

PM_{2.5} Characterization and Exposure Assessment: Lessons from the Seattle Panel Studies

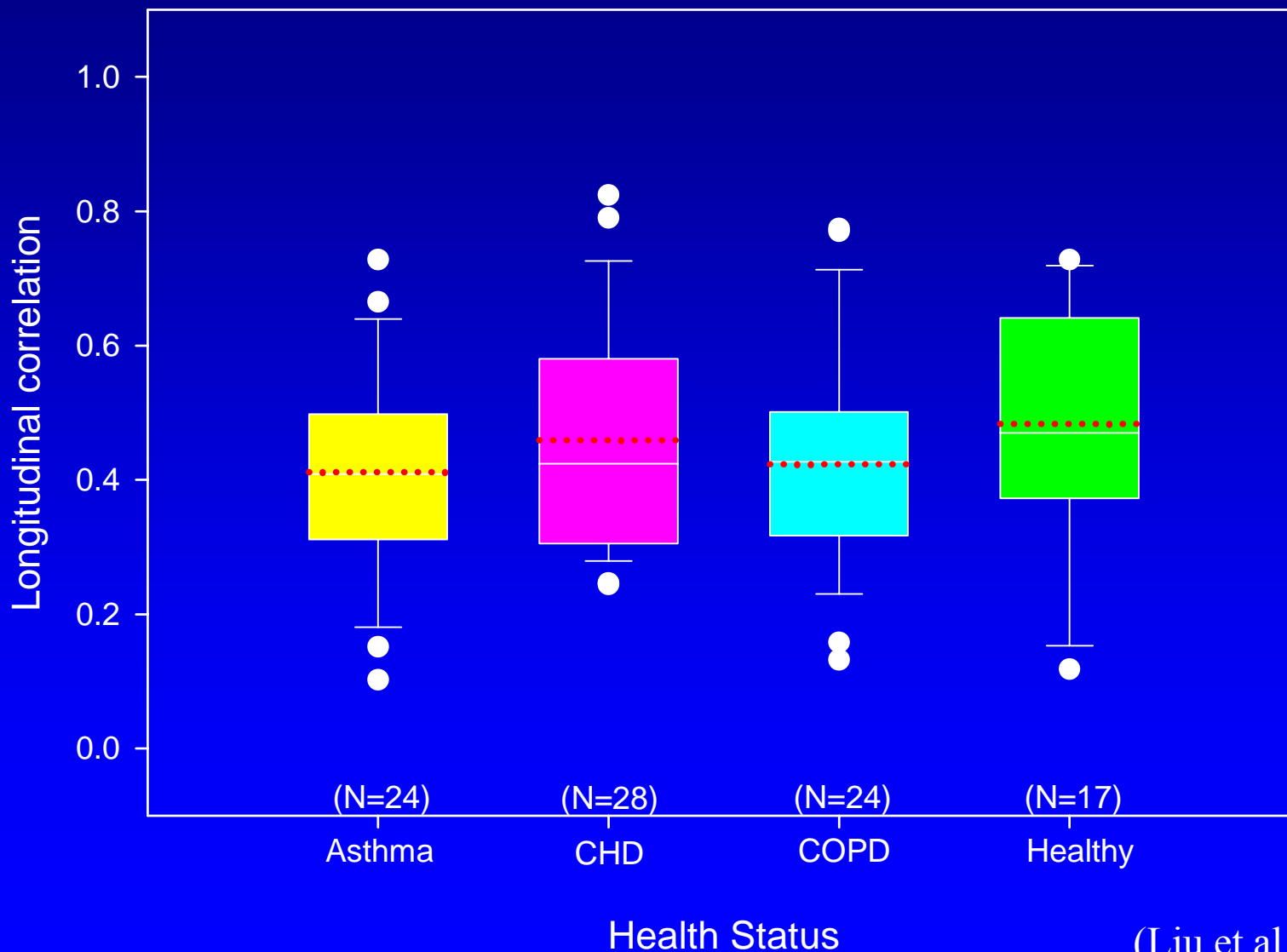
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Top 4 arguments for not using regulatory $PM_{2.5}$ data to estimate exposures

