22 September, 2021

WHO Air Quality Guidelines 2021 – Aiming for healthier air for all

A joint statement by medical, public health, scientific societies and patient representative organisations

After years of intensive research and deliberations with experts across the globe, the World Health Organization (WHO) updated its 2005 Global Air Quality Guidelines (AQG) in September 2021 (WHO 2021; WHO 2017). The new air quality guidelines (WHO AQG) are ambitious and reflect the large impact that air pollution has on global health. They recommend aiming for annual mean concentrations of $PM_{2.5}$ not exceeding 5 µg/m^3 and NO_2 not exceeding 10 µg/m^3, and the peak season mean 8-hr ozone concentration not exceeding 60 µg/m^3 (WHO 2021). For reference, the corresponding 2005 WHO guideline values for $PM_{2.5}$ and NO_2 were, respectively, 10 µg/m^3 and 40 µg/m^3 with no recommendation issued for long-term ozone concentrations (WHO 2006). While the guidelines are not legally binding, we hope they will influence air quality policy across the globe for many years to come.

The updated WHO AQG have become so necessary as an overwhelming body of evidence has accumulated over the past two decades, demonstrating that health effects of air pollution are serious and can affect nearly all organ systems of the human body (Thurston et al. 2017). Importantly, recent studies and large research programmes consistently show that the adverse effects of air pollution are not only limited to high exposures; harmful health effects can be observed all the way down to very low concentration levels, with no observable thresholds below which exposure can be considered safe (Brauer et al. 2019; Brunekreef et al. 2021; Dominici et al. 2019).

There is now broad expert consensus that air pollution is a major global public health risk factor and puts an enormous financial burden on societies. Outdoor and household air pollution together accounted for approximately 12% of all deaths in 2019. Air

pollution currently ranks fourth among major risk factors for global disease and mortality, only behind hypertension, smoking and dietary factors (Murray et al. 2020). In terms of economic burden, the estimated global health-related external costs (i.e., those borne by society as a whole) were US$ 5 trillion in 2013 with an additional US$ 225 billion in lost labour productivity (World Bank Group 2016). For the WHO European Region, the overall annual economic cost of health impacts and mortality from air pollution, including estimates for morbidity costs, stood at US$ 1.575 trillion (WHO Regional Office for Europe, OECD 2015).

The most important message of the updated WHO AQG is that each reduction in the outdoor concentrations of key air pollutants brings health benefits to the surrounding population, even in places which already have low pollution concentrations. Moreover, linear exposure-response relationships down to the lowest observable concentrations show that every individual will benefit from cleaner air (Huangfu and Atkinson 2020; Lee et al. 2020; Chen and Hoek 2020; Orellano et al. 2020; Zheng et al. 2021). These findings provide critical input into clean air policies and regulation around the world. They also are key to estimating the potential health and economic benefits from policies that reduce exposure to air pollution.

Recognising that the adverse health effects of pollution exposure can be seen at all, even at the lowest observed levels of pollution concentrations, is a milestone for cleaner air and better health policies. It offers a wake-up call, to reconsider current air quality legislation and regulations. To maximise health benefits, we now understand better the importance of implementing measures to reduce average exposures of all people. Such an approach must complement reductions in exposure at "hotspots" with high levels of air pollution, in particular to address known inequities owing to socioeconomic conditions, increased vulnerability of the residential population, and economic activities (Hooper and Kaufman, 2018). To tackle the health effects of air pollution, bold air quality actions are needed at all levels – international, national, local – and across all sectors such as transport, energy, industry, agriculture and residential.

Most jurisdictions with clean air regulations have relied on fixed limit values with little incentive to further reduce air pollution levels once compliance with the limit value is achieved (Kutlar Joss et al. 2017). Given the evidence that health effects occur all the

way down to very low concentration levels, future clean air policies must include incentives for progressive lowering of exposures of the entire population, thereby improving health for all. What is needed is a paradigm change from relying solely on fixed limit values, with a shift towards the concept of combining fixed limit values with a continuous reduction of the average exposure. For example, the current European Union (EU) Ambient Air Quality Directive already contains a non-binding average exposure reduction target (European Commission 2008). The upcoming 2022 revision of the EU Ambient Air Quality Directive will offer the chance to lead the way and implement binding average exposure reduction goals for air pollutants in combination with lowered fixed limit values.

