Air Pollution and Human Health Impacts

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EPA Regulated “Criteria Pollutants”

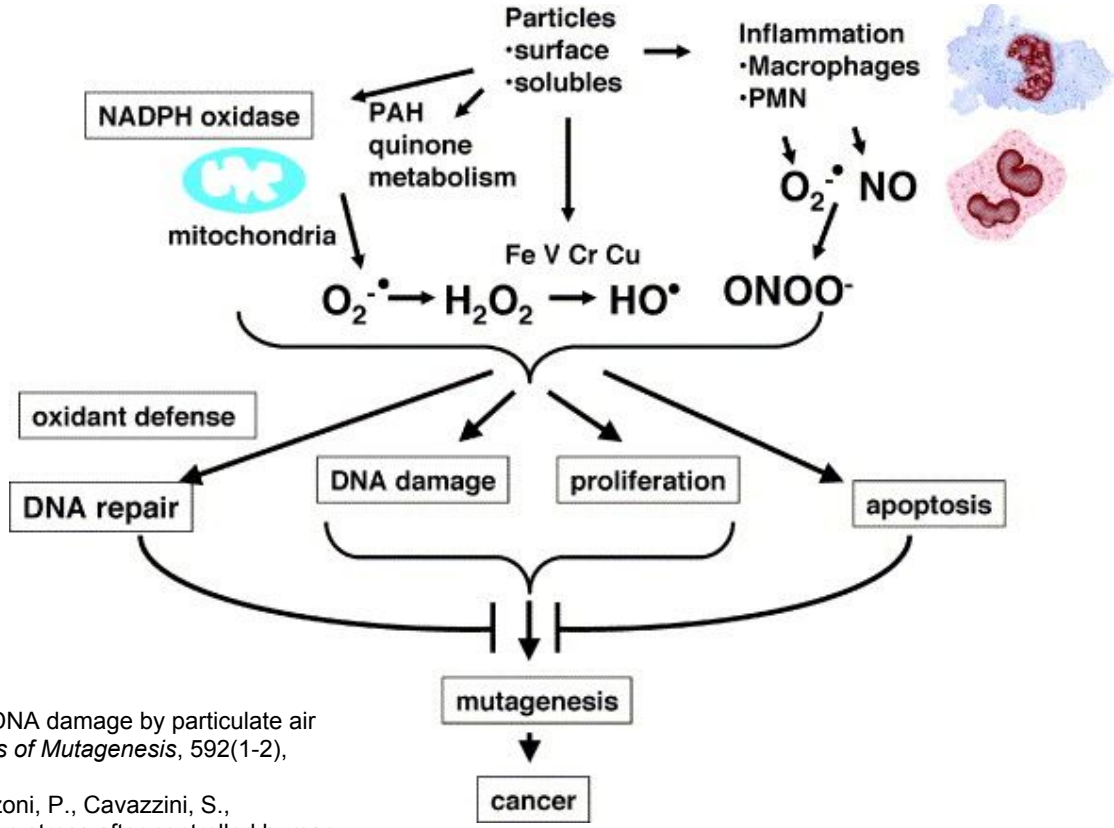
- Carbon Monoxide
- Lead
- Nitrogen Dioxide
- Sulfur Dioxide
- **Ground Level Ozone**
- **Particulate Matter**

Of these pollutants, standards for ground level ozone and particulate matter are the most frequently violated.[1]

[1] US EPA. (2018). *Green Book | US EPA*. [online] Available at: https://www.epa.gov/green-book [Accessed Apr. 2018].

Mechanisms for Health Effects: Oxidative Stress

- Damage is caused by Reactive Oxygen Species (ROS)[2]
  - $.O_2^-$
  - H_2O_2
  - .HO
  - $ONOO^-$
  - NO
  - Etc.
- ROS generation in tissue can be caused by exposure to PM or O_3. [3]



[2]Risom, L., Møller, P. and Loft, S. (2005). Oxidative stress-induced DNA damage by particulate air pollution. *Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis*, 592(1-2), pp.119-137.