- Concentrations vary within a community, e.g., they depend on proximity to roads
- People spend the majority of time indoors with a different activity patterns.
- Total personal exposure usually exceeds the ambient and indoor concentrations
- Low cross-sectional correlations are observed between personal $PM_{2.5}$ exposure and ambient measurements

Exposure is correlated with ambient measurements within an individual



Why does total PM_{2.5} exposure exceed outdoor levels?


- Total exposure can be separated into 3 groups:
 - Ambient generated particles (EPA regulated)
 - Indoor generated particles
 - Personal generated particles
- Exposure to ambient generated particles
 - Is correlated with ambient measurements
 - Can be predicted
- Exposure to non-ambient generated particles
 - Results in total exposure exceeding ambient measurements
 - Masks the personal-ambient relationship




Components of Exposure

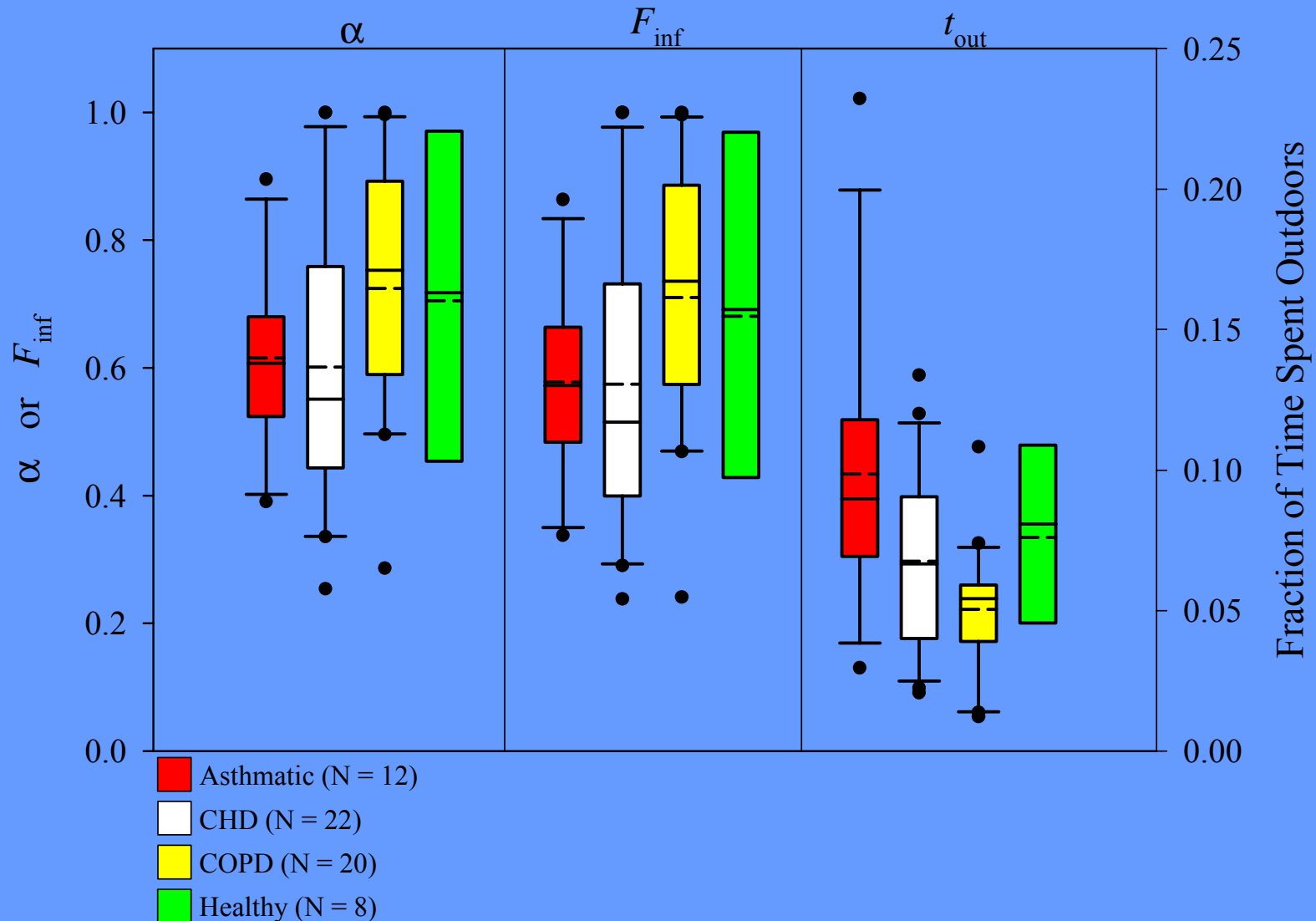
Total Exposure = Outdoor-Generated Exposure + Indoor-Generated Exposure + Personal Activity Exposure

