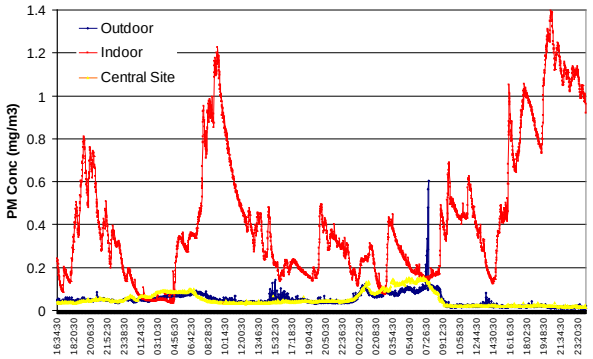
Direct Reading Instruments

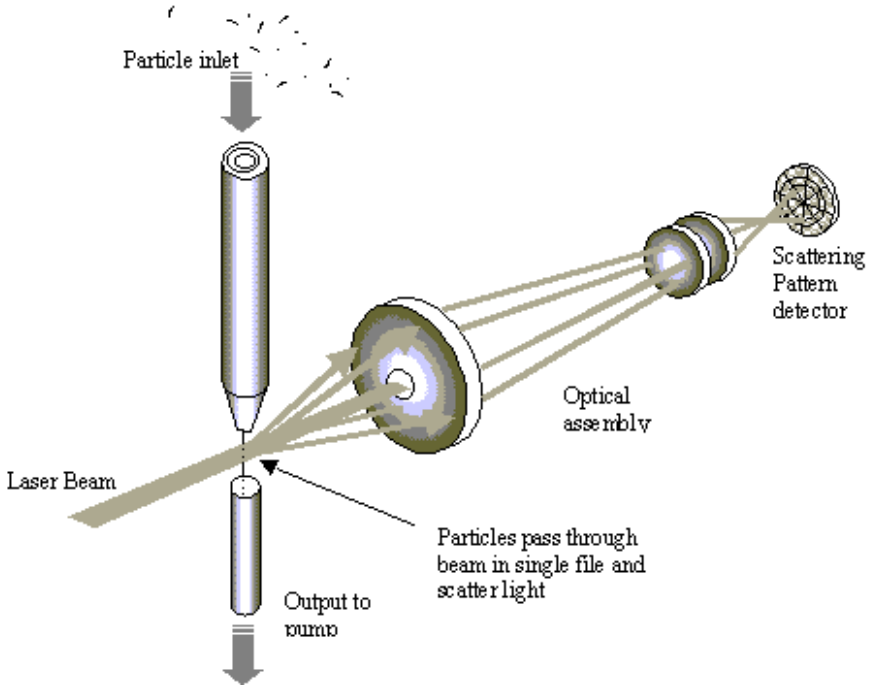
- Collect samples and perform analysis in the same instrument
  - Generally more expensive
  - Can operate either actively (i.e., with a pump) or passively
  - No analytical cost
  - Requires calibration
  - Special quality control issues
  - Provides time-resolved data