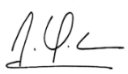
Programmes that reduce air pollutant emissions provide enormous air quality and health benefits which increase over time. The estimated health benefits of improved air quality outweigh by far the implementation costs of air quality actions. For the US, it has been estimated that the benefits from decreased mortality, lower medical expenditures for air pollution-related diseases, and higher productivity of workers are around 30 times greater than the costs of the Clean Air Act, resulting in net improvements of economic growth, and population welfare (U.S. E.P.A. 2015). In China, public health benefits were 50% greater than the costs for air quality improvement measures (Zhang et al. 2019). Similarly, for the EU, additional clean air and climate policies beyond the current obligations will lead to net benefits with positive macro-economic implications (Amann et al. 2017). Indeed, the cost effectiveness of air quality actions is enhanced by the close link between air pollution and greenhouse gas emissions. A reduction of air pollution emissions will also feed into efforts for climate neutrality and vice versa, making benefits from investments in one area count twice (Amann et al. 2014, IPCC 2021).

Conclusions

Air pollution is a major global public health threat that causes a range of adverse health effects, even at the lowest observable concentrations. There is ample evidence to strongly support government action to reduce air pollution and address climate change simultaneously. The updated WHO AQG are bold and stress the importance of lowering air pollution concentrations at every level. The benefits are clear: lowering air pollution levels will lead to enormous improvements in public health for people of all ages

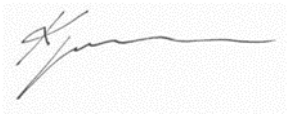
breathing cleaner air. We support the recommendations of the new WHO AQG, and urge nations to use the WHO AQG as a guide for ambitious air quality and emission reduction policies around the world.

Signatures of the undersigned organisations:

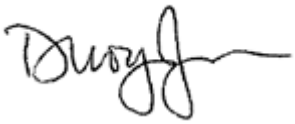


Prof. Marc Humbert, President, European Respiratory Society

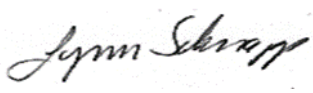
Mark Nieuwenhuijsen, President, International Society of Environmental Epidemiology



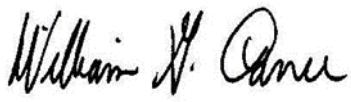
Dr Kjeld Hansen, Chair, European Lung Foundation



Prof. Donald M. Lloyd-Jones, President, American Heart Association



Prof. Lynn Schnapp, President, American Thoracic Society

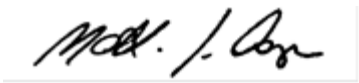


William G. Cance, MD FACS, Chief Medical and Scientific Officer, American Cancer Society, Inc.

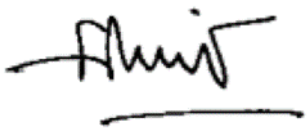
Prof. Tiffany Latrice Gary-Webb, Chair, the American Public Health Association

Prof. John Middleton, President, the Association of Schools of Public Health in the European Region

Dr P.P. Mohanan, President, Cardiological Society of India



Prof. Matti Aapro, President, European Cancer Organisation



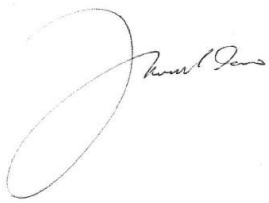
Prof. Fausto Pinto, President, World Heart Federation

European Society of Cardiology

Prof. John Upham, President, The Thoracic Society of Australia & New Zealand

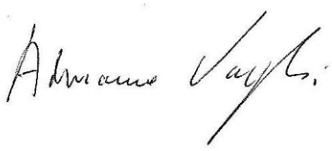
Dr Nebojsa Tasic, President, Hypertension, Infarction, and Stroke Prevention Association

Asia-Pacific Society of Respirology



Dr Riccardo Asero, President, the Italian Association of Allergologists and Immunologists

Prof. Federica Zanetto, President, Associazione Culturale Pediatri

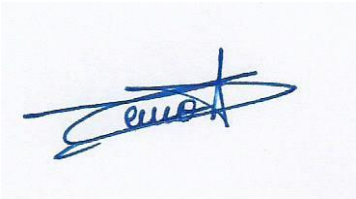


Dr Adriano Vaghi, President, Italian Thoracic Society

Prof. Gianenrico Senna, President, Società Italiana Allergologia, Asma ed Immunologia Clinica