$$E_t = E_a + E_{ig} + E_{pact}$$

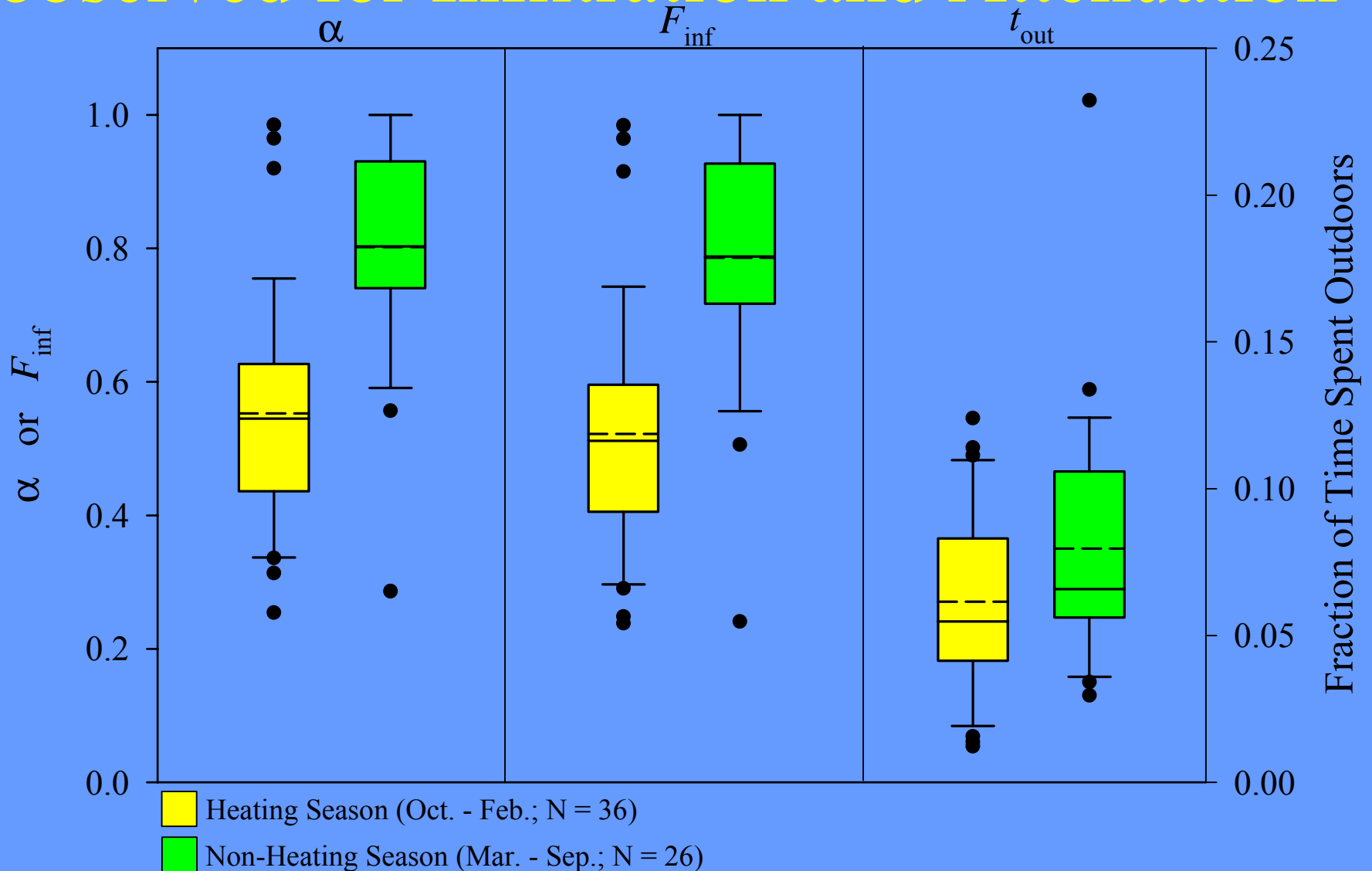

$$E_a = \alpha C_a$$


$$E_a = [t_{out} + (t_{in})(F_{inf})]C_a$$

No Differences in Infiltration or Attenuation Between Health Groups



