Characterizing Indoor Air Quality and Immune Activation in Adults with Cystic Fibrosis

Michael Zhang[1], Midhuna Chittineni[1], Thomas Hampton PhD[1], Diane Mellinger[1], Ali Ashare MD PhD[2], Laura Paulin MD MHS[2]

[1] Geisel School of Medicine at Dartmouth, [2] Department of Pulmonology , Dartmouth Hitchcock Medical Center, New Hampshire

INTRODUCTION

- Particulate matter (PM) air pollution is linked to oxidative stress, immune activation, and worse respiratory outcomes.
- Most research emphasizes outdoor air pollution, but indoor exposure is also important—especially in rural homes.
- CF patients may be uniquely susceptible to PM exposure due to chronic baseline inflammation and impaired mucociliary clearance.
- Few studies have examined immune biomarkers in relation to in-home PM exposure in CF.

OBJECTIVE

Characterize indoor PM exposure in rural New England homes and evaluate associations with systemic cytokine levels in individuals with CF.

METHODS

DATA COLLECTION

22 Adults with cystic fibrosis

- **PM Monitoring**
  Continuous (Purple Air) and integrated (UPAS) sampling over 5 days
- **Blood Draw**
  Plasma multiplex panel (40+ inflammatory cytokine markers)
- **Home Diary**
  Activities such as heating, cooking, cleaning behaviors
- **Symptom Survey**
  Symptoms reported with CFQ-R and CRISS

DATA ANALYSIS

Used Spearman correlation to assess associations between proportion of time spent in PM2.5 exposure zones and plasma cytokine concentrations.

RESULTS

Table 1: Demographic Data (n=22)

Gender	Education	Home Type	Heating	Stove
female 11 (50%)	college 4 (18%)	apartment 1 (4.8%)	boiler 2 (9.5%)	electric 17 (81%)
male 11 (50%)	professional degree 8 (36%)	detached 11 (52%)	electric 3 (14%)	gas 4 (19%)
	some college 9 (41%)	mobile 2 (9.5%)	furnace 10 (48%)	unknown 1
	vocational school 1 (4.5%)	townhouse 7 (33%)	wood stove 5 (24%)	
		unknown 1	unknown 2	

Figure 1. Representative Indoor PM 2.5 Monitoring

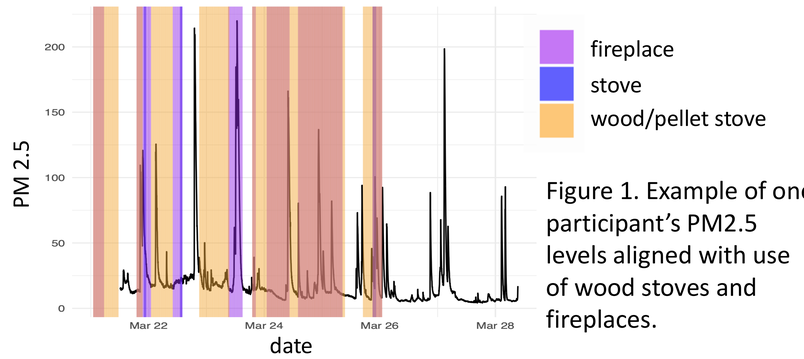

Figure 1. Example of one participant's PM2.5 levels aligned with use of wood stoves and fireplaces.

Figure 2. Time spent in each PM 2.5 exposure zone

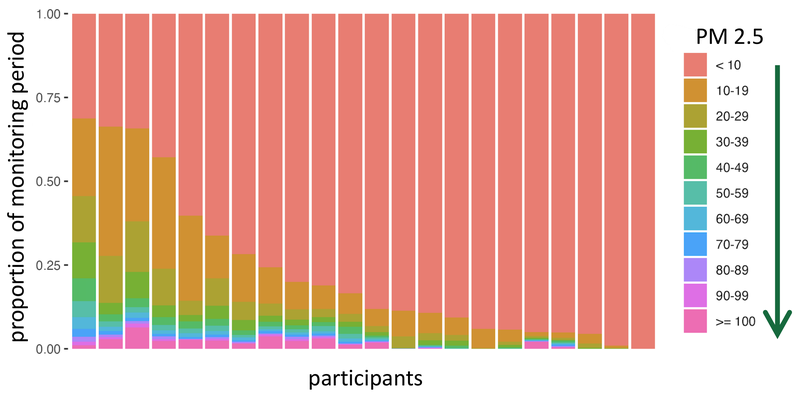

Figure 2. Proportion of monitoring period each participant spent in different PM2.5 density ranges

Figure 3. Cytokine Associations with PM2.5 Exposure

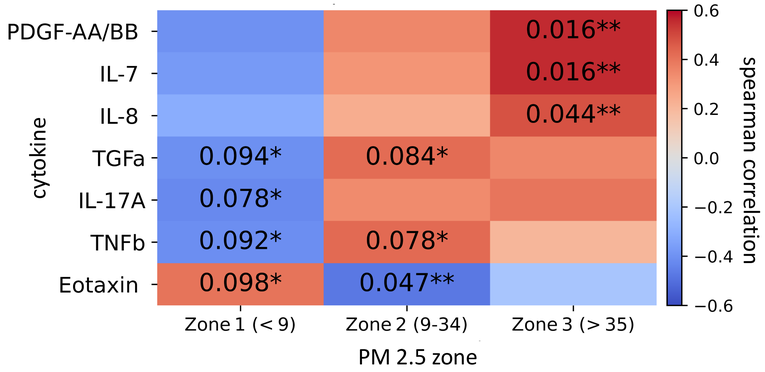

Figure 3. Spearman correlation between cytokine and PM 2.5 levels. Longer time in exposure zones was significantly associated with elevated levels of multiple inflammatory cytokines. * = p < 0.1, ** = p<0.05.

DISCUSSION

- PM2.5 exposure increased pro-inflammatory cytokines (IL-17A, IL-8, IL-7, TGF-α, PDGF-AA/BB, TNF-β), consistent with neutrophil-driven airway inflammation and tissue remodeling in CF.
- Eotaxin decreased with higher PM2.5, suggesting a shift away from eosinophilic toward neutrophilic/Th17 responses, aligning with CF airway biology.
- Together, results show that indoor PM amplifies systemic inflammation and alters immune balance in adults with CF.
- Future Directions
  - Expand to larger, multi-center cohorts
  - Incorporate longitudinal seasonal monitoring
  - Interventions (HEPA filters/behavior changes)
  - Account for key covariates in future studies

KEY FINDINGS

Indoor PM exposure linked to upregulation of pro-inflammatory cytokines in adults with CF.

michael.zhang.med@dartmouth.edu