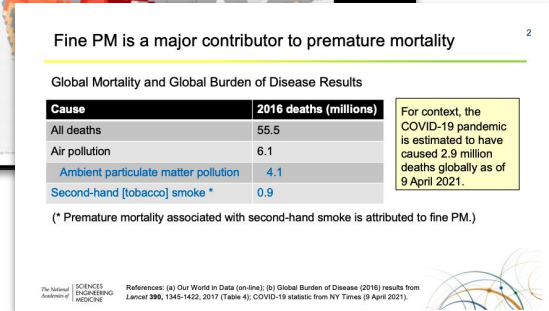
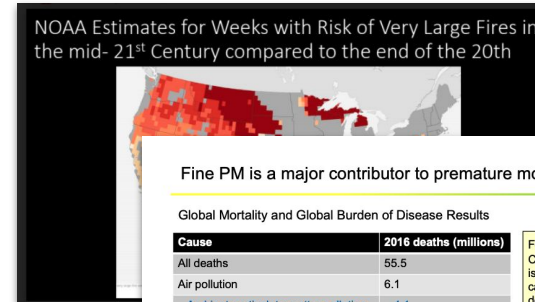
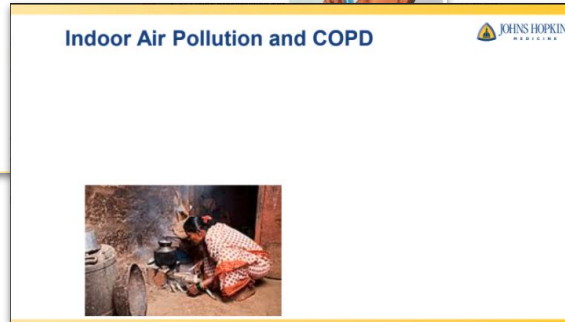
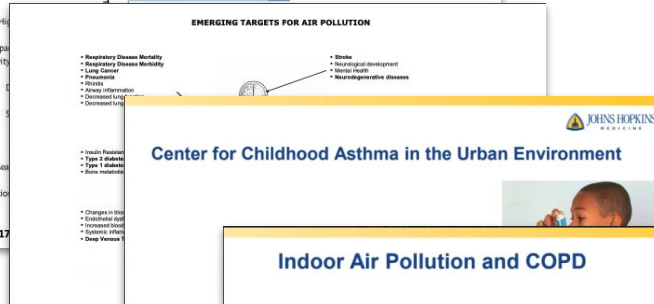
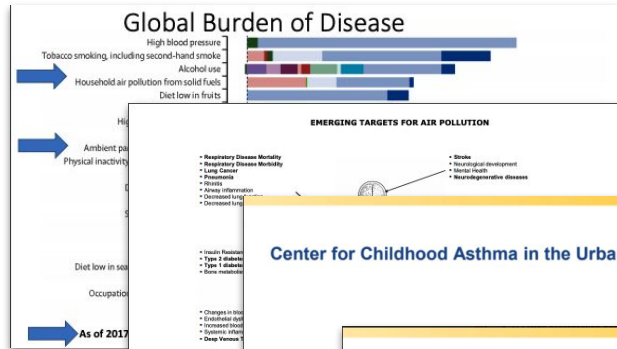


The health burden from indoor PM is significant. This is a problem worth caring about.



Measurement is important because ...

- ... It influences how we understand, attribute and quantify health burdens.
- ... It informs and validates our control efforts

Measurement (of PM & health burdens) is complex

Health Burden

- Acute or chronic
- Permanent or reversible
- Indirect, direct-reported, direct-measured, biomarkers
- Vary by PM metric
- Effect size
- Susceptibility factors / demographics
- Interactive effects
- (Study methods)

Indoor fine PM: Four dimensions of complexity 6

Size complexity From 0.01 to 2.5 μm is a range of 250x in diameter, 16,000x in mass. Etruscan	Temporal complexity Indoor concentrations can change
--	--

Simplifying the complexity: inhalation exposure to fine PM 13

Size complexity • Use $\text{PM}_{2.5}$ mass concentration or suitable proxy • Use number concentration for ultrafine particles ($< 0.1 \mu\text{m}$) • Ongoing challenge	Temporal complexity • Be mindful so that indoor measurements effectively represent conditions during occupancy.
Chemical complexity • Evidence to date does not implicate any compositional factors as a primary reason for adverse health consequences of PM exposure.	Spatial complexity • Personal monitoring is better than stationary monitoring. • Indoor data are better than outdoor data.

