EUROPEAN RESPIRATORY journal
OFFICIAL SCIENTIFIC JOURNAL OF THE ERS

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

Journal:	*European Respiratory Journal*
Manuscript ID	ERJ-01063-2021.R1
Manuscript Type:	Editorial
Date Submitted by the Author:	n/a
Complete List of Authors:	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
Key Words:	COVID-19, air pollution, health policy, climate change
Abstract:	na

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 of 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 InstituteInstituteInstitute, Boston, USA;
[8] World Health Organization, Geneve, 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 μg/m^3 in long-term average county-level concentrations of particulate matter (PM) with diameter < 2.5 µg/m^3 ($PM_{2.5}$) 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 $PM_{2.5}$ [4]. These early studies using very early, higly 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 $PM_{2.5}$ [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].

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

How did COVID-19 lockdown affect air pollution levels in Europe?

Lockdown measures to control the COVID-19 pandemic in Europe in 2020 have resulted in significant reductions in air pollutant emissions and concentrations within days and weeks, though with notable differences between pollutants, countries, and cities [19]. The largest decreases in monthly averages of up to 70% in NO_2, compared with expected concentrations in the absence of lockdown measures were observed at traffic monitoring stations in Spain and Italy, while reductions in background NO_2 concentrations for selected countries ranged from an average 61% in Spain to 20% in Czech Republic. In some cities, NO_2 levels remained relatively low even after lockdown measures were lifted (Milan, Italy), while in others (Athens, Greece) they rapidly returned to 'normal' [19]. For $PM_{2.5}$, decreases in background concentrations ranged from 30% in Spain to 9% in the Czech Republic compared to expected levels. Reductions in $PM_{2.5}$ levels were smaller and less consistent than those for NO_2 due to the generally more varied sources of $PM_{2.5}$ especially in urban areas, including the combustion of fossil fuel for heating, industrial activities, road traffic and secondary particle formation. Importantly, these reductions were largely short term, with levels rebounding as economic activity increased again.

What is the role of ambient air pollution in transmission of COVID-19?

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

What did COVID-19 teach us about planetary health?

The world today is highly interconnected with intensive global flows of people, natural resources and pollution between all parts of the world. This causes major destruction in wildlife populations and ecosystems and increases contact between human populations and wildlife reservoirs of potentially pathogenic bacteria and viruses. Ecosystem destruction leads to species loss and population decline. The disturbed system now starts to favour species with high reproductive rates and short life cycles. They form highly dense populations, typically also highly conductive and prone to transmit diseases. When natural food webs are disturbed, the resource use behaviour in higher trophic levels changes, making them prone to high mutation rate pathogens, such as SARS-Cov2 type RNA viruses. Reaching a new cyclic balance e.g. for COVID-19 may take at least two years [26]. The unprecedented scale at which animals are raised for food production nowadays also increases the risks of infectious diseases spill over from animal to human populations. The COVID-19 crisis highlights the link between human health and healthy ecosystems,

underlining the need to take a more comprehensive and planetary approach to health. The Helsinki Declaration of Planetary Health [27] calls upon impact-oriented actions in policies much beyond the health sector, both in long and short term and emphasises that both, the health of human civilisation and the state of natural systems on which it depends, must become the driver of all policies. This requires knowledge from emergence to spread, health impact, socio-political response and recovery plan from multidisciplinary research.

The tragedy of COVID-19 exposes our vulnerability as a global society and our dependence on healthy ecosystems. The pandemic has made us reflect on how we can repair the systemic failure that brought us here, and how can we restore a healthy human-nature relationship to best protect ourselves and future generations from the next manmade crisis, whether it is caused by infectious agents, climate change, or pollution. The 'WHO Manifesto for a Healthy Recovery from COVID-19' [28] provides six prescriptions for a green recovery, including: 1) recovering relationship with our nature through biodiversity; 2) providing access to safe water and basic hygiene; 3) accelerating transition to renewable energy and stopping fossil fuel combustion; 4) promoting sustainable food production, consumption and waste management; 5) building healthy and sustainable cities with health in focus of urban planning; and 6) making sure that stimulus packages for economic recovery are not funding fossil fuel-based economy. Tackling causes of air pollution is intricately connected with some of these prescriptions, and is an urgently needed investment that will reduce susceptibly and mortality from COVID-19 and other respiratory pathogens, while also reducing 6.7 million premature deaths due to air pollution annually globally.

