Ambient air pollution and the COVID-19 pandemic – any link?

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Chair Swiss Federal Commission on Air Hygiene (FCAH)

Thu 16.9.2021 – 17:00-18:00 CEST

Webinar jointly organised by ERS and the International Society for Aerosols in Medicine (ISAM)
Annual mean particulate matter concentration (PM10 in µg/m³)

- Wuhan: ~ 100+
- Lombardia: ~ 40-50

- WHO Air Quality Guideline Value: 20
Air pollution and the COVID-19 epidemic

Six aspects discussed by the Federal Commission for Air Hygiene

Luftverschmutzung und COVID-19 Epidemie

Sechs Aspekte erläutert von der Eidgenössischen Kommission für Lufthygiene

Pollution de l’air et épidémie de COVID-19

Six éléments expliqués par la Commission fédérale de l’hygiène de l’air

Inquinamento atmosferico ed epidemia di COVID-19

Sei aspetti spiegati dalla Commissione federale d’igiene dell’aria

www.ekl.admin.ch
Air pollution and COVID-19

Including elements of air pollution in rural areas, indoor air pollution, vulnerability and resilience aspects of our society against respiratory disease, social inequality stemming from air pollution.
Possible roles of ambient air pollution - 6 aspects

1. Transmission
2. Defence of the exposed
3. Resilience of population
4. COVID patient care
5. Recovery after COVID
6. Lockdown

STAY HOME
SAVE LIVES
NO2 concentration prior and during lockdown. China Jan/Feb 2020
Landrigan, Lancet Planetar Health 2021

Figure: Airborne nitrogen dioxide pollution, China, Jan 1 to Feb 28, 2020
Images are from NASA Earth Observatory images by Joshua Stevens, using modified Copernicus Sentinel 5P data processed by the European Space Agency. NO2=nitrogen dioxide.
Reduction of primary traffic-related pollutants (nitrogen oxides – NOx) due to the lockdown (at a traffic-related monitoring station in Bern, Switzerland)
Lockdown cause air pollution declines (adjusted for weather conditions) (Venter at al, PNAS 2020; 34 countries)

- 60% reduction of population-weighted average of NO2 (heavy-duty vehicles!)
- 31% reduction of fine particulate matter (PM2.5) - but more heterogeneous
Air Quality Changed Disproportionally Across World Urban Agglomerations, Countries, and Regions due to COVID-19 Containment Response Policies
(under review – do not cite nor quote) (Zhang et al & Heresh Amini)

DATA

- Jan 2019- July 2020
- 1’267 ground monitoring stations at 496 urban agglomerations
- Eight daily national COVID-19 containment response policies → mild, moderate or stringent “lockdowns”
- Adjusted for meteo and time trends

RESULTS for NO2 changes:

- Strongest air quality improvements in more polluted and populated areas
- Mild CRP: no change
- Moderate CRP: -26% (19-34%)
- Stringent CRP: -32% (25-39%)
Possible roles of ambient air pollution - 6 aspects

1. Transmission
Airborne transmission of SARS-CoV-2: The world should face the reality

Lidia Morawska\textsuperscript{a,*}, Junji Cao\textsuperscript{b}

\textsuperscript{a}International Laboratory for Air Quality and Health (IL4AIH), School of Earth and Atmospheric Sciences, Queensland University of Technology, Brisbane, Queensland 4001, Australia

\textsuperscript{b}Key Lab of Atmosphere Environmental Pollution Control, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

Droplets containing virus: large ● small

https://worldhealthorg-my.sharepoint.com/personal/forastieref_who_int/Documents/Attachments/Lidia%20Morawska.mp4
“Particulate Matter” (PM) defined by size (diameter, in micrometers) Nel et al, Science, 2005; 307:1858
SARS-Cov-2 RNA identified on ambient particulate matter

Epidemic relevance of the findings is unknown
- for transmission?
- for infections?
- as a marker of recurrence of epidemic?
Possible roles of ambient air pollution - 6 aspects

1. Transmission

2. Defence of the exposed
Hallmarks of environmental insults

Annette Peters,1,2,3,* Tim S. Nawrot,4,5 and Andrea A. Baccarelli6
Summary of air pollution health effects

