



Early View

Editorial

Clean Air in Europe for All: Taking Stock of the Proposed Revision to the Ambient Air Quality Directives. A Joint ERS, HEI, and ISEE Workshop Report

Michelle C. Turner, Zorana Jovanovic Andersen, Maria Neira, Michal Krzyzanowski, Ebba Malmqvist, Alberto González Ortiz, Gregor Kiese Wetter, Klea Katsouyanni, Bert Brunekreef, Erik Melén, Petter Ljungman, Margherita Tolotto, Francesco Forastiere, Paul Dendale, Richard Price, Ole Bakke, Sibylle Reichert, Gerard Hoek, Göran Pershagen, Annette Peters, Xavier Querol, Anna Gerometta, Evangelia Samoli, Iana Markevych, Romain Basthiste, Haneen Khreis, Pallavi Pant, Mark Nieuwenhuijsen, Jason D. Sacks, Kjeld Hansen, Thomas Lymes, Anne Stauffer, Gary W. Fuller, Hanna Boogaard, Barbara Hoffmann

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Clean Air in Europe for All: Taking Stock of the Proposed Revision to the Ambient Air Quality Directives. A Joint ERS, HEI, and ISEE Workshop Report.

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Ambient air pollution is a major public health concern and comprehensive new legislation is currently being considered to improve air quality in Europe. The European Respiratory Society (ERS), Health Effects Institute (HEI), and International Society for Environmental Epidemiology (ISEE) organised a joint meeting on May 24, 2023 in Brussels, Belgium, to review and critically evaluate the latest evidence on the health effects of air pollution and discuss ongoing revisions of the European Ambient Air Quality Directives (AAQDs). A multi-disciplinary expert group of air pollution and health researchers, patient and medical societies, and policy representatives participated. This report summarises key discussions at the meeting.

Proposal for Revision of the European AAQDs and Potential to Improve Health

In 2021, the World Health Organization (WHO) released new Air Quality Guidelines (AQGs) based on a comprehensive synthesis of scientific evidence on the health effects of air pollution [1]. WHO recommended that annual mean concentrations of particulate matter ≤ 2.5 microns in aerodynamic diameter ($PM_{2.5}$) and nitrogen dioxide (NO_2) should not exceed $5 \mu\text{g}/\text{m}^3$ and $10 \mu\text{g}/\text{m}^3$, respectively. The 2021 AQG levels are more stringent than the previous 2005 AQG levels of $10 \mu\text{g}/\text{m}^3$ for $PM_{2.5}$ and $40 \mu\text{g}/\text{m}^3$ for NO_2 [2]. The current air quality legislation in Europe—the 2008 AAQDs—sets limit values for the annual mean of $PM_{2.5}$ and NO_2 to 25 and $40 \mu\text{g}/\text{m}^3$, respectively [3].

Despite continued trends of decreasing air pollution concentrations in Europe [4], 95% and 75% of monitoring stations recorded values above 2021 WHO AQG levels for $PM_{2.5}$ and NO_2 , respectively, in 2021 [5]. $PM_{2.5}$ concentrations were highest in Central and Eastern Europe, and NO_2 in cities with high road traffic volume. Inequalities exist with regions with lower gross domestic product (GDP) per capita generally experiencing higher air pollution concentrations (Figure 1). The European Environment Agency (EEA) attributed 238,000 deaths to $PM_{2.5}$ concentrations above $5 \mu\text{g}/\text{m}^3$ in the EU-27 in 2020 [6, 7]. These deaths are preventable and the estimate does not include millions of cases of non-fatal diseases, years lived with disability, attributable hospitalisations, or health effects from other pollutants [8].

Findings from the 3rd Clean Air Outlook, analysing existing and future policies in Europe, reveal substantial projected reductions in sulfur dioxide (SO_2), nitrogen oxides (NO_x), and primary $PM_{2.5}$ emissions, and associated expected decreases in total $PM_{2.5}$ concentrations for 2030 and 2050 [9], achieving the EU target of reducing premature deaths by 55% from 2005 to 2030 [10]. However, projected reductions of ammonia (NH_3) emissions (mainly from intensive livestock farming) are modest. Importantly, the currently foreseen reductions in emissions will still cause exceedances of the WHO AQG level for $PM_{2.5}$ in large areas of Europe. Further mitigation potential exists and additional policy measures are needed including more stringent limit values, technical emission controls, accelerated energy transition, large-scale shifts towards safe and active mobility, among others (below).

