Does Particulate Matter Cause or Exacerbate Asthma?

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LTG 1 Poster 1-13

Background

Air pollution is a significant cause for exacerbation of asthma, and may contribute to development of disease as well. Particulate matter has been associated with exacerbation of asthma and wheezing in children, and is a leading cause of exacerbations, Air pollution is likely second only to viral respiratory tract infections as a precipitating factor in acute events, rescue medication use, ER visits and hospitalizations.

While earlier epidemiological studies demonstrate that PM contributes to exacerbation of asthma, the degree to which PM influences disease, and the potential for PM to contribute to pathogenesis of chronic disease remain incompletely understood. It is also unclear if PM of specific size ranges, or if specific components of PM are more likely to induce asthma. PM is composed of bioaerosol components (e.g. endotoxin and lipoteichoic acid), metals, organic molecules such as polyaromatic hydrocarbons and elemental carbon. Biological responses to these individual components agents likely play a central role in determining individual susceptibility to asthma.

Previous studies also indicate that a significant action of PM is to enhance atopic immune response to allergens, and diverse agents such as PAHs on diesel exhaust and endotoxin have been shown to enhance primary and recall response to allergen. Mechanisms by which this occurs are also incompletely understood.

Understanding these mechanisms may provide insight into targets for individual intervention approaches and regulatory strategies to minimize the impact of PM on asthma

Science Questions

A number of scientific hypotheses have been addressed in the research outlined in this poster. These hypotheses address the following questions:

- Does PM contribute to exacerbation of asthma?
- Does PM contribute to development of asthma?
- How does PM influence immune function in the airway to promote asthma?
- Are patients with asthma at increased risk to the cardiac health effects of PM?

Findings and Conclusions

Epidemiological and animal studies demonstrate that PM can exacerbate asthma and increase atopy and airway hyperreactivity

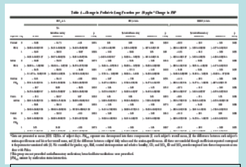
Population studies show that PM, traffic and other air pollutants can increase the risk of developing asthma

Animal, Human and in vitro studies demonstrate that PM and components augment antigen presentation which would enhance reactivity with allergen and promote asthma

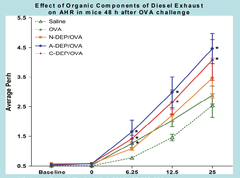
Human time-series and controlled exposure studies show that asthmatics may be at increased risk to the cardiac effects of PM

Poor Air Quality Can Exacerbate Asthma

Change in Pediatric Lung Function per 10 µg/m³ Change in PM in Seattle, WA

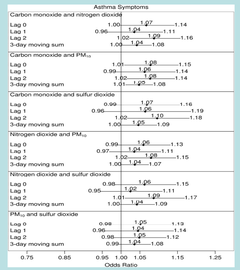


Trenga C. A. et.al. Chest 2006;129:1614-1622



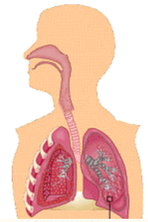
Stevens, T. et al. Toxicol. Sci. 2009 107:322-334

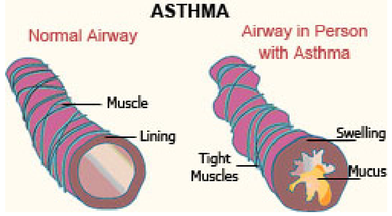
Odds ratios for daily asthma symptoms associated with shifts in within-subject concentrations of two pollutants



Schildcrout et al., Am J Epidemiol 164: 505-517

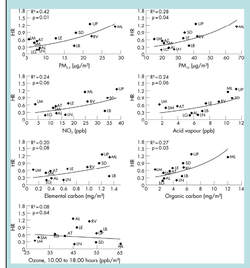
Methods/Approach





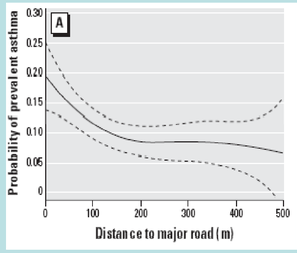
Poor Air Quality Can Cause Asthma

Hazard ratio of newly diagnosed asthma in 12 communities by average ambient pollutants



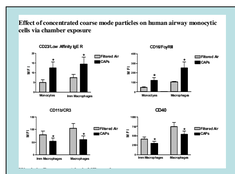
Islam et al., Thorax 2007 62:957-963

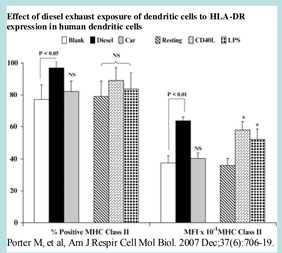
Prevalence of asthma by distance of residence to a major road



McConnell et al., Environ Health Perspect 2006 114: 766-772

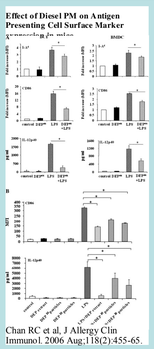
PM-induced enhanced antigen-presentation may promote asthma





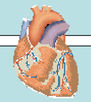
Porter M, et al, Am J Respir Cell Mol Biol. 2007 Dec;37(6):706-19.

