



Air pollution and COVID-19 - clearing the air and charting a post-pandemic course: a joint workshop report of ERS, ISEE, HEI and WHO

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Complete List of Authors:	<p>Andersen, Zorana; University of Copenhagen Department of Public Health, Public Health Hoffmann, Barbara; Heinrich Heine University Düsseldorf, Institute for Occupational, Social and Environmental Medicine Morawska, Lidia; Queensland University of Technology, International Laboratory for Air Quality and Health; Adams, Martin; European Environment Agency Furman, Eeva; Finnish Environment Institute Yorgancioglu, Arzu; Celal Bayar University, Pulmonary Diseases Greenbaum, Dan; Health Effects Institute, Neira, Maria; World Health Organization Brunekreef, Bert; Utrecht University, Institute for Risk Assessment Sciences and Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht Forastiere, Francesco ; Imperial College London, Department of Epidemiology Rice, Mary; Beth Israel Deaconess Medical Center, Medicine Wakenhut, Francois; European Commission, Clean Air Unit, Directorate-General Environment Colen, Erika; Belgian Asthma and Allergy Association Boogaard, Hanna; Health Effects Institute, Gehring, Ulrike; Utrecht University, Institute for Risk Assessment Sciences Melén, Erik; Karolinska Institutet, Institute of Environmental Medicine Ward, Brian; ERS Office, EU Affairs De Matteis, Sara; Imperial College London, Respiratory Epidemiology, Occupational Medicine & Public Health, National Heart and Lung Institute</p>
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**Air pollution and COVID-19: clearing the air and charting a post-pandemic course: a joint workshop
report of ERS, ISEE, HEI and WHO**

Zorana J. Andersen,¹ Barbara Hoffmann,² Lidia Morawska,³ Martin Adams,⁴ Eeva Furman,⁵ Arzu Yorgancioglu,⁶ Dan Greenbaum,⁷ Maria Neira,⁸ Bert Brunekreef,⁹ Francesco Forastiere,¹⁰ Mary B. Rice,¹¹ François Wakenhut,¹² Erika Coleen,¹³ Hanna Boogaard,⁷ Ulrike Gehring,⁹ Erik Melén,¹⁶ Brian Ward,¹⁷ Sara De Matteis^{18,19}

¹ Environmental Epidemiology Group, Section of Environmental Health, Department of Public Health, Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark;

² Institute for Occupational, Social and Environmental Medicine; Centre for Health and Society, Medical Faculty, Heinrich-Heine-University of Düsseldorf, Düsseldorf, Germany;

³ International Laboratory for Air Quality and Health (ILAQH), School of Earth and Atmospheric Sciences, Queensland University of Technology, Brisbane, Queensland 4001, Australia;

⁴ European Environment Agency, Copenhagen, Denmark;

⁵ Finnish Environment Institute, Helsinki, Finland;

⁶ Celal Bayar University Medical Faculty Department of Pulmonology, Manisa, Turkey;

⁷ Health Effects Institute, Boston, USA;

⁸ World Health Organization, Geneva, Switzerland;

⁹ Institute for Risk Assessment Sciences (IRAS), Utrecht University, Utrecht, The Netherlands;

¹⁰ Imperial College, London, UK;

¹¹ Division of Pulmonary, Critical Care and Sleep Medicine, Beth Israel Deaconess Medical Center, Boston, MA, USA;

¹² Clean Air Unit, Directorate-General Environment, European Commission (The opinions expressed in this manuscript are those of the authors and should not be considered to represent an official position of the European Commission);

¹³ Belgian Asthma and Allergy Association, Brussels, Belgium;

¹⁶ Department of Clinical Sciences and Education, Karolinska Institutet, Södersjukhuset, Stockholm, Sweden

¹⁷ European Respiratory Society;

¹⁸ Department of Medical Sciences and Public Health, University of Cagliari, Cagliari, Italy;

¹⁹ National Heart and Lung Institute, Imperial College London, London, UK.