Optical Methods for Particle Detection

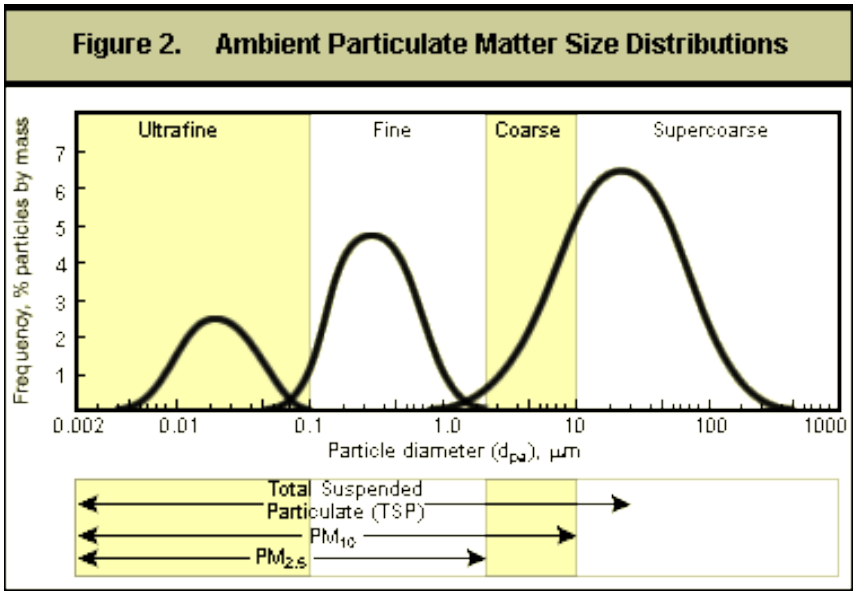
- Personal or area monitoring

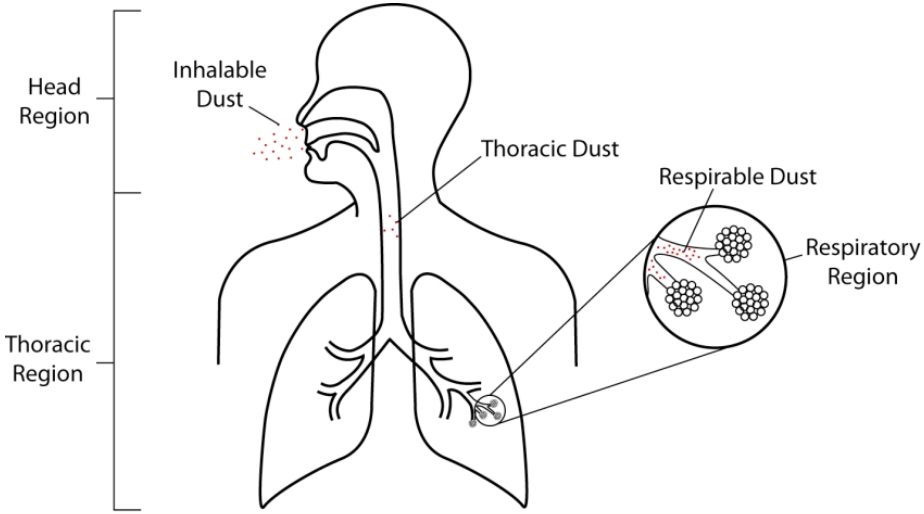


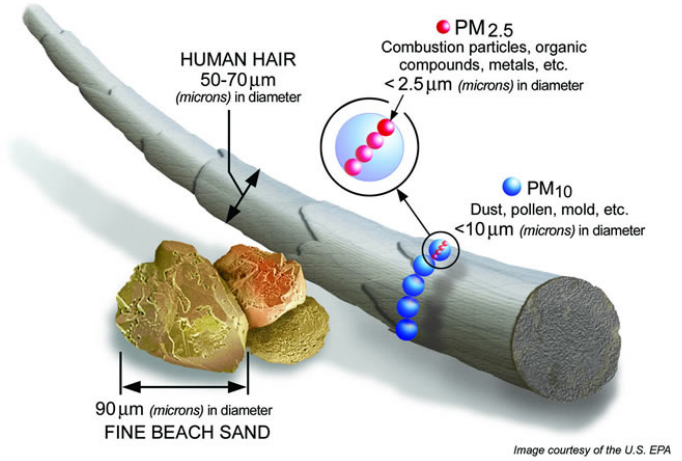


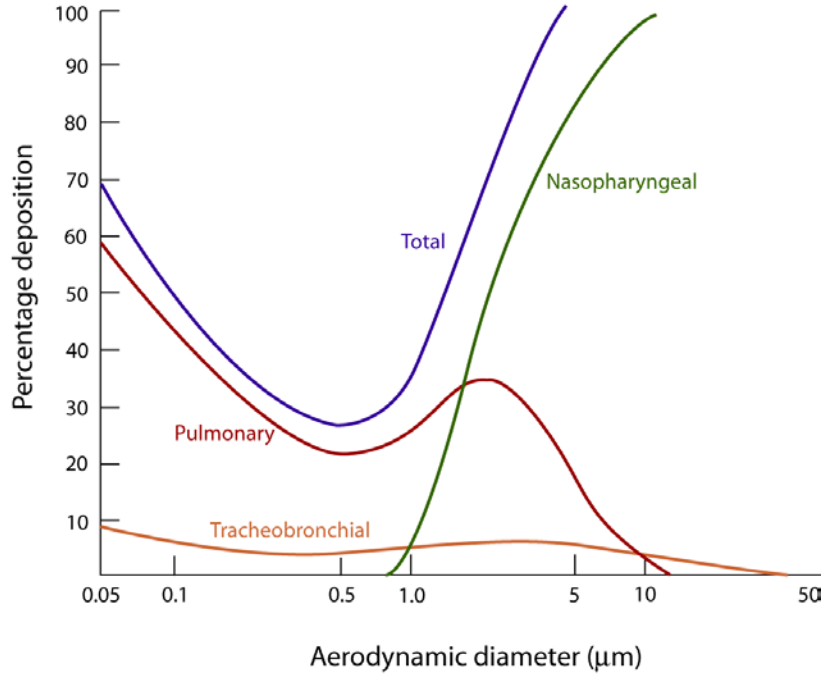


Importance of Particle Size



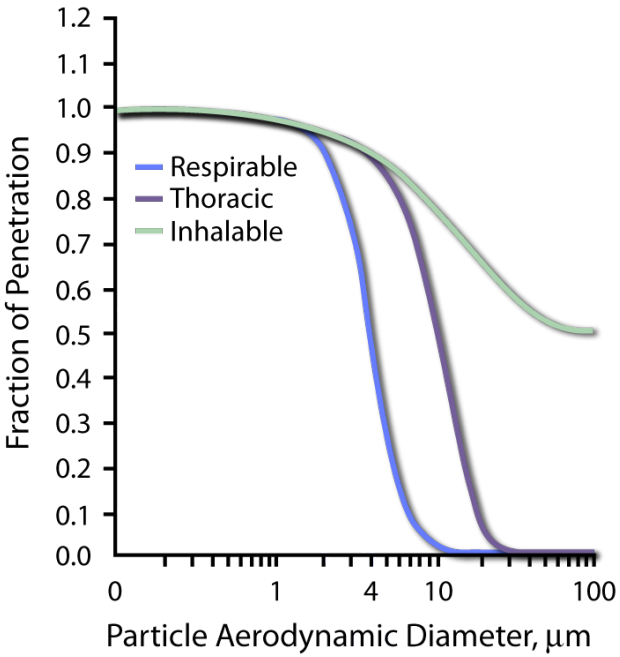




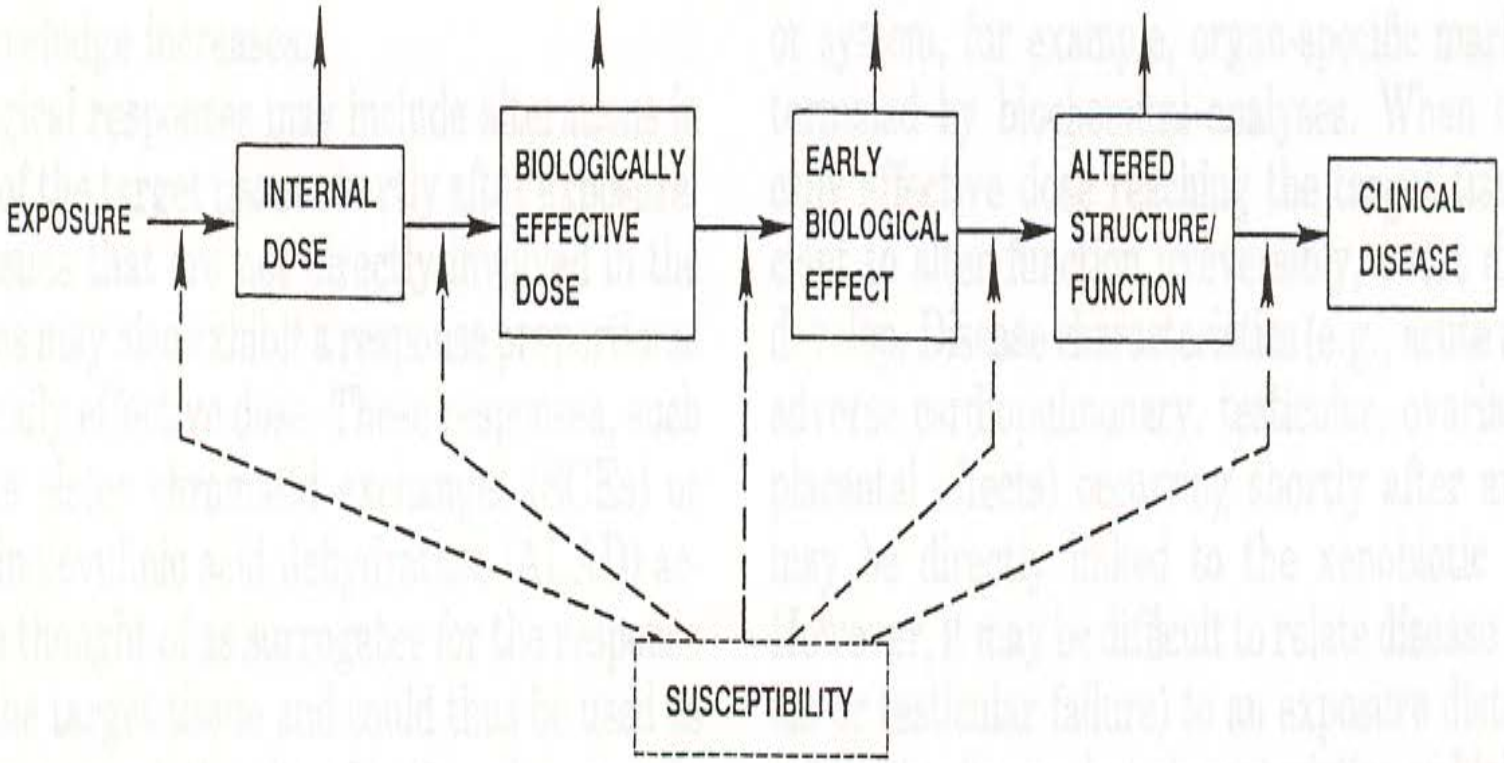


Particle Size Sampling Conventions

- Environmental Protection Agency
  - PM_{10} Particles less than 10 µm in diameter
  - $PM_{2.5}$ Particles less than 2.5 µm in diameter
    - Fine PM
  - $PM_{2.5\text{-}10}$ Particles between 2.5 -10 µm in diameter
    - Coarse PM
- Occupational Conventions
  - Inhalable dust
  - Thoracic dust
  - Respirable dust



Biomarker Paradigm



Cook Stove Household Air Pollution

- Incomplete combustion of biomass fuels produces a complex, highly variable pollutant mixture