Acute

- Respiratory problems, cough, dyspnoea
- Asthma attacks
- Myocardial infarction,
- Stroke
- Hospital admissions
- Doctoral visits
- Death
- ...
A lot of poor science got high media attention.
"Ecologic correlation" does not imply "causation"

Examples of flawed COVID / air pollution studies with inadequate ecologic research design: see letter by Ricco

Science of the Total Environment 734 (2020) 139489
Air pollution interacts with tuberculosis infection

AJRCCM online Sept 21

Indoor Air Pollution and Susceptibility to Tuberculosis Infection in Urban Vietnamese Children

Robert J. Blount MD, MAS¹, Ha Phan PhD²,³, Trang Trinh BS²,³, Hai Dang BS²,³, Cindy Merrifield RN, BSN²,⁴,⁵, Michael Zavala BS¹, Joseph Zabner MD, PhD¹, Alejandro P. Comellas MD¹, Emma M. Stapleton PhD¹, Mark R. Segal PhD⁶, John Balmes MD⁴,⁷, Nguyen Viet Nhung MD, PhD²,⁸, Payam Nahid MD, MPH²,⁴,⁵

109 household contacts of 72 cohort patients with active tuberculosis

OUTCOME: Cross-sectional correlates of asymptomatic (latent) Tbc of those contacts

Potential determinants studied: range of personal factors, personally monitored PM2.5 and personal sources of environmental exposure (passive smoking, indoor cooking etc.)

RESULTS:

53% with latent Tbc

Significant correlates:

- Number of smokers in households,
- living on 1st floor,
- 3-7 motorcycles parked inside house;

Personal PM2.5: no clear association
Hospitalization due to culture-negative pneumonia increases by 1-3% (lag days 0-6) per 7 ug/m$^3$ increase in the daily mean PM$_{2.5}$ concentration (500’000 adults, New York; Croft et al, 2019)
Established acute health effects of ambient air pollution: number of cases are higher if air pollution increases, thus pressure on health care system further increased...

Severity

RESPIRATORY
- Asthma attacks
- COPD exacerbations
- Pneumonia
- Bronchitis
- Cough

CARDIOVASCULAR
- Myocardial infarction
- Coronary syndrom
- Stroke
- Arrhythmia
- Blood clotting

Death
Hospitalization
Emergency room
Doctor’s visit
Reduced activity
Medication
Symptoms
Changes in physiologic measures

Numbers affected

Established acute health effects of ambient air pollution:

- Number of cases are higher if air pollution increases, thus pressure on health care system further increased.

Severity:

- RESPIRATORY: Asthma attacks, COPD exacerbations, Pneumonia, Bronchitis, Cough
- CARDIOVASCULAR: Myocardial infarction, Coronary syndrom, Stroke, Arrhythmia, Blood clotting

Health effects:

- Death
- Hospitalization
- Emergency room
- Doctor’s visit
- Reduced activity
- Medication
- Symptoms
- Changes in physiologic measures
Pre-lockdown exponential growth of COVID-19: number of days to double # of cases (until March 15th, 2020)

<table>
<thead>
<tr>
<th>Country</th>
<th>Days to Double</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>4 days</td>
</tr>
<tr>
<td>Iran</td>
<td>7 days</td>
</tr>
<tr>
<td>South Korea</td>
<td>14 days</td>
</tr>
<tr>
<td>Spain</td>
<td>3 days</td>
</tr>
<tr>
<td>France</td>
<td>4 days</td>
</tr>
<tr>
<td>Germany</td>
<td>3 days</td>
</tr>
<tr>
<td>United States</td>
<td>4 days</td>
</tr>
<tr>
<td>Switzerland</td>
<td>3 days</td>
</tr>
</tbody>
</table>