Correspondence: Zorana Jovanovic Andersen, Section of Environmental Health, Department of Public Health, University of Copenhagen, Øster Farimagsgade 5, Opgang B, 1014 Copenhagen, Denmark. e-mail: zorana.andersen@sund.ku.dk; Tlf: +4520740462.

The 'take home' message:

The potential role of air pollution in the spread and worsening of health impacts of COVID-19, and the influence of the pandemic on air pollution levels in Europe is explored. We outline the major lessons learned to chart a healthy post-pandemic course.

Introduction

Air pollution is now recognized by governments, international institutions and civil society as a major global public health risk factor. The health burden of air pollution is large: 509,000 premature deaths every year in Europe [1] and serious aggravations of heart and lung diseases that affect millions of patients, both children and adults. This 'silent killer' is one the most important determinants of health, surpassed only by high blood pressure, tobacco use, and poor diet. The COVID-19 pandemic has raised concerns about whether air pollution can increase the severity of disease and risk of death after infection as well as facilitate the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Chronic lung disease patients are in the epicentre of the current crisis, as they are more vulnerable to both the adverse effects of a SARS-CoV-2 infection and air pollution exposure, as well as their possible interactions. At the same time, the lockdown measures to control the spread of COVID-19 brought historical short-term reductions in air pollution levels around the globe, and increasing general public interest and demand for clean air policies. The COVID-19 pandemic, an emerging infectious disease probably caused by a spill over from animals, and its possible interactions with air pollution, is an existential reminder that we are a part of a larger ecosystem, and that human health is closely connected with the health of our environment and planet. Here we provide a short summary on the potential role of air pollution in the spread and worsening of health impacts of COVID-19, and on the influence of the pandemic on air pollution levels in Europe. Moreover, we outline the major lessons learned to chart a healthy post-pandemic course. This work summarizes the key messages from a workshop that took place on December 2nd, 2020, organized by the European Respiratory Society (ERS), the International Society for Environmental Epidemiology (ISEE), the Health Effects Institute (HEI), endorsed by the World Health Organization (WHO), and hosted by the European Parliament Lung Health Group, and the European Commission.

Does Air Pollution Increase COVID-19 Severity?

Ecological studies showing simple correlations between regional long-term air pollution levels and COVID-19 mortality rates have given rise to the hypothesis of increased susceptibility of populations living in areas with high air pollution towards COVID-19 [2]. However, these studies as well as more sophisticated ecological assessments, where mean air pollution levels in an area (county, municipality, etc.) were linked to the COVID-19 mortality or case-fatality rates in that area, are inadequate for assessing the potential association between air pollution and COVID-19 [3, 4]. The major limitation of these studies is that the aggregated data cannot be used for inference at the individual level, as they are prone to an error commonly called 'ecological fallacy'. Furthermore, results of these studies should be interpreted with caution, as many were published ahead of rigorous peer-review, and may have methodological flaws, such as lack of adjustment for social contacts and mobility, which are important drivers of the COVID-19 epidemic. For example, a US study raised headlines globally in May 2020 by showing that a small increase of $1 \mu\text{g}/\text{m}^3$ in long-term average county-level concentrations of particulate matter (PM) with diameter $< 2.5 \mu\text{g}/\text{m}^3$ ($\text{PM}_{2.5}$) was associated with a sizeable 15% increase in the county-level COVID-19 death rate [3]. Notably, this estimate was soon corrected to 8% when taking into account dynamic of the disease in terms of the time of virus introduction in each county, demonstrating the necessity of correcting for those factors. Notably, another US study using the same data, but with more complete control for confounding and spatial autocorrelation, found no associations with $\text{PM}_{2.5}$ [4]. These early studies using very early, highly aggregated population data, have motivated calls for individual level (cohort) data with careful control for relevant confounders and underlined the importance of rigorous research on air pollution and COVID-19 [5, 6]. Consequently, with the current lack of individual-level studies, attempts to quantify the fraction of global COVID-19 deaths attributed to $\text{PM}_{2.5}$ [7] is premature and imprecise [8].