Even before it emerged that air pollution may be a risk factor for more severe illness from COVID-19, the pandemic alerted us to a number of issues: 1) the importance of lung health, and our vulnerability to infectious respiratory pathogens that can spread rapidly in our highly mobile society; 2) the massive disparities in social determinants of health that are clearly visible around the world; 3) society´s remarkable willingness to make severe personal and economic sacrifices for the sake of health, especially when decision making is transparent and evidence based. In the joint statement 'Bounce Back Better: Sustainable Strategies for a Healthy Recovery from the Pandemic' [29] by the ERS, American Thoracic Societies (ATS), and ISEE, professional societies dedicated to promoting respiratory and environmental health, the COVID-19 pandemic is viewed as a historic opportunity to rethink societal priorities towards clean energy and sustainability in all areas.

The European Commission has adopted a European Green Deal (EGD) in December 2019, just ahead of the COVID-19 crisis, as a strategy to be the first climate neutral (reducing greenhouse gas emissions as much as possible and compensating for any remaining emission) continent in the world. An integral part of the EGD is 'A Zero Pollution Ambition', at the core of which is clean air. Within the EGD, the European Commission has proposed to revise the EU Air Quality Standards to align them more closely with the WHO Air Quality Guideline recommendations [30], of which a new update will be published in 2021. It will be important that the latest scientific evidence on the health effects of air pollution is presented and considered in the legislative discussions. Impact of COVID-19 lockdowns on air quality was notable, but came at a significant short-term economic disruption. Seeing that we can achieve drastic air pollution reductions, we need to build those into structural changes as part of a long-term green recovery strategy, including key principles of 'do no harm', including zero pollution, and clean air objectives.

Conclusion

Air pollution can increase the severity and risk of death from COVID-19 infection, by compromising the individual's immune system´s ability to fight infections and by increasing the risk of predisposing chronic diseases. The COVID-19 pandemic has painfully demonstrated the close interconnectedness of a fossil fuel-based economy, climate change, air pollution, and emerging infectious diseases, and provides compelling additional motivation for stricter air pollution regulation, as integral and imperative part of post pandemic

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.