Alexis NE et al, Ann Allergy Asthma Immunol. 2008 Mar;100(3):206-15.



Chan RC et al, J Allergy Clin Immunol 2006 Aug;118(2):455-65.

PM exposure can cause cardiovascular effects in asthmatics

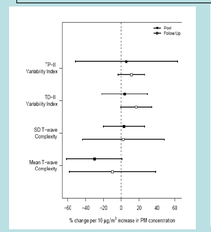


Change in HRV per 1 µg/m3 increase in PM in adults with asthma

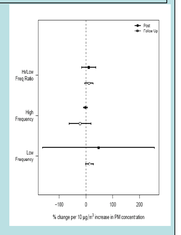
	$PM_{2.5-10}$				$PM_{2.5}$			
	Estimated regression coefficient	SE	*p*-Value	95% CI	Estimated regression coefficient	SE	*p*-Value	95% CI
HRV								
Max heart rate	−1.95	0.88	0.03	−3.67 to −0.23	0.40	0.43	0.36	−0.45 to 1.24
ASDNN5	−0.77	0.37	0.05	−1.59 to −0.04	−0.67	0.15	0.63	−0.37 to 0.22
SDANN5	−3.76	1.53	0.02	−6.76 to −0.76	1.66	0.65	0.02	0.39 to 2.93
SDNN24HR (msec)	−3.36	1.38	0.02	−6.06 to −0.65	1.16	0.58	0.06	0.02 to 2.29
rMSSD	−0.75	0.53	0.16	−1.79 to 0.28	0.53	0.20	0.01	0.14 to 0.91
pNN50_24hour	−0.50	0.27	0.07	−1.03 to 0.03	−0.66	0.11	0.58	−0.27 to 0.15
pNN50_7min	−1.88	0.55	0.07	−2.95 to −0.81	0.47	0.42	0.27	−0.35 to 1.29
Low-frequency power	−0.19	0.42	0.65	−1.01 to 0.63	−0.23	0.14	0.11	−0.51 to 0.05
Percent low frequency	0.57	1.08	0.60	−1.55 to 2.69	−0.78	0.41	0.07	−1.59 to 0.03
High-frequency power	−0.46	0.17	0.01	−0.79 to −0.14	0.14	0.07	0.07	−0.01 to 0.28
Percent high frequency	−2.14	0.94	0.03	−3.98 to −0.30	0.64	0.36	0.09	−0.07 to 1.34

Yeatts et al., Environ Health Perspectt 2007 115: 709-714

Coarse PM exposure induces cardiac changes in asthmatics



Repolarization



HRV Frequency Domain

Impact and Outcomes

What are the public health and environmental outcomes of this research?

- Evidence that diesel, fine and coarse mode PM identify targets for regulation and community mitigation strategies to protect asthmatics from PM-associated health effects.
- Potential community mitigation strategies include:
  - •Better emission controls on mobile sources for PM
  - •Continue to examine state implementation plans for point source producers of PM that affect asthmatics
  - •Consider placement of schools and residential buildings in proximity to roadways
- Individual Intervention strategies include:
  - •Use of anti-inflammatory medications to decrease effect of PM on antigen presenting cells and response to allergen
  - •Influence family decisions regarding living in proximity to roadways
  - •Have asthma treatment plans that minimize co –exposures to allergens and indoor pollutants

Future Directions

- Studies to determine how PM enhances response to allergen. Focus on effects on the following:
  - •Antigen specific IgE
  - •Antigen presenting cells
  - •Cells which bear IgE (basophils, mast cells)
- Genetic Risks associated with pollutant exposures
  - •Examination of gene expression profiles to identify candidate mechanisms which mediate response to PM in asthmatics
  - •Examination of effect of oxidant stress genes thought to play a role in ozone and diesel induced airway responses, including GSTM1
- Examine novel interventions
  - •Pursue studies examining the role of antioxidants such as sulforaphane, vitamin C and vitamin E in minim
- Effect of co-exposures on asthma outcomes
  - •Determine if PM augments the effect of other pollutants such as ozone

US EPA ARCHIVE DOCUMENT

Health and Exposure