Air Pollution and Health

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Outline

• Outdoor Air Pollution
• Air Pollution and the Acute Respiratory Distress Syndrome
• Air Pollution and COVID-19
Pollution is the largest environmental cause of disease and premature death in the world today. Diseases caused by pollution were responsible for an estimated 9 million premature deaths in 2015 — 16% of all deaths worldwide — three times more deaths than from AIDS, tuberculosis, and malaria combined and 15 times more than from all wars and other forms of violence. In the most severely affected countries, pollution-related disease is responsible for more than one death in four.
Sources of Air Pollution

Natural Sources

Anthropogenic Sources

Stationary

Mobile
Outdoor Air Pollution

- Multiple sources
- Mixture of gases and particulate matter
- Traffic-related air pollution
Ozone

- Prototypic oxidant pollutant
- Major source: motor vehicle emissions
- Photochemistry during sunny afternoons
Ozone: Health Effects

- Respiratory symptoms, lower lung function, airway inflammation in healthy people
- Asthma
  - Exacerbations
  - New onset
- Mortality
Ambient Particulate Matter (PM)

- PM is a mixture, including particles of differing origin (combustion, crustal, biological) and varying size.
- Regulated by particle size in the developed world
- Multiple sources
  - Ultrafines (PM$_{<0.1}$): Fuel (including biomass) combustion
  - PM$_{2.5}$: Fuel (including biomass) combustion
  - PM$_{10-2.5}$: Road dust, crustal, and biological material
Particulate Matter: Health Effects

• Asthma
  – Exacerbation
  – New-onset

• Decreased lung function growth

• Mortality
  – Ischemic heart disease

• Lung cancer
Acute Respiratory Distress Syndrome (ARDS)

- Acute respiratory distress syndrome (ARDS) can occur in those who are critically ill or who have significant injuries. It is often fatal, the risk increasing with age and severity of illness.
- Fluid fills the alveoli (air sacs)
- Berlin definition
  - Bilateral opacities on chest imaging
  - Respiratory failure not fully explained by cardiac failure or fluid overload
  - Low PaO₂/FIO₂ ratio (hypoxemia)
Acute Respiratory Distress Syndrome (ARDS)

- Patients with ARDS typically require mechanical ventilation to maintain adequate oxygenation of their blood.
- This requires intubation with an endotracheal tube.
- Because positive pressure ventilation can injure the lungs (barotrauma), lung protective strategies are used.
- Compliance of the lung is monitored with modern ventilators as well as PaO2 and end-tidal CO2.
- Prone position can improve oxygenation.
Air Pollution and ARDS

Long-term ozone exposure is associated with development of ARDS in at-risk critically ill patients, particularly in trauma patients and current smokers.

Long-term low- to moderate-level exposure to PM2.5 is associated with a greater risk of developing ARDS after severe trauma.
Acute Effects of Pollution on Respiratory Infection

- Controlled exposure\(^1\) to NO\(_2\), O\(_3\) and/or PM\(_{2.5}\) worsens viral proliferation and severity of infection by other viruses:
  - Influenza
  - Rhinovirus
  - RSV

- Mechanisms of increased severity of viral infection:
  - Impaired ciliary function (first line defense of upper airways)\(^2\)
  - Oxidative stress and production of free radicals, causing local damage\(^1\)
  - Reduced ability of macrophages to phagocytose\(^1\)

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Gowdy et al. Particle and Fibre Toxicol 2010
PM$_{2.5}$ Link to Flu and Pneumonia Hospitalization

Lag 0–1 concentrations of PM$_{2.5}$ and hospital admissions for flu-like illness during flu season in Beijing, 2008-2014

Feng et al. *Environ Health.* 2016

3-day moving average (lag 0–2) concentrations of PM$_{2.5}$ and hospital admissions for pneumonia in 184 cities in China, 2014–2017

Coal Pollution and the 1918 Flu Pandemic

All-Age Mortality from Flu (High vs Low Coal Pollution)

- High coal vs. Low coal
- Medium coal vs. Low coal

Clay K. Economics and Human Biology. 2019
Suspended Particles May Spread Virus

- Particulate matter pollution may be platforms for viruses to spend more time in the air and travel longer distances.
- In Italy and China, COVID-19 mortality greatest in most polluted areas.
- SARS-COV-2 RNA has been found on outdoor particulate matter in Bergamo.

PM$_{10}$ Levels Feb 10-29, 2020

Covid-19 Fatalities Feb 10-29, 2020

2. Frontera et al. J Infect. 2020
Outdoor Pollution and Mortality from the original SARS in China

Thank you