References

1. WHO. Burden of disease from ambient air pollution for 2016; 2018.
2. Fattorini D, Regoli F. Role of the chronic air pollution levels in the Covid-19 outbreak risk in Italy. *Environ Pollut* 2020: 264: 114732.
3. Wu X, Nethery RC, Sabath BM, Braun D, Dominici F. Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study. *medRxiv* 2020.
4. Liang D, Shi L, Zhao J, Liu P, Sarnat JA, Gao S, Schwartz J, Liu Y, Ebelt ST, Scovronick N, Chang HH. Urban Air Pollution May Enhance COVID-19 Case-Fatality and Mortality Rates in the United States. *Innovation (New York, NY)* 2020: 1(3): 100047.
5. Villeneuve PJ, Goldberg MS. Methodological Considerations for Epidemiological Studies of Air Pollution and the SARS and COVID-19 Coronavirus Outbreaks. *Environmental health perspectives* 2020: 128(9): 95001.
6. Heederik DJJ, Smit LAM, Vermeulen RCH. Go slow to go fast: a plea for sustained scientific rigour in air pollution research during the COVID-19 pandemic. *The European respiratory journal* 2020: 56(1).
7. Pozzer A, Dominici F, Haines A, Witt C, Münzel T, Lelieveld J. Regional and global contributions of air pollution to risk of death from COVID-19. *Cardiovascular research* 2020: 116(14): 2247-2253.
8. Bert B, George D, Francesco F, Ulrike G, Dick JJH, Gerard H, Marion PGK, Lidwien AMS, Roel CHV. Air pollution and COVID-19. Including elements of air pollution in rural areas, indoor air pollution and vulnerability and resilience aspects of our society against respiratory disease, social inequality stemming from air pollution, study for the committee on Environment, Public Health and Food Safety, Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg, 2021.; 2021.
9. Bourdrel T, Annesi-Maesano I, Alahmad B, Maesano CN, Bind MA. The impact of outdoor air pollution on COVID-19: a review of evidence from in vitro, animal, and human studies. *European respiratory review : an official journal of the European Respiratory Society* 2021: 30(159).
10. Ciencewicki J, Jaspers I. Air pollution and respiratory viral infection. *Inhal Toxicol* 2007: 19(14): 1135-1146.
11. Schraufnagel DE, Balmes JR, Cowl CT, De Matteis S, Jung SH, Mortimer K, Perez-Padilla R, Rice MB, Riojas-Rodriguez H, Sood A, Thurston GD, To T, Vanker A, Wuebbles DJ. Air Pollution and Noncommunicable Diseases: A Review by the Forum of International Respiratory Societies' Environmental Committee, Part 1: The Damaging Effects of Air Pollution. *Chest* 2019: 155(2): 409-416.
12. Schraufnagel DE, Balmes JR, Cowl CT, De Matteis S, Jung SH, Mortimer K, Perez-Padilla R, Rice MB, Riojas-Rodriguez H, Sood A, Thurston GD, To T, Vanker A, Wuebbles DJ. Air Pollution and Noncommunicable Diseases: A Review by the Forum of International Respiratory Societies' Environmental Committee, Part 2: Air Pollution and Organ Systems. *Chest* 2019: 155(2): 417-426.
13. Hajat A, Allison M, Diez-Roux AV, Jenny NS, Jorgensen NW, Szpiro AA, Vedal S, Kaufman JD. Long-term exposure to air pollution and markers of inflammation, coagulation, and endothelial activation: a repeat-measures analysis in the Multi-Ethnic Study of Atherosclerosis (MESA). *Epidemiology (Cambridge, Mass)* 2015: 26(3): 310-320.