  - Particles of varying sizes and composition
  - Gases
    - Carbon monoxide
    - Oxides of nitrogen
    - Formaldehyde
  - Volatile and semi-volatile organic compounds

Household Air Pollution Related to Solid Fuel Use and Health: The Need for Improved Exposure Assessment

- May 2011 international workshop
  - Led by the NIH
  - > 150 participants to review the state of the science regarding the health impacts of exposures to household air pollution
- This paper is the product of the exposure assessment and biomarkers (EAB) working group
  - Currently in final draft stage

Exposure Assessment Approaches

- Qualitative
  - Fuel type/Stove type
- Semi-quantitative
  - Fuel type/Stove type with additional measures
  - e.g. time-activity, cooking behavior, fuel quality, stove condition, and ventilation
- Indirect quantitative measures
  - Area/kitchen pollutant concentrations
  - Area/kitchen pollutant concentrations with additional semi-quantitative measures
    - Time-activity, cooking behavior, other pollutant sources
- Direct measures
  - Personal exposures
  - Biomarkers of exposure
- Hybrid model approach
  - Combined area/kitchen and personal pollutant concentrations

Biomarkers

- Exhaled carbon monoxide or carboxyhemoglobin
- Hydroxylated polycyclic aromatic hydrocarbons (OH-PAHs)
  - Most commonly used
  - Not unique to biomass
- Methoxyphenols and levoglucosan
  - Associated with wood smoke exposure
- More studies are necessary to determine the correlations between biomarkers of exposure and measured personal exposure concentrations
  - Adults versus children