Prof. Lucia Bisceglia, President, Italian Association of Epidemiology

Prof. Carla Ancona, President, Italian Network of Environment and Health



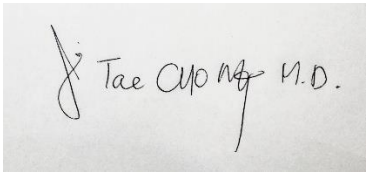
Dr Zeina Aoun, President, Lebanese Pulmonary Society

Associate Prof. Dr. Pang Yong Kek, President, Malaysian Thoracic Society

Prof. Luca Richeldi, President, Italian Respiratory Society

Prof. Oya Itil, President, Turkish Thoracic Society

Prof. Paweł Śliwiński, President, Polskie Towarzystwo Chorób Płuc



Prof. Ji Tae Choung, President, Korean Academy of Medical Sciences

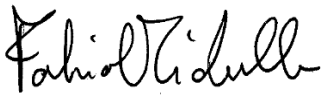
Prof. Hae-Kwan Cheong, President; Prof. Sin Kam, Chair of the Board, the Korean Society for Preventive Medicine

Prof. Soon Young Lee, President, Korean Society of Epidemiology

Prof. Jung-Wan Koo, President, Korean Society of Occupational and Environmental Medicine

Prof. Susana I. García, President, Ibero-American Society for Environmental Health

Prof. Mauro Silvestrini, President, Italian Stroke Association



Prof. Fabio Midulla, President, Società Italiana per le Malattie Respiratorie Infantili

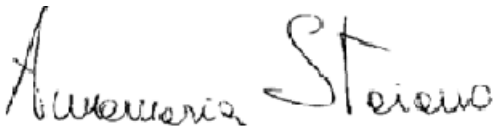
Prof. Ülkü Yılmaz, President, Turkish Respiratory Society

Prof. Kamlesh Tewary, President, Association of Physicians of India

Prof. Irma de Godoy, President, Sociedade Brasileira de Pneumonologia e Tisiologia

Prof. Philip J. Landrigan, President, Collegium Ramazzini

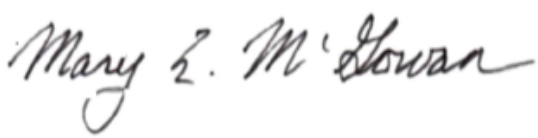
Canadian Lung Association



Prof. Annamaria Staiano, President, Società Italiana di Pediatria

Prof. Stylianos Loukides, President, Hellenic Thoracic Society

Dr Jukka Takala, President, International Commission on Occupational Health



Dr Louise M. Perkins, President, Foundation for Sarcoidosis Research

Claudia Spina, President, Associazione Italiana Bronchiettasie

Shane Fitch, President, Lovexair

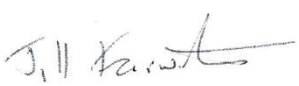
Alpha 1 Spain

FairLife

Dr Catia Cilloniz Campos, President, the Association for the Support of Patients with Pneumonia and their Families

European Cancer Patient Coalition (ECPC)

Natalia Maeva, President, Bulgarian Society of the patients with PH



Jill Fairweather, Co-founder, Aspergillosis Trust

La Federación Española de Asociaciones de pacientes alérgicos y con Enfermedades Respiratorias (FENAER)

Peter Bruce, Chair, Pulmonary Fibrosis Trust

Delfina Pérez, President, Asociación de Pacientes con EPOC (APEPOC)

Prof. Chantal Raherison, President, SPLF

German Society for Epidemiology

German Society for Public Health

Deutsche Gesellschaft für Kardiologie

Dr Mark A. Ferro, Canadian Society for Epidemiology and Biostatistics

Netherlands Respiratory Society

Steve Jones, President, EU-IPFF

Patiëntenvereniging longtransplantatie UZ Leuve (HALO vzw)

Associazione Nazionale Alfa 1-At ODV

Prof. Dr Christophe von Garnier, President, Swiss Society of Pneumology

Helping Hands Foundation

Healthy Lungs-Nepal

Sarcoidose.nl

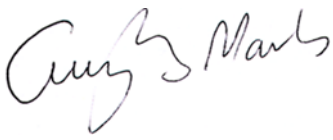
LAM Action

Dr Sonali Johnson (PhD), Head, Knowledge, Advocacy and Policy, Union for International Cancer Control (UICC)

Dr Julián Ciruzzi, President, Asociación Argentina de Medicina Respiratoria

Philippine College of Chest Physicians

Sociedad Española de Neumología y Cirugía Torácica (SEPAR)



Prof. Guy Marks, President, International Union Against Tuberculosis and Lung Disease