To reduce the health and financial burden of air pollution, and achieve EU Green Deal goals, the European Commission (EC) published in October 2022 a proposal for revision of the EU AAQDs, which is currently being considered by the European Parliament and Council [11, 12]. The proposed new annual limit value for $PM_{2.5}$ by 2030 is $10 \mu\text{g}/\text{m}^3$ and for NO_2 $20 \mu\text{g}/\text{m}^3$. The proposal also includes non-binding target values and long-term objectives for O_3 , as well as additional monitoring and modeling requirements, including of ultrafine particles (UFPs) and black carbon (BC), a regular review mechanism, and access to justice for non-compliance.

The proposed EC limit values would result in total gross benefits of 42 billion EUR/year that outweigh by 7 times mitigation costs of 5.6 billion EUR/year, and result in a positive net GDP

impact of +0.38% [11, 12]. Although the EC proposal presents important steps toward cleaner air in Europe, it falls short of complete alignment with the 2021 WHO AQGs which would ensure additional health benefits and further reduce the health burden from air pollution [12-14].

Latest Science on Air Pollution and Health

The HEI-funded ELAPSE study is the most recent and comprehensive European study investigating health effects of low levels of air pollution [15-17]. ELAPSE documented adverse effects of long-term exposure to PM_{2.5} and NO₂ at levels below current EU limit values, and to BC, with total and cardio-respiratory mortality in analysis of 28 million individuals.

Associations for PM_{2.5} and NO₂ were stronger in ELAPSE than summary estimates from systematic reviews underpinning the 2021 WHO AQGs and European burden and impact assessments [6, 18]. The WHO AQG systematic reviews included studies published up to September 2018 world-wide and did not include ELAPSE findings, which were published later. To use the most relevant and recent evidence for Europe, the EC and EEA conducted additional analyses using the concentration-response functions of ELAPSE for PM_{2.5} and NO₂ which resulted in higher attributable mortality estimates, indicating that the current health and financial burden of air pollution may be underestimated in Europe [12, 19, 20].

Recent research shows a range of impacts of air pollution on morbidity. Exposure to air pollution in pregnancy and early childhood can adversely impact lung function trajectories across the life course [21, 22], impair cognitive growth and development in children [23, 24], and accelerate cognitive decline in older adults [25, 26]. Findings from Stockholm, Sweden, indicated adverse effects of air pollution on lung function in infants and improvements in lung function in children with reductions of air pollution, even at levels below the EC proposal [27, 28]. There is robust evidence of adverse effects of PM_{2.5} on incidence of stroke, ischemic heart disease, atrial fibrillation, and heart failure [29]. ELAPSE and other studies in Europe showed a relationship between PM_{2.5} and lung cancer incidence, even at low air pollution concentrations [30] and of associations with cancers other than lung cancer [31-34].

For UFPs and BC/elemental carbon, which are currently not regulated, there is a need to further develop emission inventories, systematic monitoring, source apportionment, and research on health effects [1]. UFPs and BC are closely linked and likely responsible for systemic impacts of combustion-related particles on organs beyond the lung [35].

There has been an increase in pollutants from so called 'natural' sources, including desert dust and wildfires, closely linked with climate change and increase in extreme weather events such as droughts, heatwaves and storms [36-39]. Evidence on adverse health effects of pollution from wildfires and dust storms is growing [40, 41]. Pollution from natural sources often occurs simultaneously with heatwaves and during the high tropospheric ozone (O₃) season, raising concerns about additional adverse health effects of these synergistic exposures. In the current AAQDs, natural contributions are only considered regarding exceedances of PM limit values if they occur with anthropogenic (non-natural or resulting from human activities) emissions. However, in line with the 2021 WHO AQGs, measures to reduce exposure to natural source pollutants should be implemented; the need for reductions in anthropogenic emissions is also further emphasised [42].