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Challenges:

- Exposure (and dose) mischaracterization
- Metric (and measurement method) selection

Large Gradients in Concentrations Around Sources

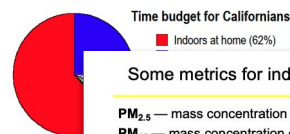


What do we mean by "Exposure"?

Locations of PM_{2.5} Monitors



Exposures occur where people and pollutants meet



Some metrics for indoor particulate matter

PM_{2.5} — mass concentration of particles ≤ 2.5 μm diameter

PM₁₀ — mass concentration of particles ≤ 10 μm diameter

UFP — (typically) number concentration of particles

I/O ratio — indoor to outdoor ratio of a particle measure

Infiltration factor — I/O ratio in the absence of indoor sources

Penetration factor — proportion of particles entering with infiltration

Filtration efficiency — fractional removal of particles through a ventilation filter

Air-cleaner effectiveness — fractional reduction of particle measure

The epidemiology of indoor exposures to air pollutants has been done BUT WE DON'T ACKNOWLEDGE IT

• ACUTE AND CHRONIC EPIDEMIOLOGY / CLINICAL STUDIES ATTRIBUTING HEALTH EFFECTS TO AMBIENT PM_{2.5} ARE ACTUALLY PREDOMINANTLY STUDIES OF INDOOR EXPOSURES RATHER THAN OUTDOOR.

• No epidemic (indirectly outdoor)

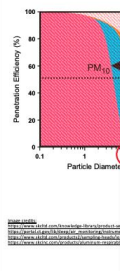
• US mortality ~300,000

• Indoor exposure

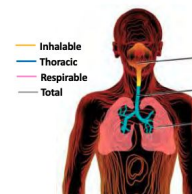
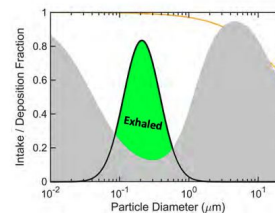
PM Exposure to Health Effect



Not all Particle Sizes Penetrate the Respiratory Tract



Where Particles Deposit Matters



Opportunity: New measurement tools & methods

Chronicle – Implantable Hemodynamic Monitor
©Medtronic Inc. - Minneapolis, MN



RV pressure sensor measures:
Cardiac and Diastolic pressures

Density of Monitoring Networks

Philadelphia: 6.1 M in metro area

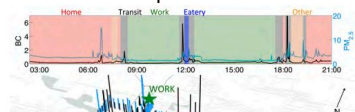


Atlanta: 6.0 M in metro area



Rich et. al. EHP, 2008.

Example: Personal Exposure with GPS



Assessment of low-cost PM sensors and monitors

- About 10% of studies made reference to published protocols
- Researchers typically adopt their own protocol for assessment of sensors and monitors
- Variable judgement criteria for "good enough"

Morawaka et al. 2018 Environ Int 118: 286-299

- Methods differ in:
 - Duration of testing (short >> long)
 - Measurement environments (lab >> field)
 - Number of replicate technologies
 - Reference method utilized

Studies	Footbot/Reference
Montero-R. et al. 2018, JSSS	1.23-1.43
Demaregna et al. 2021, BAE	0.57
Singer and Delp, 2016, Indoor Air	0.53 - 0.63



Typical performance indicators:

- Comparison with reference measurements
- Repeatability & reproducibility
- Limit of detection (LOD)
- Dependence on particle size and composition
- Dependence on indoor climate

DOI: 10.1111/ina.12333

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Workshop on Indoor Exposure to Fine Particulate Matter and Practical Mitigation Approaches
Queen Lorna | lorna.lorna@epfl.ch

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April 28 - Mitigation & Wrap-Up

How to Reduce Wildfire Smoke Exposure For Kids

▼ ≤ 100%
Go Somewhere Without Smoke

▼ ~50-80%
Go inside with (1) HVAC & MERV 13 filter or

▼ ~30%
Go Inside and Shut Windows

DO NOT spend unnecessary time outside if the AQI is in the unhealthy ranges.

Cloth face coverings (like those for COVID) DO NOT filter out small

Guideposts for improving indoor air quality



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Image source: <https://www.microbe.net/2013/09/16/four-principles-for-good-indoor-air-minimize-indoor-emissions-keep-dry-ventilate-protect-against-outdoor-pollution/>
Reference: WW Nazaroff, Indoor Air 23, 353-366, 2013.

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