[3] Corradi, M., Alinovi, R., Goldoni, M., Vettori, M., Folesani, G., Mozzoni, P., Cavazzini, S., Bergamaschi, E., Rossi, L. and Mutti, A. (2002). Biomarkers of oxidative stress after controlled human exposure to ozone. *Toxicology Letters*, 134(1-3), pp.219-225.

Oxidative Stress and Cancer

- 19% increased risk of lung cancer per 10 $\mu g/m^3$ increase in PM
  - Followed 8,111 residents in 6 U.S. cities
  - Conducted 1974-1989
- 14% increased risk of lung cancer per 10 $\mu g/m^3$ increase in $PM_{2.5}$
  - Followed 500,000 men and women
  - Conducted over 17 years
- 10% increased risk of lung cancer from exposure to < 30 $\mu g/m^3$ PM, and 40% increased risk of lung cancer from exposure to >30 $\mu g/m^3$ PM
  - Followed 755 Italian men
  - Conducted 1979-1986
- Smaller particles tend to have higher toxicity (deeper lung penetration, higher concentrations of PAH and transition metals)

[4] VALAVANIDIS, A., FIOTAKIS, K. and VLACHOGIANNI, T. (2008). Airborne Particulate Matter and Human Health: Toxicological Assessment and Importance of Size and Composition of Particles for Oxidative Damage and Carcinogenic Mechanisms. *Journal of Environmental Science and Health, Part C*, 26(4), pp.339-362.

Oxidative Stress and Other Respiratory Conditions

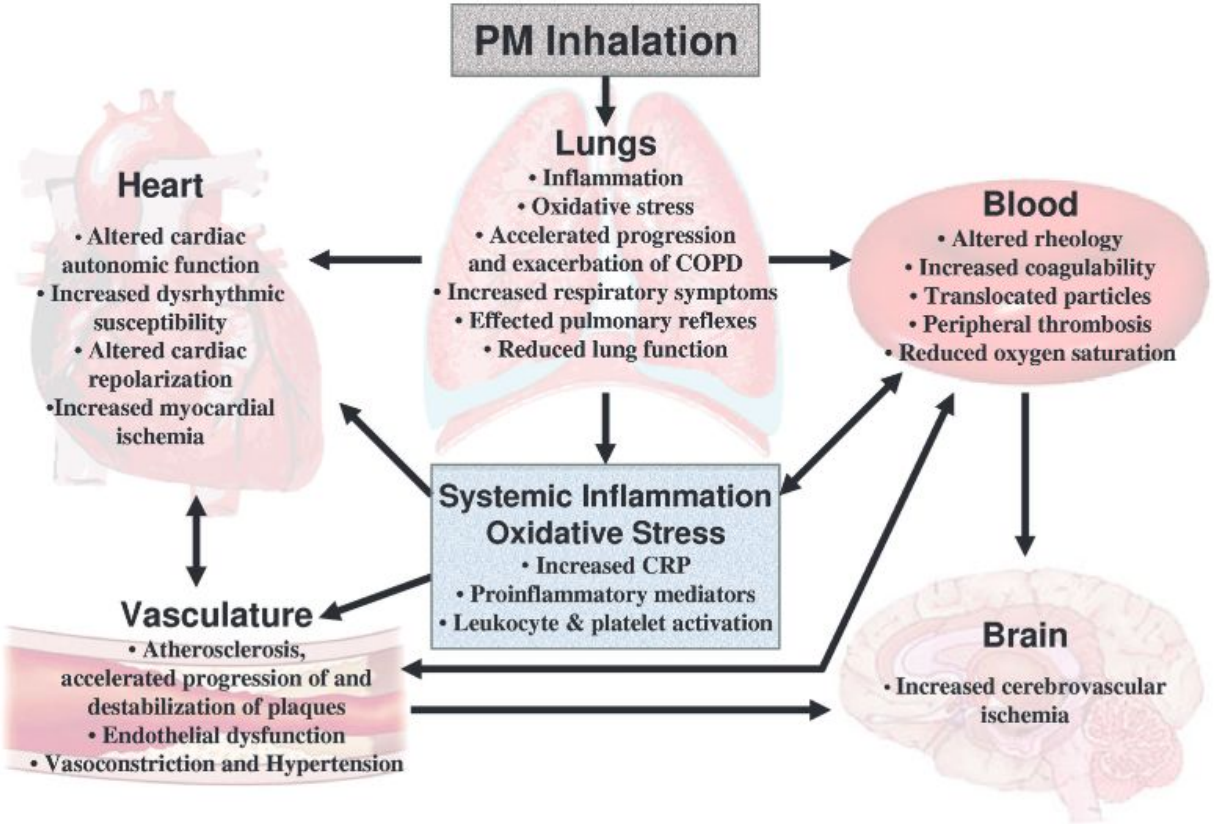
- ACOS- Asthma-COPD Overlap Syndrome: A condition where an asthma patient develops Chronic Obstructive Pulmonary Disease and experiences symptoms worse than those with only one of the two conditions
  - Higher mortality rates
  - More frequent hospital visits for asthma attacks
- Risk of developing ACOS is 31% higher per 10 ppb increase in O_3
- Risk of developing ACOS is 2.78 times higher per 10 $\mu g/m^3$ in $PM_{2.5}$