Dr Anne-Marie Baird, President, Lung Cancer Europe

Federasma e Allergie

Taiwan Society of Pulmonary and Critical Care Medicine

APH Macedonia "Moment plus"

Prof. Coenraad Koegelenberg, President, South African Thoracic Society

German Association for Medical Informatics, Biometry and Epidemiology

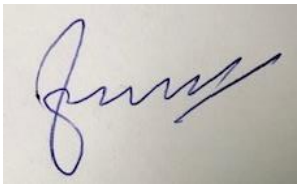
German Society for Social Medicine and Prevention

Hilde De Keyser, Chief Executive Officer, CF Europe

M.R. Rutgers, Director, Longfonds

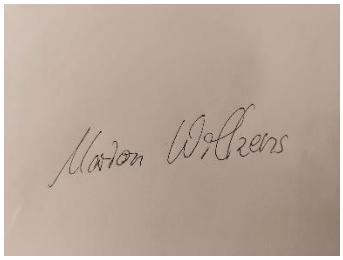
Prof. Camille Raynes-Greenow, Chair, International Network for Epidemiology in Policy

Dr Neil Schluger, Co-Founder, Inspire: Health Advocates for Clean Air



Dr Tewodros H. Gebremariam, President, Ethiopian Thoracic Society

Syaogi Ahmed 'Azizy, President, Center for Indonesian Medical Students' Activities



Marion Wilkens, 1st Chairsperson, Alpha 1 Germany

Carla Jones, President, European Federation of Allergy and Airways Diseases Patients' Associations

Danijela Pesic, President, PHA Europe

Floris Italianer, Director, Dutch Heart Foundation

Gesellschaft für Pädiatrische Pneumologie

Kristina Sparreljung, Secretary General, the Swedish Heart-Lung Foundation

Sarcoidosis UK

Sarah Woolnough, Chief Executive, Asthma UK/British Lung Foundation

Eva Garcia, President, Asociación Nacional de Hipertensión Pulmonar

Breathe Easy

European Chronic Disease Alliance

Dr Milka Sokolovic, Director-General, European Public Health Alliance

Prof. Dr Marc Saez, Main Researcher, Research Group on Statistics, Econometrics and Health (GRECS), University of Girona, Spain and CIBER of Epidemiology and Public Health (CIBERESP)

Alpha 1 Belgium

American Lung Association

Associazione Nazionale Alfa 1

Belgian Respiratory Society

European Alliance of Associations for Rheumatology

Korean Academy of Tuberculosis and Respiratory Diseases

Stichting Huize Aarde

Swedish Asthma and Allergy Association

European Chronic Disease Alliance

Association for Respiratory Technology & Physiology (ARTP)

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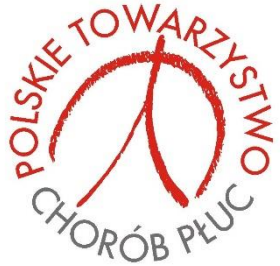
Türk Toraks Derneği
Turkish Thoracic Society



Korean Academy of Medical Sciences

대한예방의학회
The Korean Society for Preventive Medicine

KSE
KOREAN SOCIETY OF EPIDEMIOLOGY

대한직업환경의학회

Turkish
Respiratory
Society

ASSOCIATION OF PHYSICIANS INDIA

SOCIEDADE BRASILEIRA DE PNEUMOLOGIA E TISIOLOGIA · 1937 ·

DA VENIAM SCRIPTIS QUORUM NON GLORIA NOBIS CAUSA, SED UTILITAS OFFICIUMQUE FUIT

BREATHE
the lung association

Società Italiana di Pediatria

ΕΛΛΗΝΙΚΗ ΠΝΕΥΜΟΝΟΛΟΓΙΚΗ ΕΤΑΙΡΕΙΑ
HELLENIC THORACIC SOCIETY

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AIB
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Pulmonary Fibrosis Trust

APEPOC
ASOCIACIÓN DE PACIENTES CON EPOC

SPLF
Société de Pneumologie de Langue Française

DG epi DEUTSCHE GESELLSCHAFT FÜR EPIDEMIOLOGIE

Deutsche Gesellschaft für PUBLIC HEALTH e.V.

DGK.
Deutsche Gesellschaft für Kardiologie
– Herz- und Kreislaufforschung e.V.