Major Seasonal Differences were observed for Infiltration and Attenuation



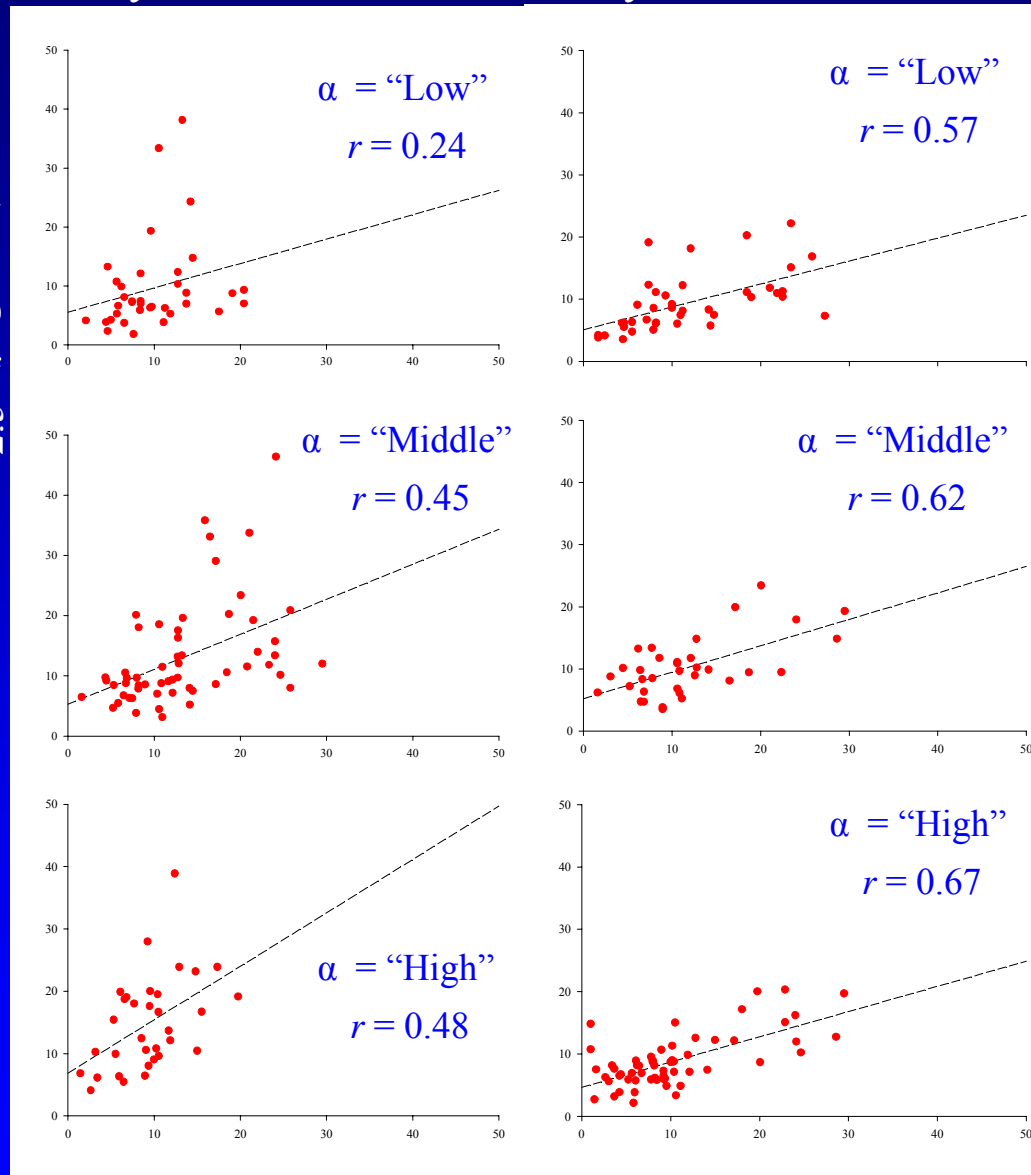
Households with good ventilation and little activities experience higher exposure to ambient PM