Nevertheless, an association of long-term exposure to air pollution with an increased COVID-19 infection risk and severity is biologically plausible [9]. Experimental studies show that PM exposure can impair cell immunity and weaken host defence mechanisms, increasing susceptibility to respiratory infections [10].

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4 This is caused by direct cellular damage, and indirectly, via oxidative stress and inflammation in the lung
5 and systemically [11-13]. Furthermore, PM_{2.5} was found to cause over-expression of ACE (angiotensin-
6 converting-enzyme)-2 receptors [14], the key target of SARS-CoV-2 to enter human cells, thereby
7 promoting viral entry and damage to the cell [15]. The so called 'double hit' model of air pollutants and
8 SARS-CoV-2 interaction therefore proposes, that air pollution increases susceptibility to infection and
9 severity of disease via facilitating viral entry as well as reducing host defences [16]. Consistent with this,
10 epidemiological studies conducted prior to the COVID-19 pandemic have linked long-term exposure to air
11 pollution to increased risk of respiratory infections such as pneumonia [17]. Furthermore, it is well known
12 that air pollution increases the risk of a number of chronic (respiratory, cardiometabolic) diseases, the same
13 ones reported as the co-morbidities increasing the risk of being hospitalized or dying from COVID-19 [18].
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16 How did COVID-19 lockdown affect air pollution levels in Europe?

17 Lockdown measures to control the COVID-19 pandemic in Europe in 2020 have resulted in significant
18 reductions in air pollutant emissions and concentrations within days and weeks, though with notable
19 differences between pollutants, countries, and cities [19]. The largest decreases in monthly averages of up
20 to 70% in NO₂, compared with expected concentrations in the absence of lockdown measures were
21 observed at traffic monitoring stations in Spain and Italy, while reductions in background NO₂
22 concentrations for selected countries ranged from an average 61% in Spain to 20% in Czech Republic. In
23 some cities, NO₂ levels remained relatively low even after lockdown measures were lifted (Milan, Italy),
24 while in others (Athens, Greece) they rapidly returned to 'normal' [19]. For PM_{2.5}, decreases in background
25 concentrations ranged from 30% in Spain to 9% in the Czech Republic compared to expected levels.
26 Reductions in PM_{2.5} levels were smaller and less consistent than those for NO₂ due to the generally more
27 varied sources of PM_{2.5} especially in urban areas, including the combustion of fossil fuel for heating,
28 industrial activities, road traffic and secondary particle formation. Importantly, these reductions were
29 largely short term, with levels rebounding as economic activity increased again.
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33 What is the role of ambient air pollution in transmission of COVID-19?

34 There has been speculation that particles in the air may serve as a carrier of SARS-CoV-2 virus-laden
35 respiratory particles, thereby enhancing transmission in areas with higher levels of PM pollution. Most
36 outdoor air particles are small, within the lower submicrometre size range [20, 21]. A "naked" SARS-CoV-2
37 virus measures approximately 0.12 µm, however, virus-laden respiratory particles also contain water,
38 mucus and salts [22] and measure up to a few micrometres [23, 24]. Thus, since an aerosolised virus in the
39 air is not "naked", the majority of particles in urban air, which are small [25] cannot be carriers of such
40 bigger, virus-laden particles. Furthermore, the interaction between same size PM and SARS-CoV-2 virus
41 particles is very slow, because their respective concentrations in outdoor air are low, in contrast to indoor
42 air, where the majority of human exposure to SARS-CoV-2 virus occur. Hence, the ambient air pollution
43 particles likely do not play a role in the transmission of SARS-CoV-2 virus.
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47 What did COVID-19 teach us about planetary health?