14. Borro M, Di Girolamo P, Gentile G, De Luca O, Preissner R, Marcolongo A, Ferracuti S, Simmaco M. Evidence-Based Considerations Exploring Relations between SARS-CoV-2 Pandemic and Air Pollution: Involvement of PM2.5-Mediated Up-Regulation of the Viral Receptor ACE-2. *International journal of environmental research and public health* 2020: 17(15).
15. Gupta A, Madhavan MV, Sehgal K, Nair N, Mahajan S, Sehrawat TS, Bikdeli B, Ahluwalia N, Ausiello JC, Wan EY, Freedberg DE, Kirtane AJ, Parikh SA, Maurer MS, Nordvig AS, Accili D, Bathon JM, Mohan S, Bauer KA, Leon MB, Krumholz HM, Uriel N, Mehra MR, Elkind MSV, Stone GW, Schwartz A, Ho DD, Bilezikian JP, Landry DW. Extrapulmonary manifestations of COVID-19. *Nature medicine* 2020: 26(7): 1017-1032.
16. Frontera A, Cianfanelli L, Vlachos K, Landoni G, Cremona G. Severe air pollution links to higher mortality in COVID-19 patients: The "double-hit" hypothesis. *The Journal of infection* 2020: 81(2): 255-259.
17. Grigg J. Air Pollution and Respiratory Infection: An Emerging and Troubling Association. *American journal of respiratory and critical care medicine* 2018: 198(6): 700-701.
18. Guan WJ, Liang WH, Zhao Y, Liang HR, Chen ZS, Li YM, Liu XQ, Chen RC, Tang CL, Wang T, Ou CQ, Li L, Chen PY, Sang L, Wang W, Li JF, Li CC, Ou LM, Cheng B, Xiong S, Ni ZY, Xiang J, Hu Y, Liu L, Shan H, Lei CL, Peng YX, Wei L, Liu Y, Hu YH, Peng P, Wang JM, Liu JY, Chen Z, Li G, Zheng ZJ, Qiu SQ, Luo J, Ye CJ, Zhu SY, Cheng LL, Ye F, Li SY, Zheng JP, Zhang NF, Zhong NS, He JX. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. *The European respiratory journal* 2020: 55(5).
19. Air quality in Europe - 2020 report. Report. European Environment Agency (EEA); 2020.
20. de Jesus AL, Thompson H, Knibbs LD, Hanigan I, De Torres L, Fisher G, Berko H, Morawska L. Two decades of trends in urban particulate matter concentrations across Australia. *Environmental research* 2020: 190: 110021.
21. Beddows DCS, Dall'Osto M, Harrison RM, Kulmala M, Asmi A, Wiedensohler A, Laj P, Fjaeraa AM, Sellegri K, Birmili W, Bukowiecki N, Weingartner E, Baltensperger U, Zdimal V, Zikova N, Putaud JP, Marinoni A, Tunved P, Hansson HC, Fiebig M, Kivekäs N, Swietlicki E, Lihavainen H, Asmi E, Ulevicius V, Aalto PP, Mihalopoulos N, Kalivitis N, Kalapov I, Kiss G, de Leeuw G, Henzing B, O'Dowd C, Jennings SG, Flentje H, Meinhardt F, Ries L, Denier van der Gon HAC, Visschedijk AJH. Variations in tropospheric submicron particle size distributions across the European continent 2008–2009. *Atmos Chem Phys* 2014: 14(8): 4327-4348.
22. Morawska L, Johnson GR, Ristovski ZD, Hargreaves M, Mengersen K, Corbett S, Chao CYH, Li Y, Katoshevski D. Size distribution and sites of origin of droplets expelled from the human respiratory tract during expiratory activities. *Journal of Aerosol Science* 2009: 40(3): 256-269.
23. Santarpia JL, Herrera VL, Rivera DN, Ratnesar-Shumate S, Reid SP, Denton PW, Martens JWS, Fang Y, Conoan N, Callahan MV, Lawler JV, Brett-Major DM, Lowe JJ. The Infectious Nature of Patient-Generated SARS-CoV-2 Aerosol. *medRxiv* 2020: 2020.2007.2013.20041632.
24. Ma J, Qi X, Chen H, Li X, Zhang Z, Wang H, Sun L, Zhang L, Guo J, Morawska L, Grinshpun SA, Biswas P, Flagan RC, Yao M. COVID-19 patients in earlier stages exhaled millions of SARS-CoV-2 per hour. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America* 2020.
25. de Jesus AL, Rahman MM, Mazaheri M, Thompson H, Knibbs LD, Jeong C, Evans G, Nei W, Ding A, Qiao L, Li L, Portin H, Niemi JV, Timonen H, Luoma K, Petäjä T, Kulmala M, Kowalski M, Peters A, Cyrys J, Ferrero L, Manigrasso M, Avino P, Buonano G, Reche C, Querol X, Beddows D, Harrison RM, Sowlat MH, Sioutas C, Morawska L. Ultrafine particles and PM(2.5) in the air of cities around the world: Are they representative of each other? *Environment international* 2019: 129: 118-135.
26. Kissler SM, Tedijanto C, Goldstein E, Grad YH, Lipsitch M. Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. *Science (New York, NY)* 2020: 368(6493): 860-868.
27. Halonen JI, Erhola M, Furman E, Haahtela T, Jousilahti P, Barouki R, Bergman Å, Billo NE, Fuller R, Haines A, Kogevinas M, Kolossa-Gehring M, Krauze K, Lanki T, Vicente JL, Messerli P, Nieuwenhuijsen M, Paloniemi R, Peters A, Posch KH, Timonen P, Vermeulen R, Virtanen SM, Bousquet J,

Antó JM. The Helsinki Declaration 2020: Europe that protects. *The Lancet Planetary health* 2020: 4(11): e503-e505.
28. WHO Manifesto for a healthy recovery from COVID-19. WHO; 2020.
29. Bounce Back Better: Sustainable Strategies for a Healthy Recovery from the Pandemic: official statement by American Thoracic Society (ATS), European Respiratory Society (ERS) and International Society for Environmental Epidemiology (ISEE); 2020.
30. WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2005. WHO; 2006.

UNIVERSITY OF COPENHAGEN
DEPARTMENT OF PUBLIC HEALTH

European Respiratory Journal

Dear Editor,

April 4th, 2021

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

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). 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