There are increasing concerns about air pollution and climate change interactions on health, with initial research showing synergistic effects of short-term exposure to heat and PM_{2.5} on

respiratory and cardiovascular mortality [43]. Air pollution and climate mitigation and abatement policies have substantial overlaps, leading to important opportunities and co-benefits in exposure reduction and prevention of acute and chronic diseases.

Perspectives Towards Clean Air

Cities across Europe are taking actions to reduce air pollution. Implementing multimodal urban and transportation policies in policy packages is most effective at reducing emissions and ambient air pollution levels in cities, while at the same time targeting climate-friendly and health-promoting environments [42, 44]. In Paris, implementation of the first phases of low emission zones, decreasing speed limits, increasing bicycle paths, limiting traffic on streets near schools and closing of streets on specific days to cars were effective in decreasing PM_{2.5} and NO_x. A new online catalogue of urban and transportation policy studies summarises the evidence-base for decision-makers [45]. Some of the most studied policies with emissions reductions included alternative fuel technologies, vehicle retrofitting, road pricing, low emission zones, and parking charges.

Focus on Eastern Europe

In Eastern and Southeastern Europe, there is a paucity of research on the health effects of air pollution. Over 70% of the Southeastern European population live in areas that exceed the current annual PM_{2.5} EU limit value of 25 µg/m³ [46]. Main air pollution sources in the region include coal combustion for energy production and wood and coal for domestic heating and cooking. There is a need for air quality monitoring, investments in research, and sustained targeted actions [46, 47]. Previous initiatives included campaigns during the home heating season and individual behavioural nudging. Challenges linked to socio-economic conditions remain, including energy poverty, access to clean energy, and information for citizens.

Where Do We Go from Here?

The current policy debate regarding the EU AAQDs and alignment with the 2021 WHO AQGs [13] has important repercussions in Europe and also worldwide. Ambitious new European air quality legislation is of importance for motivating action. Although there are differences in legislative and policy-making processes in Europe compared to other regions (for example in consideration of achievability, cost-benefit, implementation and enforcement), the final version of the updated AAQDs in Europe will set an international benchmark.

It is imperative to support research to maintain a robust and up to date evidence base of emissions, exposure, and health effects of ambient air pollution, and to monitor the impacts of policies and practices to maximise public health benefits. There are opportunities to reinforce linkages of air pollution reduction with broader efforts to reduce environmental pollution, mitigation of and adaption to climate change, increase of sustainable agriculture and food production, prevention of biodiversity loss, improved productivity, fiscal policies, and reduction of health care costs.

There is a need for further efforts to improve communication and information about air pollution to the general public, patients and patient organisations, health professionals, scientific societies, and decision-makers. Citizens, as well as citizen scientists, play an important role in ensuring clean air through improving awareness, exerting political pressure, supporting and performing research, and sharing and adapting knowledge on best practices. It is important to harmonize air pollution communications, indices, and alert systems across

Europe, such as the EEA's mobile phone application on the European air quality index in 24 languages [48].

Further support to cities and networks sharing experiences in air quality interventions, local spatial planning and development, and policies are important public health measures showcasing successes and helping to avoid unwanted negative impacts. It is important to engage health professionals more systematically in policy discussions. Increased efforts to reinforce training of health and medical professionals on the environment, air pollution and health is needed. Emerging clinical guidance for healthcare professionals should be disseminated broadly [49].

The adverse health effects caused by air pollution are serious, debilitating diseases that result in a large burden to society. The ongoing revision of the EU AAQDs provide a unique opportunity to be bold in its ambitions, and to maximize public health benefits for Europe and beyond.

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Conflicts of Interest:

Hanna Boogaard and Pallavi Pant work at the Health Effects Institute, an organization jointly funded by the United States Environmental Protection Agency (EPA) and certain motor vehicle and engine manufacturers. The views expressed in this article are those of the authors and do not necessarily reflect the views of the Health Effects Institute or its sponsors.