Canadian Society for Epidemiology and Biostatistics
CSEB-SCEB
Société Canadienne d'Épidémiologie et de Biostatistique

NRS
NETHERLANDS RESPIRATORY SOCIETY

EU-IPFF
EUROPEAN IDIOPATHIC PULMONARY FIBROSIS & RELATED DISORDERS FEDERATION

HALO vzw
Patiëntenvereniging longtransplantatie UZ Leuven

ASSOCIAZIONE A1AT ODV

SCHWEIZERISCHE GESELLSCHAFT FÜR PNEUMOLOGIE
SOCIÉTÉ SUISSE DE PNEUMOLOGIE
SOCIETÀ SVIZZERA DI PNEUMOLOGIA

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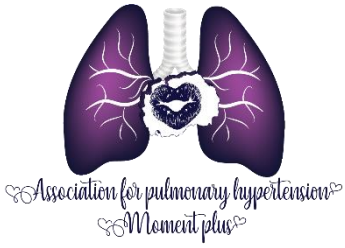

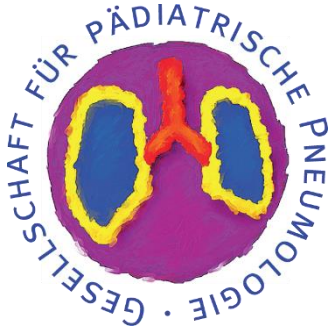

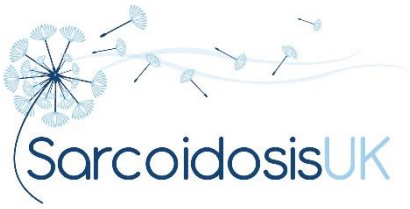

Members of the writing group: Barbara Hoffmann, Hanna Boogaard, Audrey de Nazelle, Zorana J. Andersen, Michael Abramson, Michael Brauer, Bert Brunekreef, Francesco Forastiere, Wei Huang, Haidong Kan, Joel Kaufman, Klea Katsouyanni, Michal Krzyzanowski, Nino Künzli, Francine Laden, Mark Nieuwenhuijsen, Adetoun Mustapha, Pippa Powell, Mary Rice, Aina Roca-Barceló, Charlotte Roscoe, Agnes Soares, Kurt Straif, George Thurston

Publication bibliography

Amann, Markus; Borken-Kleefeld, Jens; Cofala, Janusz; Heyes, Chris; Hoglund-Isaksson, Lena; Kiesewetter, Gregor et al. (2017): Support to the development of the Second Clean Air Outlook. Specific Contract 6 under Framework Contract. European Commission; International Institute for Applied Systems Analysis (IIASA) (ENV.C.3/FRA/2017/0012).

Amann, Markus; Heyes, Chris; Kiesewetter, Gregor; Schöpp, Wolfgang; Wagner, Fabian (2014): Air quality. Complementary impact assessment on interactions between EU air quality policy and climate and energy policy. Edited by European Parliamentary Research Service. European Parliament. Brussels (COM(2013)0920 final).

Brauer, Michael; Brook, Jeffrey R.; Christidis, Tanya; Chu, Yen; Crouse, Dan L.; Erickson, Anders et al. (2019): Mortality–Air Pollution Associations in Low-

Exposure Environments (MAPLE): Phase 1. In *Research Reports: Health Effects Institute* 2019.

Brunekreef, B; Strak, M; Chen, J; Andersen, Z; Bauwelinck, M (2021): Mortality and Morbidity Effects of Long-Term Exposure To Low-Level PM2.5, Black Carbon, NO2 and O3: An Analysis of European Cohorts - ELAPSE project: Effects of Low-Level Air Pollution. In *Health Effects Institute (HEI) Research Report 208*, https://www.healtheffects.org/publication/mortality-and-morbidity-effects-long-term-exposure-low-level-pm25-bc-no2-and-o3-analysis. Checked on 9/2/2021.

Chen, Jie; Hoek, Gerard (2020): Long-term exposure to PM and all-cause and cause-specific mortality: A systematic review and meta-analysis. In *Environment International* 143, p. 105974. DOI: 10.1016/j.envint.2020.105974.

Dominici, Francesca; Schwartz, Joel; Di, Qian; Braun, Danielle; Choirat, Christine; Zanobetti, Antonella (2019): Assessing Adverse Health Effects of Long-Term Exposure to Low Levels of Ambient Air Pollution: Phase 1. In *Research Reports: Health Effects Institute* 2019.

European Commission (2008.): Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe (OJL 152).