“Low”: $\alpha < 0.50$
 “High”: $\alpha > 0.68$

Personal PM_{2.5} ($\mu\text{g}/\text{m}^3$)

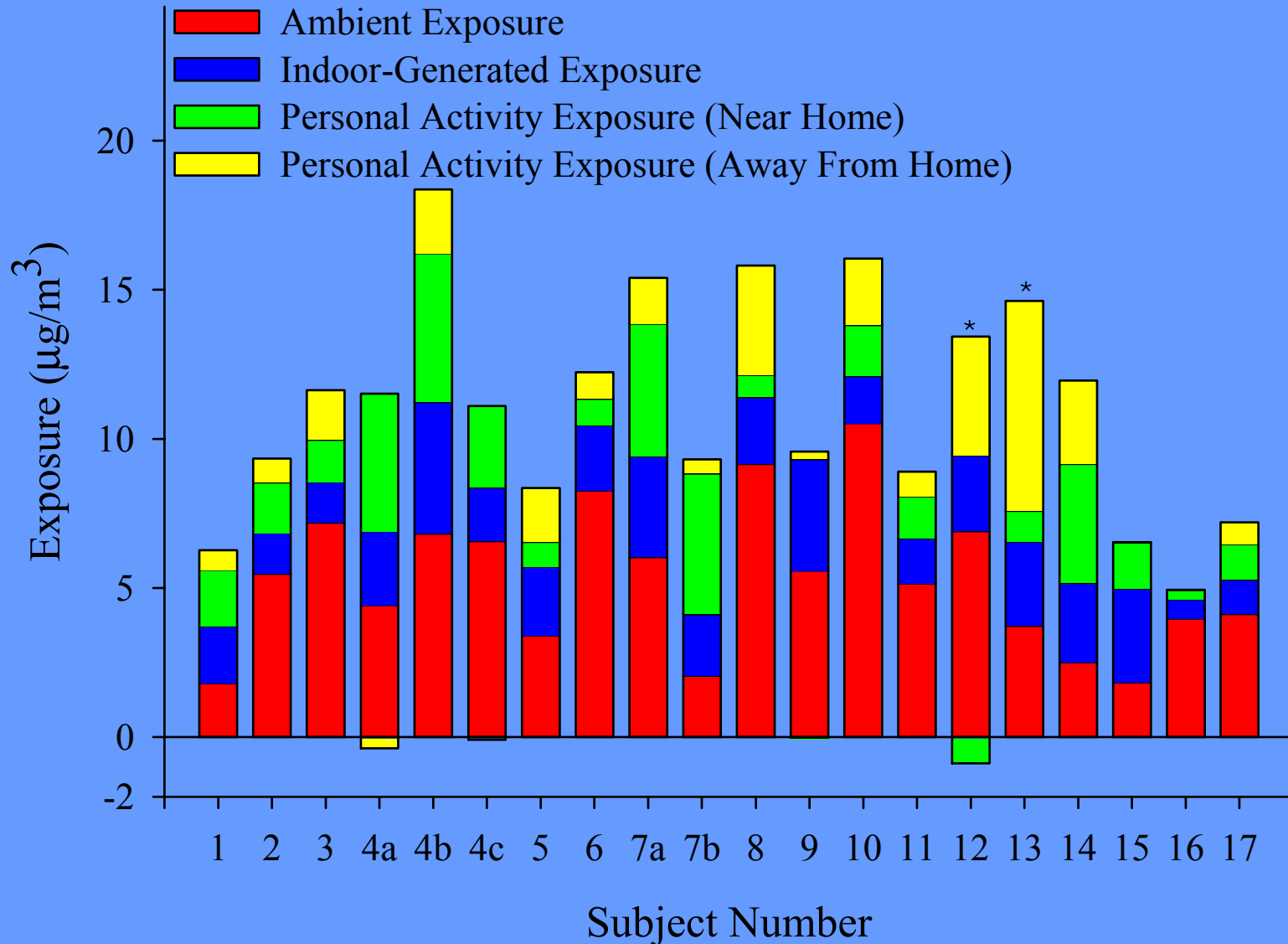
Exposure Dominated by **Indoor** Sources

