Epidemiological evidence of air pollution increasing COVID-19

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Epidemiological evidence of air pollution increasing Covid-19

- Is there evidence that air pollution increases Covid-19 incidence and severity?
  - Previously reported with SARS in China
- How does air pollution increase Covid-19?

Pubmed search 08/09/21: “Covid-19” and “air pollution”
  - 2020: 554 articles - 80 systematic reviews
  - 2021: 690 articles - 107 systematic reviews
Covid-19 cases not distributed evenly

https://news.google.com/covid19/map?hl=en-AU&mid=%2Fm%2F02j71&gl=AU&ceid=AU%3Aen&state=1
THE BURDEN OF AIR POLLUTION

- Ambient air pollution is the 5th leading cause of death worldwide. Contributing to:
  ~ 4.2 million deaths worldwide
  ~400,000 deaths of children under five
- Air pollution distribution is not even with many LMICs subjected to poor air quality

Ambient air pollution sources

Volcanic eruptions
Industrial emissions
Diesel engines
Burning garbage

Forest fires
Diesel engines
Traffic emissions
Burning crop stubble
Major Outdoor Pollutants

- Particulate matter
  - Complex mixture of solid and liquid components
  - Carbon core with adsorbed chemicals, metal, etc
  - EPFRs
  - Toxicity depends on what was burnt

- Ozone
- Nitrogen oxides
- Carbon monoxide
- Sulfur dioxide
Size Matters

- **Coarse particles** (2.5–10 μm) deposited in the upper respiratory tract and large airways
- **Fine particles** (< 2.5 μm) may reach terminal bronchioles and alveoli
- **Ultrafine** (<1.0 μm) reach alveoli and may penetrate into blood stream
Ozone ($O_3$): “Secondary Pollutant”

- photochemical reaction, VOCs, $NO_2 + O_2$
  - Peaks late afternoon
  - Maximum in hot, stagnant air
  - Summer $>$ winter
Deposition of Pollutants in Respiratory Tract

<table>
<thead>
<tr>
<th>Water Solubility</th>
<th>Initial Level of Impact</th>
<th>Compounds</th>
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</thead>
<tbody>
<tr>
<td>High</td>
<td>Eyes, Nose, Pharynx, Larynx</td>
<td>Aldehydes, Ammonia, Chlorine, Sulfur dioxide</td>
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<tr>
<td>Medium</td>
<td>Trachea, Bronchi</td>
<td>Ozone</td>
</tr>
<tr>
<td>Low</td>
<td>Bronchioles, Alveoli</td>
<td>Nitrogen dioxide, Phosgene</td>
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</tbody>
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*CDC*
HOUSEHOLD AIR POLLUTION

Number of Deaths

- 0 to < 10,000
- 10,000 to < 35,000
- 35,000 to < 100,000
- 100,000 to < 250,000
- 250,000 to < 607,000
- No Data

Household air pollution

Low-income settings (HAP)

- Open, unflued fires
- Solid, unclean and biomass fuel use
- Tobacco smoke
- Cottage industries
- Bioaerosols
- Religious practices
- Earthen floors
- Ambient air pollution

Affluent settings (IAP)

- Volatile organics
- Household chemicals
- Unflued gas cooking / heating
- Bioaerosols
- Tobacco smoke
- Religious practices
- Car fumes (attached garage)
- Radon (basements)
- Religious practices
- Ambient air pollution
SMR for 10 age groups from Covid-19 (to June 2020, 2019 population) and PM\(_{10}\) for 36 Italian provinces. Correlation \([\beta 0.147 \ (0.059-0.234), \ p=0.001]\) and spatial autocorrelation b/w SMA and PM\(_{10}\)

Red dots: Po valley locations

Dettorri M, Environ Res 192 (2021) 110459
Associations between air pollution (2018 data or 5 y average) and Covid-19 cases and mortality, UK-Biobank, 1464 tests, 664 +ve. Similar associations for air pollution data from 2018, or 5-year averages - ? Chronic effect
Change in **daily Covid-19 case rates** associated with **air pollution** exposure, with **lags up to 21 days** in 120 Chinese cities between Jan 23 and Feb 29 2020
Review of 26 articles from many countries shows association between short term air pollution exposure and increased cases of Covid-19. Data suggest increased transmission. Effects on mortality less certain.

Long-term air pollution exposure associated with increased severity and mortality.

Acute exposure to bushfire smoke increases Covid-19 cases.

10µg/m³ ↑ in 7-day average PM$_{2.5}$ → 6.3% relative ↑ in SARS-COV-2 positive test rate, Reno, Nevada 2020

Kiser D, J Exposure Sci Environ Epi 2020 DOI 10.1038/s41370-021-00366-w
Racial disparity in Covid-19 cases and deaths

COVID-19 fatality rates

<table>
<thead>
<tr>
<th>Demographic</th>
<th>New York state</th>
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<tbody>
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Contributing socioeconomic, racial & environmental factors:
- Structural racism
- Crowded living conditions, multi-generational homes
- Limited access to health care and healthy foods
- "Working in low paying "essential" jobs"
- Chronic exposure to air pollution

Yearly average PM_{2.5} (g/m^2) levels

# of COVID-19 deaths per 1 million
HOW DOES AIR POLLUTION INCREASE COVID-19?

Potential mechanisms

- Virus attaches to PM and “hitches” into lungs
- Pollution
  - degrades epithelial integrity
  - reduces anti-viral immune responses
    - Vit D, anti-viral peptides, interferons
  - Increases expression of ACE-2 receptor
Corona virus life cycle in epithelial cell

Entry

Uncoating

Positive-sense RNA genome
Translation of Orf1/Orf1b

Plasma Membrane

Receptor ACE2

Virions

Exocytosis

Vesicle

Golgi

ERGIC

Assembly and Budding

Cytoplasm

Nucleus

5' Negative-sense RNA

3' Positive-sense RNA genome

Replication

Translation

S
nsp 3a/3b
E
M
nsp 6
nsp 7a/7b
nsp 8a/8b
N/nsp9a

5' Negative-sense RNA

3' Transcription

5' Positive-sense RNA genome

Replicase-transcriptase complex

DMVs

pp1a & pp1ab

Proteolysis

Woodby B, Ann NY Acad Sci 1486 (2021) 15-38
Potential mechanisms by which air pollution increase Covid-19
Air pollution inactivates the Vit-D dependent anti-microbial peptide LL37
Crane-Godreau Frontiers in Public Health
28 May 2020
AIR POLLUTION AND COVID-19

- Short term air pollution exposure
  - Reasonable evidence of increased transmission of SARS-COV-2, less evidence on increased mortality

- Chronic air pollution exposure
  - Increased transmission and mortality

- Many potential mechanisms but little direct evidence