Total Coronavirus Cases in the United States

25-50% increase PER DAY
Possible roles of ambient air pollution - 6 aspects

1. Transmission
2. Defence of the exposed
3. Resilience of population
## Summary of air pollution health effects

<table>
<thead>
<tr>
<th>Acute</th>
<th>Long-term effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Respiratory problems, cough, dyspnoea</td>
<td>- Chronic lung diseases</td>
</tr>
<tr>
<td>- Asthma attacks</td>
<td>- Poor lung function</td>
</tr>
<tr>
<td>- Myocardial infarction, Stroke</td>
<td>- Atherosclerosis</td>
</tr>
<tr>
<td>- Hospital admissions</td>
<td>- Lung cancer</td>
</tr>
<tr>
<td>- Doctoral visits</td>
<td>- Shorter life expectancy</td>
</tr>
<tr>
<td>- Death</td>
<td>- Diabetes</td>
</tr>
<tr>
<td>- ...</td>
<td>- Likely:</td>
</tr>
<tr>
<td></td>
<td>- reduced cognitive function;</td>
</tr>
<tr>
<td></td>
<td>- Low birth weight</td>
</tr>
<tr>
<td></td>
<td>- Etc.….</td>
</tr>
</tbody>
</table>
Percentage of four causes of death attributable to ambient air pollution


- COPD (Chronic Obstructive Lung Diseases): 40%
- Heart Diseases: 20%
- Lung Cancer: 19%
- Diabetes: 19%
Very high uncertainty about the quantitative contribution of air pollution to severe COVID-19 cases (death)

Estimated % change in COVID-19-Case Fatality Rate per 10µg/m3 PM10 (China; Yao et al 2020)

~0.2 %

Estimated % change in COVID-19-death per 10µg/m3 PM10 (Wu, USA))

~150%

Updated April 5, 2020

Exposure to air pollution and COVID-19 mortality in the United States

Xiao Wu MS, Rachel C. Nethery PhD, M. Benjamin Sabath MA, Danielle Braun PhD, Francesca Dominici PhD

All authors are part of the Department of Biostatistics, Harvard T.H. Chan School of Public Heath, Boston, MA, 02115, USA
Scoping review posted on 20.8.2020 on pre-print server
Bashkar et al confirms large inconsistencies across
studies – inadequate study designs.
Bhaskar et al medRxiv

• 28 publications identified
• 16 «short-term» effect studies
• 12 «long-term» studies
• 27 with «ecologic study design»
• Large quantitative discrepancies in the observed
associations
Association between coronavirus disease 2019 (COVID-19) and long-term exposure to air pollution: Evidence from the first epidemic wave in China

Pai Zheng a,1, Zhangjian Chen a,1, Yonghong Liu b,1, Hongbin Song c,1, Chieh-Hsi Wu d,1, Bingying Li b, Moritz U.G. Kraemer e,f,g, Huaiyu Tian b, Xing Yan b, Yuxin Zheng h, Nils Chr. Stenseth i, Guang Jia a,∗

Env Internat, 2021

• 324 cities in China
• First wave only
• Long-term home outdoor NO2, PM2.5, PM10 models
• Adjustment for ecologic co-variates including lockdown measures (mobility data)

• Severe diseases increased 38%, 32% and 14% per 10ug/m3 NO2, PM2.5 and PM10
Association between 2018 home outdoor mean PM2.5 and COVID-19 hospitalization rates among 169,102 veterans with a positive SARS-COV2-test
Bowe et al, Env Internat 2021

Hospitalizations (N=25,000) defined as those within 3 weeks around the positive test

- Hospitalization risk increased by ~10% per 1.9 ug/m3 long-term mean PM2.5
- Strongest in black and areas with high deprivation (ADI)
COVID-19 mortality in the UK Biobank cohort: revisiting and evaluating risk factors

Joshua Elliott¹,²,³ · Barbara Bodinier¹,² · Matthew Whitaker¹,² · Cyrille Delpierre⁴ · Roel Vermeulen⁶ · Ioanna Tzoulaki¹,²,⁵ · Paul Elliott¹,² · Marc Chadeau-Hyam¹,²

Received: 17 September 2020 / Accepted: 21 January 2021
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In 473’000 U.K. Biobank cohort participants, 2010 mean concentrations of pollutants (home outdoor models) were not associated with COVID-19 mortality in 2020
Association between ambient air pollution and tuberculosis risk: A systematic review and meta-analysis