[5] To, T., Zhu, J., Larsen, K., Simatovic, J., Feldman, L., Ryckman, K., Gershon, A., Lougheed, M., Licskai, C., Chen, H., Villeneuve, P., Crighton, E., Su, Y., Sadatsafavi, M., Williams, D. and Carlsten, C. (2016). Progression from Asthma to Chronic Obstructive Pulmonary Disease. Is Air Pollution a Risk Factor?. *American Journal of Respiratory and Critical Care Medicine*, 194(4), pp.429-438.

Oxidative Stress and Cardiovascular Disease

- Per 20 μg/m^3 increase in PM_{10}
  - 1.8% increase in cardiac-related hospital admissions
  - 2.8% increase in heart failure admissions
  - 1.6% increase in ischemic heart disease admissions
  - 1.6 % increase in dysrhythmia related admissions
  - 1.8% increase in cardiac-related mortality events
- Multiple potential mechanisms have been proposed, but the exact path or paths which lead to cardiovascular health problems from PM are still being debated

[6] Pope, C. and Dockery, D. (2006). Health Effects of Fine Particulate Air Pollution: Lines that Connect. *Journal of the Air & Waste Management Association*, 56(6), pp.709-742.

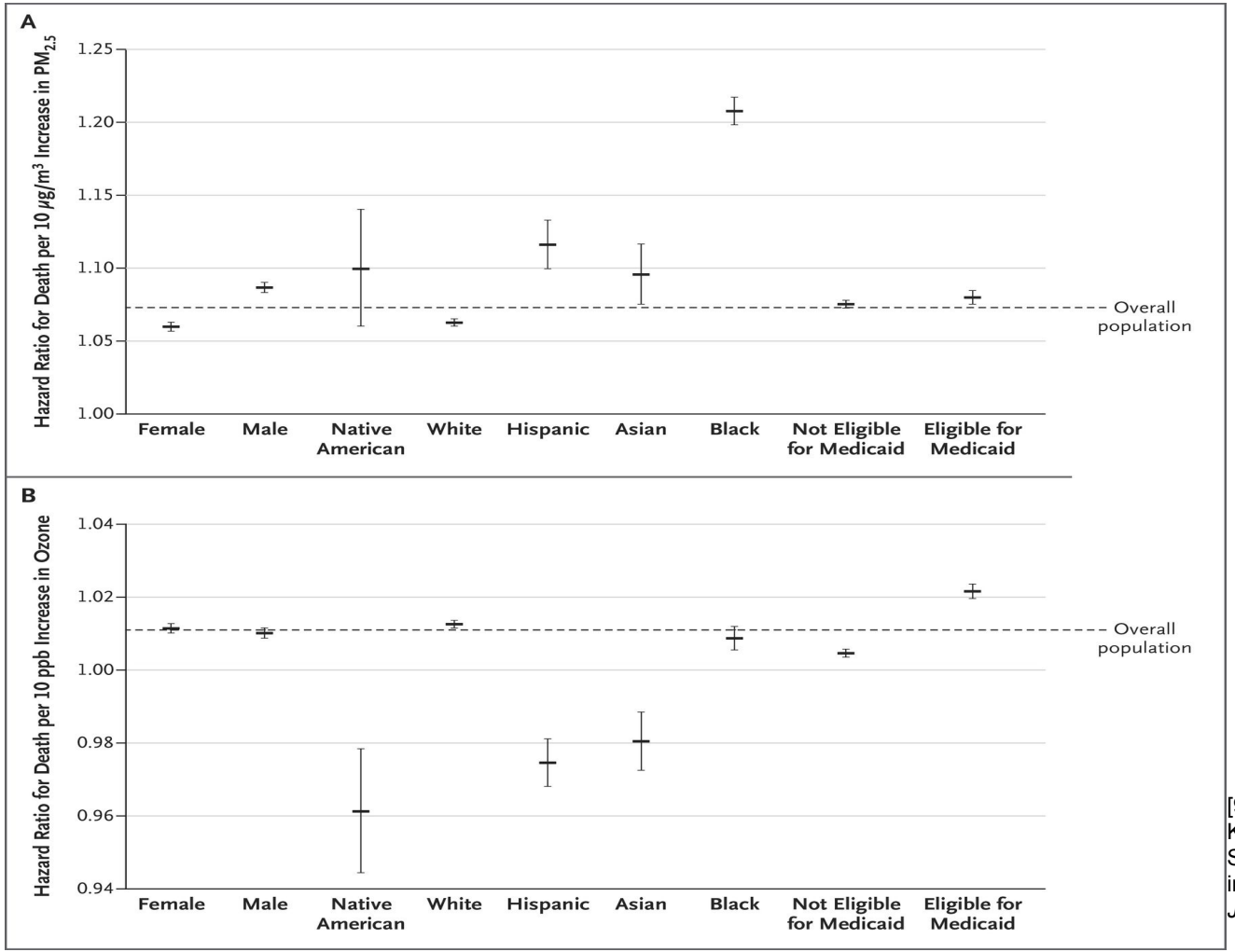