Exposure Dominated by **Outdoor** Sources



Central Site PM_{2.5} ($\mu\text{g}/\text{m}^3$)

Ambient source contributes on average 50% of total exposure but contributions vary by subject



*Children

Exposure to ambient derived PM_{2.5} can be predicted, using ambient measurements

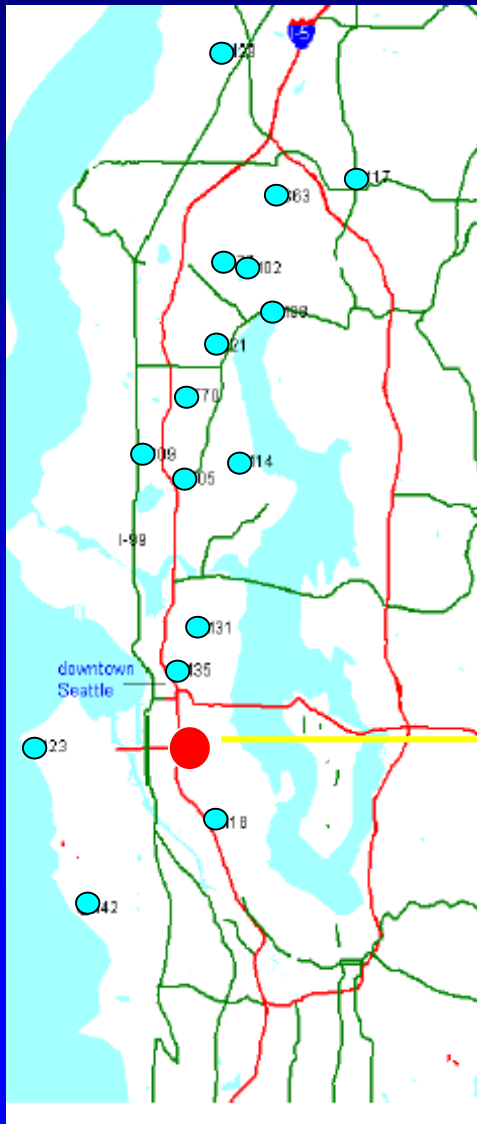
- Time spent outdoors
- Time spent indoors and infiltration efficiency of particles
 - Type of residence
 - Private home
 - Private apartment
 - Group retirement facility
 - Use of air cleaner
 - Average outdoor temperature
 - Average daily rainfall