Exposure Assessment Challenges

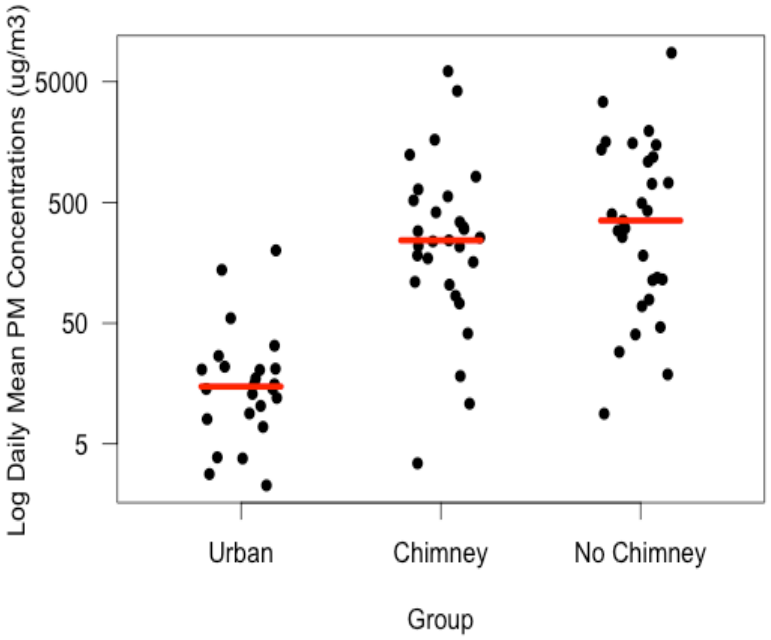
- Previous cook stove studies relied heavily on qualitative and semi-quantitative indirect exposure assessments
  - Documented the wide range of significant health impacts
  - Documented the need to intervene
  - Failed to answer the question
    - “How clean is clean enough?”
  - There is a critical need to characterize exposure response relationships in order to implement evidence-based interventions

Exposure Assessment Challenges

- Air sampling equipment commercially available was developed for measuring ambient air pollution
  - Where exposures are orders of magnitude lower than in cook stove settings
- Few large scale health effects studies have invested the resources needed to conduct detailed quantitative direct or indirect exposure assessments
  - Greater investment in exposure assessment is needed

Indoor Particulate Matter ($PM_{2.5}$) and Carbon Monoxide Concentrations in Peru

$PM_{2.5}$



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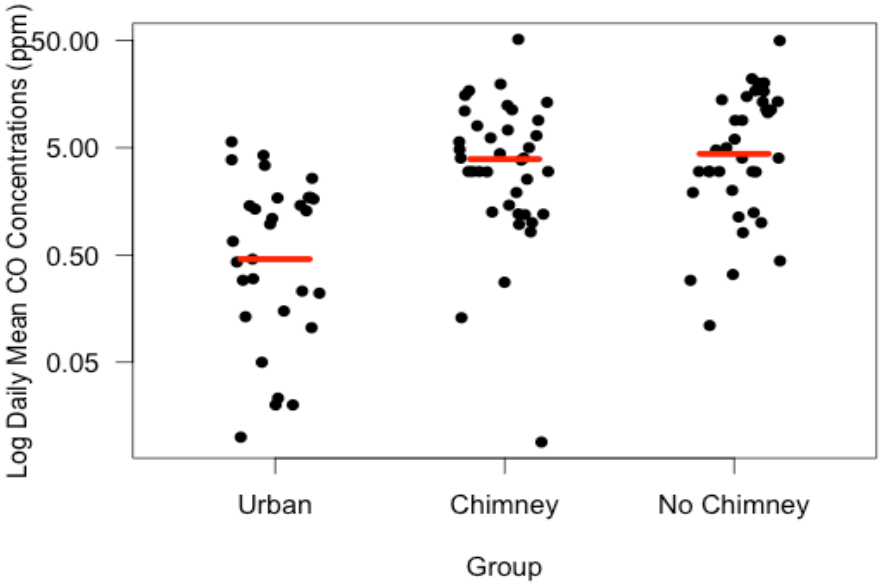


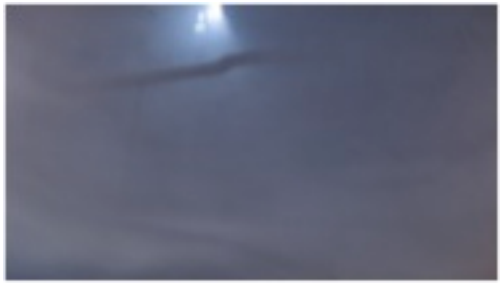
Exposure Assessment Challenges

- Cook stoves and open fires are small in scale but high in emission intensity, they create steep spatial concentration gradients that are difficult to characterize
- Considerable uncertainty regarding the nature and magnitude of exposure variability
  - Multiple sources of exposure measurement error currently lead to considerable uncertainty around the exposure-response curve
  - Limiting our ability to estimate health benefits from proposed exposure reductions

Orientation
Particulate Matter Concentration

90 ug/m^3

12 ug/m^3



Indoor air in Peru
2,000 – 3,000 ug/m^3

London smog 1952
1,000 – 2,000 ug/m^3

4 Breakout Groups

- Station 1 – Real-time particulate matter sampling
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