[6] Pope, C. and Dockery, D. (2006). Health Effects of Fine Particulate Air Pollution: Lines that Connect. *Journal of the Air & Waste Management Association*, 56(6), pp.709-742.

Oxidative Stress and All-Cause Mortality

- 7.3% increase in mortality with a 10 $\mu g/m^3$ increase in $PM_{2.5}$
- 1.1% increase in mortality with a 10 ppb increase in O_3
- 13.6% increase in mortality with a 10 $\mu g/m^3$ increase in $PM_{2.5}$ for individuals with base exposure levels < 12 $\mu g/m^3$
- 1.0% increase in mortality with a 10 ppb increase in O_3 for individuals with base exposure levels <50 ppb
- Mortality rate appears to increase for members of racial minorities and economically disadvantaged groups

[7] Di, Q., Wang, Y., Zanobetti, A., Wang, Y., Koutrakis, P., Choirat, C., Dominici, F. and Schwartz, J. (2017). Air Pollution and Mortality in the Medicare Population. *New England Journal of Medicine*, 376(26), pp.2513-2522.



[9] Di, Q., Wang, Y., Zanobetti, A., Wang, Y., Koutrakis, P., Choirat, C., Dominici, F. and Schwartz, J. (2017). Air Pollution and Mortality in the Medicare Population. *New England Journal of Medicine*, 376(26), pp.2513-2522.

Questions?