Kun Xiang, Zhiwei Xu, Yu-Qian Hu, Yi-Sheng He, Yi-Lin Dan, Qian Wu, Xue-Hui Fang, Hai-Feng Pan

Long-term exposure (but not short-term) to PM10, NO2 and SO2 are associated with increased tuberculosis incidence
Possible roles of ambient air pollution - 6 aspects

1. Transmission
2. Defence of the exposed
3. Resilience of population
4. COVID patient care
5. Recovery after COVID
Mortality among lung cancer patients in California increased with the outdoor concentration of nitrogen dioxide (per 20 µg/m³ NO₂) 
(Eckel et al. 2016)
The «magic mountain» approach: clean air for tuberculosis patients
Possible roles of air ambient pollution - 6 aspects

1. Transmission
2. Defence of the exposed
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5. Recovery after COVID
### SUGGESTED EFFECTS AND EVIDENCE

<table>
<thead>
<tr>
<th>SUGGESTED EFFECT</th>
<th>HYPOTHESIS</th>
<th>SCIENTIFIC EVIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Transmission per se: no evidence for a role of air pollution</td>
<td>QUESTIONABLE</td>
<td>NONE</td>
</tr>
<tr>
<td>2. Acute immune defence of exposed might be jeopardized if air pollution is high</td>
<td>PLAUSIBLE</td>
<td>SOME INDIRECT</td>
</tr>
<tr>
<td>3. Resilience against severe COVID might be compromised in those with a history of long-term exposure to ambient air pollution</td>
<td>STRINGENT</td>
<td>SOME</td>
</tr>
<tr>
<td>4. Acute course of Covid-19 disease might be compromised during periods of higher air pollution</td>
<td>PLAUSIBLE</td>
<td>NONE</td>
</tr>
<tr>
<td>5. Longer-term recovery from COVID-19 might profit from cleaner air</td>
<td>PLAUSIBLE</td>
<td>NONE for Covid</td>
</tr>
<tr>
<td>6. Lockdowns of sources of air pollution result in lower concentrations of primary pollutants</td>
<td>STRINGENT</td>
<td>STRONG</td>
</tr>
</tbody>
</table>
Clean air policies work! A major success story (in some countries)
Fine particulate annual means (PM$_{2.5}$) 1990 - 2015

Western Europe
- Italy
- Germany
- Belgium
- Netherlands
- Luxembourg
- Austria
- Greece
- Switzerland
- France
- Malta
- Cyprus
- U.K.
- Denmark
- Spain
- Portugal
- Andorra
- Ireland
- Sweden
- Finland
- Norway
- Iceland

Hungary
- Chech Republic
- Slovakia
- Romania
- Poland

Eastern Europe
- Bulgaria
- Serbia
- Macedonia
- Slovenia
- Croatia
- Albania
- Bosnia & Herzegovina
- Montenegro

WHO Guideline Value

Figures: from Brauer et al. ES&T 2016
• Better individual-level study designs
• Stronger case definition (e.g. confirmed COVID-19 cases are only a proxy for the true SARS-CoV-2 infection incidence rate; notification day may fall well outside real and more appropriate infection time lapse (onset of symptoms)
• Better control of pandemic control measures, compliance and behaviour (e.g. highly polluted areas are often characterized by higher rates of human interaction and international travelers AND control measures are potentially stronger in high density areas)
• Control of lockdown measures (e.g. affecting air pollutant concentrations but also health determinants etc.)
• Better control for important individual-level confounders (e.g. population density, temperature, humidity, autocorrelation, mobility, policy measures, socioeconomic and lifestyle factors)
In sum, use the «right arguments» and research methods for the «right case»

- Emergency clean air policies to not «flatten the curve» during the pandemic crisis
- Research will estimate the overall contribution of air pollution to the pandemic (and the air pollution related benefits of the lockdown)

BUT

- Air pollution causes morbidities and diseases at risk for severe COVID-19 illnesses
- Populations with less exposure to ambient air pollution are healthier
- Healthier populations are more resilient
- Sustained globalized clean air policies and ambient air quality standards are needed to protect peoples health

Thank you for your attention

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Special thanks go to Ron Kappeler, Swiss TPH for the continued screening of the literature