(R²=0.69, Allen et al. JAWMA 2004; Koenig et al. EHP 2004 in press)

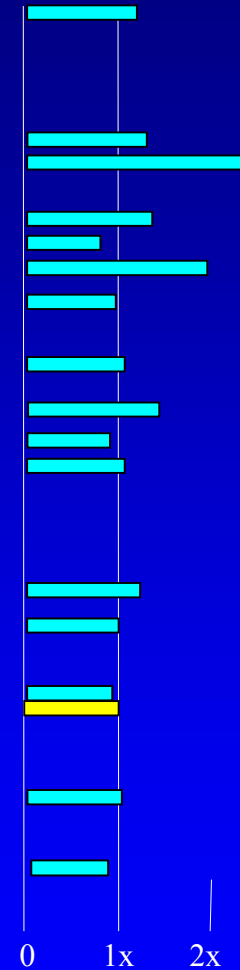
However, the sources of $PM_{2.5}$ differ by season and location.

- Regional particles, such as sulfur, sulfate and nitrate, are spatially homogeneous.
- Local particles, such as vehicle exhaust and wood smoke, exhibit spatial variability
- Ultrafine particles show substantial variation near highways

Significant spatial variation in PM_{2.5} in Seattle



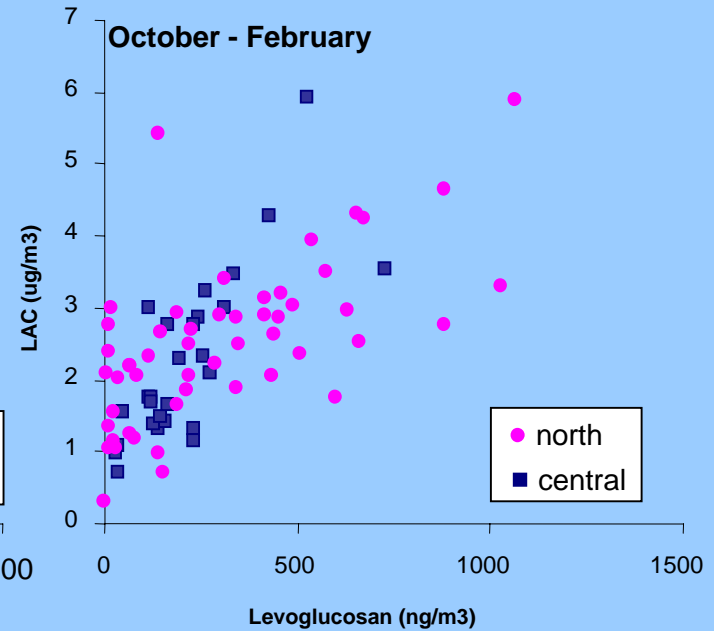
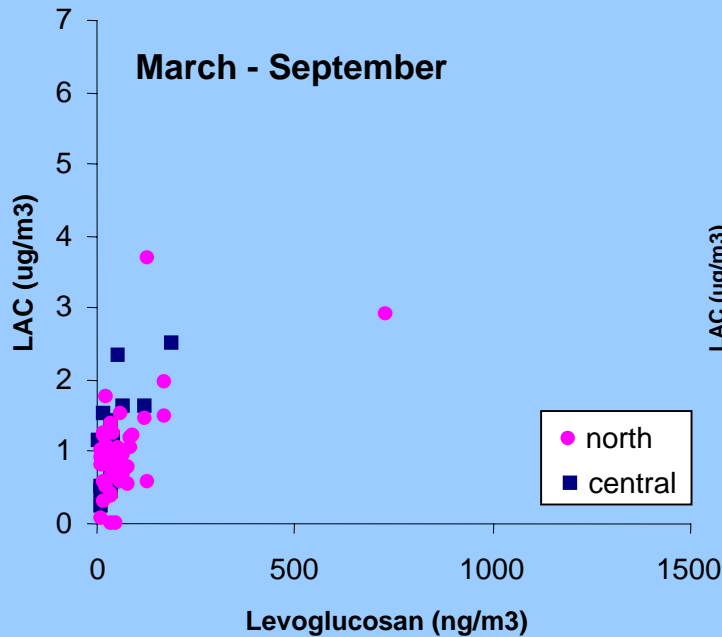
Beacon Hill