Hooper, L. G., & Kaufman, J. D. (2018). Ambient Air Pollution and Clinical Implications for Susceptible Populations. *Ann Am Thorac Soc* Vol 15, Supplement 2, pp S64–S68 https://Doi.Org/10.1513/AnnalsATS.201707-574MG, 15, S64–S68. https://doi.org/10.1513/ANNALSATS.201707-574MG

Huangfu, Peijue; Atkinson, Richard (2020): Long-term exposure to NO2 and O3 and all-.cause and respiratory mortality: A systematic review and meta-analysis. In *Environment International* 144, p. 105998. DOI: 10.1016/j.envint.2020.105998.

IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

Kutlar Joss, Meltem; Eeftens, Marloes; Gintowt, Emily; Kappeler, Ron; Künzli, Nino (2017): Time to harmonize national ambient air quality standards. In *Int J Public Health* 62 (4), pp. 453–462. DOI: 10.1007/s00038-017-0952-y.

Lee, Kuan Ken; Spath, Nicholas; Miller, Mark R.; Mills, Nicholas L.; Shah, Anoop S. V. (2020): Short-term exposure to carbon monoxide and myocardial infarction:

A systematic review and meta-analysis. In *Environment International* 143, p. 105901. DOI: 10.1016/j.envint.2020.105901.

Murray, Christopher J. L.; Aravkin, Aleksandr Y.; Zheng, Peng; Abbafati, Cristiana; Abbas, Kaja M.; Abbasi-Kangevari, Mohsen et al. (2020): Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. In *The Lancet* 396 (10258), pp. 1223–1249. DOI: 10.1016/S0140-6736(20)30752-2.

Orellano, Pablo; Reynoso, Julieta; Quaranta, Nancy; Bardach, Ariel; Ciapponi, Agustin (2020): Short-term exposure to particulate matter (PM10 and PM2.5), nitrogen dioxide (NO2), and ozone (O3) and all-cause and cause-specific mortality: Systematic review and meta-analysis. In *Environment International* 142, p. 105876. DOI: 10.1016/j.envint.2020.105876.

Thurston, George D.; Kipen, Howard; Annesi-Maesano, Isabella; Balmes, John; Brook, Robert D.; Cromar, Kevin et al. (2017): A joint ERS/ATS policy statement: what constitutes an adverse health effect of air pollution? An analytical framework. In *The European respiratory journal* 49 (1). DOI: 10.1183/13993003.00419-2016.

U.S. EPA. (2015): Benefits and Costs of the Clean Air Act 1990-2020, the Second Prospective Study. U.S. Environmental Protection Agency. Washington, DC. Available online at https://www.epa.gov/clean-air-act-overview/benefits-and-costs-clean-air-act-1990-2020-second-prospective-study, checked on 6/4/2021.

WHO Regional Office for Europe, OECD (2015): Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth. Edited by WHO Regional Office for Europe, Copenhagen, Denmark.

World Health Organization (2006): Air Quality Guidelines, Global Update 2005. WHO Regional Office for Europe, Copenhagen, Denmark.

World Health Organization (2021): WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, suflur dioxide and carbon monoxide. Executive summary. Geneva: World Health Organization; Licence: CCBY-NC-SA3.0 IGO.

World Health Organization (2017): Evolution of WHO air quality guidelines: past, present and future. WHO Regional Office for Europe, Copenhagen, Denmark. Available online at https://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2017/evolution-of-who-air-quality-guidelines-past,-present-and-future-2017, checked on 23/08/2021.

World Bank Group (2016): The cost of air pollution : strengthening the economic case for action (English). Washington, D.C. (Working Paper, 108141). Available online at http://documents.worldbank.org/curated/en/781521473177013155/The-cost-of-air-pollution-strengthening-the-economic-case-for-action, updated on 9/8/2016, checked on 8/3/2021.

Zhang, Jing; Jiang, Hongqiang; Zhang, Wei; Ma, Guoxia; Wang, Yanchao; Lu, Yaling et al. (2019): Cost-benefit analysis of China's Action Plan for Air Pollution Prevention and Control. In *Front. Eng. Manag.* 6 (4), pp. 524–537. DOI: 10.1007/s42524-019-0074-8.

Zheng, Xue-yan; Orellano, Pablo; Lin, Hua-liang; Jiang, Mei; Guan, Wei-jie (2021): Short-term exposure to ozone, nitrogen dioxide, and sulphur dioxide and emergency department visits and hospital admissions due to asthma: A systematic review and meta-analysis. In *Environment International* 150, p. 106435. DOI: 10.1016/j.envint.2021.106435.