The remaining authors have no conflict of interest to declare.

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Figures

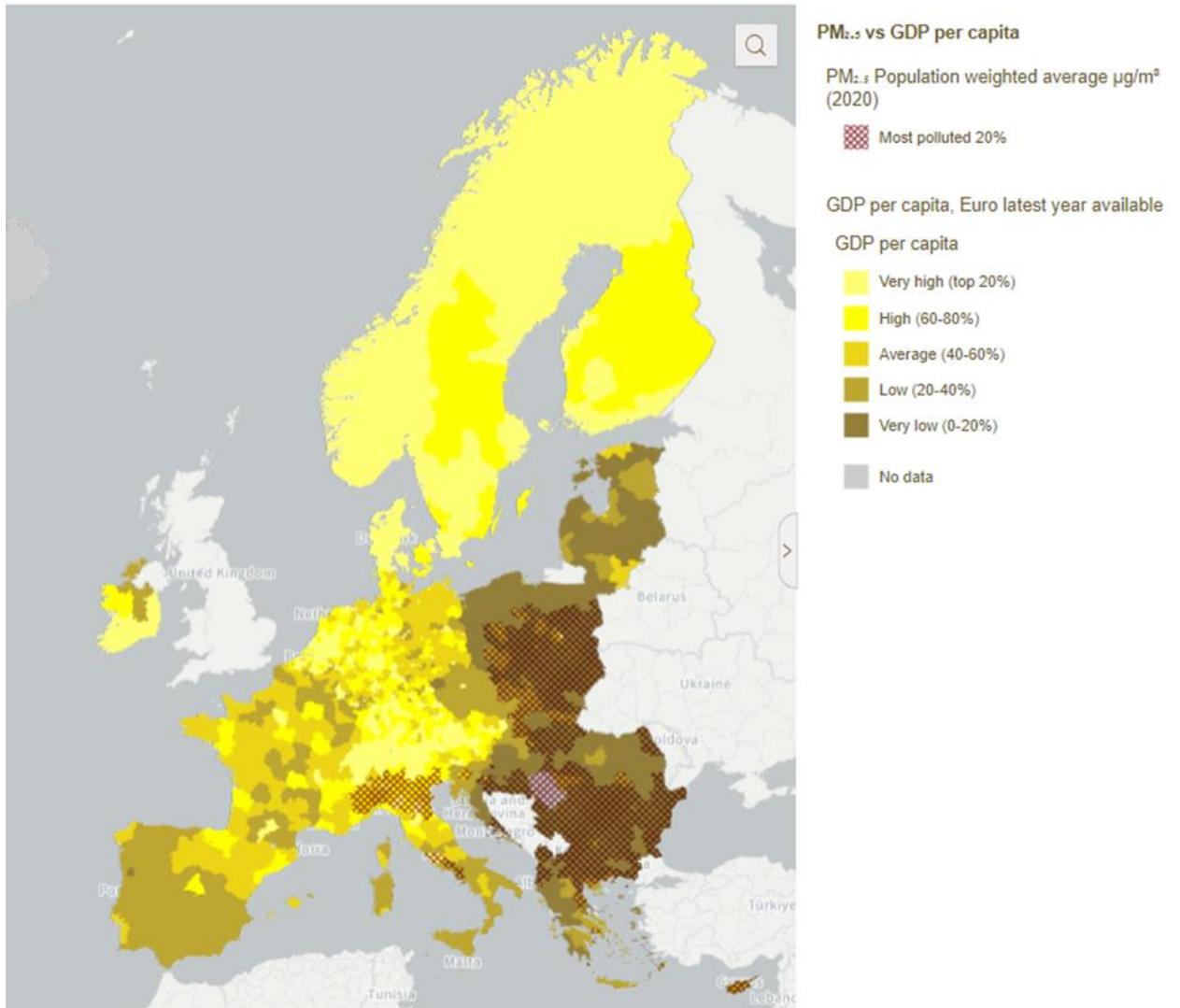


Figure 1. Combined risks and inequalities. PM_{2.5} vs GDP per capita [50]