48 The world today is highly interconnected with intensive global flows of people, natural resources and
49 pollution between all parts of the world. This causes major destruction in wildlife populations and
50 ecosystems and increases contact between human populations and wildlife reservoirs of potentially
51 pathogenic bacteria and viruses. Ecosystem destruction leads to species loss and population decline. The
52 disturbed system now starts to favour species with high reproductive rates and short life cycles. They form
53 highly dense populations, typically also highly conductive and prone to transmit diseases. When natural
54 food webs are disturbed, the resource use behaviour in higher trophic levels changes, making them prone
55 to high mutation rate pathogens, such as SARS-Cov2 type RNA viruses. Reaching a new cyclic balance e.g.
56 for COVID-19 may take at least two years [26]. The unprecedented scale at which animals are raised for
57 food production nowadays also increases the risks of infectious diseases spill over from animal to human
58 populations. The COVID-19 crisis highlights the link between human health and healthy ecosystems,
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4 underlining the need to take a more comprehensive and planetary approach to health. The Helsinki
5 Declaration of Planetary Health [27] calls upon impact-oriented actions in policies much beyond the health
6 sector, both in long and short term and emphasises that both, the health of human civilisation and the
7 state of natural systems on which it depends, must become the driver of all policies. This requires
8 knowledge from emergence to spread, health impact, socio-political response and recovery plan from
9 multidisciplinary research.
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12 The tragedy of COVID-19 exposes our vulnerability as a global society and our dependence on healthy
13 ecosystems. The pandemic has made us reflect on how we can repair the systemic failure that brought us
14 here, and how can we restore a healthy human-nature relationship to best protect ourselves and future
15 generations from the next manmade crisis, whether it is caused by infectious agents, climate change, or
16 pollution. The 'WHO Manifesto for a Healthy Recovery from COVID-19' [28] provides six prescriptions for a
17 green recovery, including: 1) recovering relationship with our nature through biodiversity; 2) providing
18 access to safe water and basic hygiene; 3) accelerating transition to renewable energy and stopping fossil
19 fuel combustion; 4) promoting sustainable food production, consumption and waste management; 5)
20 building healthy and sustainable cities with health in focus of urban planning; and 6) making sure that
21 stimulus packages for economic recovery are not funding fossil fuel-based economy. Tackling causes of air
22 pollution is intricately connected with some of these prescriptions, and is an urgently needed investment
23 that will reduce susceptibility and mortality from COVID-19 and other respiratory pathogens, while also
24 reducing 6.7 million premature deaths due to air pollution annually globally.
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28 Even before it emerged that air pollution may be a risk factor for more severe illness from COVID-19, the
29 pandemic alerted us to a number of issues: 1) the importance of lung health, and our vulnerability to
30 infectious respiratory pathogens that can spread rapidly in our highly mobile society; 2) the massive
31 disparities in social determinants of health that are clearly visible around the world; 3) society's remarkable
32 willingness to make severe personal and economic sacrifices for the sake of health, especially when
33 decision making is transparent and evidence based. In the joint statement 'Bounce Back Better: Sustainable
34 Strategies for a Healthy Recovery from the Pandemic' [29] by the ERS, American Thoracic Societies (ATS),
35 and ISEE, professional societies dedicated to promoting respiratory and environmental health, the COVID-
36 19 pandemic is viewed as a historic opportunity to rethink societal priorities towards clean energy and
37 sustainability in all areas.
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41 The European Commission has adopted a European Green Deal (EGD) in December 2019, just ahead of the
42 COVID-19 crisis, as a strategy to be the first climate neutral (reducing greenhouse gas emissions as much as
43 possible and compensating for any remaining emission) continent in the world. An integral part of the EGD
44 is 'A Zero Pollution Ambition', at the core of which is clean air. Within the EGD, the European Commission
45 has proposed to revise the EU Air Quality Standards to align them more closely with the WHO Air Quality
46 Guideline recommendations [30], of which a new update will be published in 2021. It will be important that
47 the latest scientific evidence on the health effects of air pollution is presented and considered in the
48 legislative discussions. Impact of COVID-19 lockdowns on air quality was notable, but came at a significant
49 short-term economic disruption. Seeing that we can achieve drastic air pollution reductions, we need to
50 build those into structural changes as part of a long-term green recovery strategy, including key principles
51 of 'do no harm', including zero pollution, and clean air objectives.
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53 Conclusion