Concentration outside home
Concentration at Beacon Hill

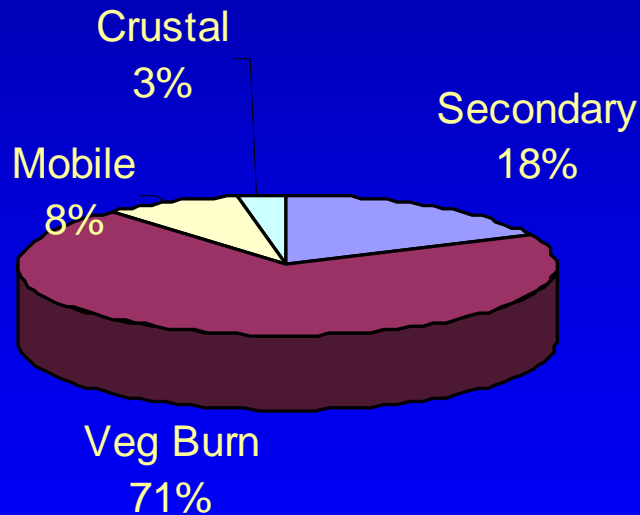
(Goswami et al. JAWMA 2002)

Black carbon from wood burning is the major source in Seattle in winter

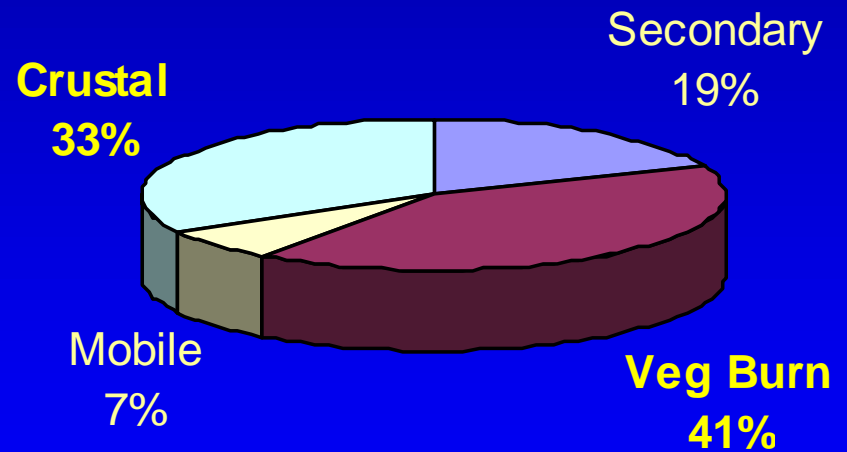


Source contributions differ between ambient and personal air

Home outdoor



Personal



While ambient PM can be used to predict personal exposure, it may not predict exposure to certain sources.

(N=61 from 20 residences/subjects. Larson et al. JAWMA 2004)

Conclusions

- It is appropriate in Seattle to use ambient measurements as surrogates of exposure to $PM_{2.5}$ of outdoor origin.
- Exposure to ambient generated $PM_{2.5}$ varies by individuals but can be predicted.
- Exposure to regional $PM_{2.5}$ (i.e. sulfur) can be easily predicted using ambient measurements.
- However, personal exposure to combustion related $PM_{2.5}$ is more difficult to predict.
- The variation in LAC in the winter in Seattle is dominated by wood burning