54 Air pollution can increase the severity and risk of death from COVID-19 infection, by compromising the
55 individual's immune system's ability to fight infections and by increasing the risk of predisposing chronic
56 diseases. The COVID-19 pandemic has painfully demonstrated the close interconnectedness of a fossil fuel-
57 based economy, climate change, air pollution, and emerging infectious diseases, and provides compelling
58 additional motivation for stricter air pollution regulation, as integral and imperative part of post pandemic
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policies ensuring more healthy and resilient populations. The unprecedented decreases in air pollution around Europe during the COVID-19 lockdown showed an example of what can be achieved. As air pollution is increasing again back to pre-pandemic levels, we need bold policies and structural changes in our cities, transportation, industry, agriculture, and energy systems to ensure long-term reductions in air pollution and greenhouse gases, moving away from fossil fuels. As cleaner air policies will provide immediate substantial health benefits to European citizens, their co-benefits in tackling climate change crises, make them central to ensuring more healthy and resilient populations, environment and the planet.

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SECTION OF ENVIRONMENTAL
HEALTH

DEPARTMENT OF PUBLIC
HEALTH

ØSTER FARIMAGSGADE 5
DK-1014 COPENHAGEN K
DENMARK

TLF: +45 20740462

EMAIL:

zorana.andersen@sund.ku.dk

Dear Editor,

Hereby, on the behalf of my co-authors, I submit the Editorial with title 'Air pollution and COVID-19: clearing the air and charting a post-pandemic course: a joint workshop report of ERS, ISEE, HEI and WHO'. This Editorial is written as a summary of the key messages from a workshop that took place on December 2nd, 2020, organized by the European Respiratory Society (ERS), the International Society for Environmental Epidemiology (ISEE), the Health Effects Institute (HEI), endorsed by the World Health Organization (WHO), and hosted by the European Parliament Lung Health Group, and the European Commission. You can find more information about this event here: [Air pollution and COVID-19 – Clearing the air and charting a post-pandemic course - ERS - European Respiratory Society \(ersnet.org\)](https://www.ersnet.org). Air pollution is the major risk factor for mortality and morbidity, contributing to around 509,000 premature deaths every year in Europe, as well as serious aggravations of lung disease in children and adults. The COVID-19 pandemic has raised concerns about air pollution role in the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), as well as whether air pollution can increase the population susceptibility to the severity of disease and risk of death after infection. Lung patients are in the epicentre of the current crisis, as they are especially vulnerable to this potential interaction between SARS-CoV-2 infection and air pollution exposure. At the same time, the lockdown measures to control the spread of COVID-19 brought historical short-term reductions in air pollution levels around the globe generating unprecedented awareness and demand for clean air policies. Furthermore, the COVID-19 pandemic is a reminder of our growing susceptibility to newly emerging infectious diseases caused by a spill over from animals, and that our health is closely connected with that of our environment and planet. In this Editorial, we provide a short summary on the potential role of air pollution in the spread and worsening of health impacts of COVID-19, and on the influence of the pandemic on air pollution levels in Europe. Moreover, we outline the major lessons learned to chart a healthy post-pandemic course. This Editorial stresses the importance of clean air and closely related climate change policies, as the key element of the sustainable pandemic recovery efforts, to provide for healthier and more resilient European citizens to both, current and future environmental and infectious diseases challenges.

Sincerely,

Zorana Jovanovic Andersen
Professor in Environmental Epidemiology
Chair of the European Respiratory Society Environment and Health Committee