A Science-Policy Initiative

Air Pollution and Health

空气污染 与健康

Academy of Science of South Africa

Brazilian Academy of Sciences

German National Academy of Sciences Leopoldina

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空气污染虽然可防可控，但严重威胁着人类健康、福祉和可持续发展的实现。据估计，空气污染每年造成至少全球500万人过早死亡。尽管在肮脏空气面前，无人可以幸免，但受空气污染负面影响冲击最大的群体主要包括儿童、妇女及贫困人口等在内的弱势群体，而他们正是国际人权法认为国家应对其负有特殊义务的群体。

恶劣的空气质量危害人类生活、健康以及儿童未来的发展。空气污染同时威胁着地球环境的可持续性，因为对地球上的生命而言，洁净空气的重要性决不亚于洁净水。

科学证据明确表明，空气污染对个人健康可以带来永久的损害，导致疾病、残疾和死亡，降低每个人的生活质量，而且会损害肺部、心脏、大脑、皮肤和其他器官，增加患病和残疾的风险，几乎影响人体的所有系统。

空气污染对中低收入国家造成的社会和经济损失巨大。庞大的经济损失足以阻滞可持续发展。以空气污染为代价、罔顾公共健康及环境影响的经济增长难以持续、有悖道德。

燃烧化石燃料和生物质是造成全球空气污染的头号元凶。它也是产生黑碳、甲烷和地面臭氧等短期气候污染物的重要源头，以及造成二氧化碳排放的主要来源。空气污染问题的许多解决方案也将对减缓气候变化产生积极影响，为实现1.5° C的气候温控目标做出重要贡献。

解决空气污染面临着公共和私人投放资源不足且与事态规模不匹配的困境。虽然我们不乏在空气污染控制、减缓气候变化和可持续发展之间实现协同作用的机会，但却未充分加以利用。

空气污染是可以防范的问题。但如果不采取新行动，空气污染将继续成为全球人口死亡的主要杀手。再加之老龄化、人口增长和城市化问题的加剧，死亡人数将逐年增多。

我们可以采取低成本、高效益的方式控制空气污染，将政策、立法、法规、标准和执法有效结合，推行新技术，提高社会认知。空气污染控制有利于避免疾病、防止生产力损失，从而促进经济增长，造福国民经济。

南非、巴西、德国和美国的国家科学院和医学科学院呼吁政府领导、企业和民众采取紧急行动，减少全球空气污染，以促进人类健康和福祉，推进环境保护，为可持续发展创造有利条件。许多联合国可持续发展目标都与解决空气污染问题息息相关。

五所国家科学院提议通过一项关于空气污染的全球契约，将控制和减少空气污染作为所有国家的优先事项。

空气污染危及每个人的健康

洁净的空气对生命和健康不可或缺。空气污染是当今世界上导致疾病和过早死亡的最主要环境原因，每年至少500万人因空气污染相关原因而过早死亡。尽管空气污染面前无人幸免，但其对贫穷弱势人口、少数和边缘化群体所造成的疾病负担最为沉重。

空气污染危害人的一生，从呱呱坠地到人生尽头，从成长发育之初到耄耋高龄，它导致各类急慢性疾病，而对此尤为敏感的群体包括胎儿、儿童、老年人和患有慢性疾病的人士。肺部、心脏、大脑、血管系统、新陈代谢和生殖，几乎所有人体器官、系统和过程均难逃空气污染的影响。

空气污染是导致婴儿及儿童罹患肺炎、支气管炎和哮喘的主要原因，致使儿童和青少年正处发育中的肺部出现生长迟缓。它还可引发心脏病（包括心律失常和急性心肌梗死）、中风、癌症、哮喘、慢性阻塞性肺病、糖尿病、过敏、湿疹和皮肤老化。越来越多的证据表明，空气污染可能导致成人痴呆症，并影响儿童的大脑发育。

因使用固体燃料（煤和生物质燃料）进行烹饪而产生的家庭空气污染对低收入国家妇女的影响尤为严重，她们也是罹患由污染诱发相关疾病最为严重的群体。然而妇女还需挑起重担，照顾其他患上与空气污染有关的健康问题的家庭成员。

各个社会的空气污染风险各不相同，受影响程度也因人而异。个人的受影响程度与年龄、性别、教育、社会经济地位、地理位置和居所、用于烹饪及取暖的燃料以及职业等因素有关。包括遗传易感性和原发疾病（如哮喘、心脏病或糖尿病）在内的生物因素也会增加个人的受影响程度。

与空气污染有关的疾病造成生产力损失，进而可能减少国内生产总值，导致缺勤、缺课的情况，致使现有的社会不平等现象不断延续。此外，在快速工业化的国家中，这些疾病所产生的医疗保健成本可多达国家卫生预算的7%。

根据估算，2015年，176个国家的空气污染（室内及室外）相关疾病所造成的全球经济负担达3.8万亿美元。而对抗空气污染所产生的健康和经济效益却将在总体上远远超过这些举措的成本。

污染空气的行为招致种种健康问题，而污染者非但不为之买单，还将这种种恶果转嫁到全人类身上。因此，共同保护公众健康、免受空气污染威胁是对全人类的道德约束。

燃烧化石和生物质燃料是空气污染的主要来源

对人类健康构成最大威胁的空气污染物是空气中的颗粒物。未经过滤的燃烧排放物中含有大量的超细颗粒物、细颗粒物和大颗粒物，其中包括黑碳及有害气体。

空气污染是由不同因素构成的复杂问题。细颗粒水平（$PM_{2.5}$质量浓度）和臭氧水平可作为监管工作的可靠指标；黑碳则可作为监测燃烧排放物的参考。

与燃烧有关的空气污染主要来源于：a）固定燃烧设施，b）家庭供暖和烹饪，c）受控生物质燃烧和废物燃烧，以及d）流动污染源。不同污染源的相对重要性因国家而异。

固定污染源包括发电厂、制造设施和受到排放限制的采矿行为。最严重的违规行为通常涉及燃烧煤炭或其他劣质燃料的设施，或由于电网不稳定而依赖柴油发电机的设施。

家庭是空气污染的重要来源，特别是在依赖生物质燃料取暖和烹饪的低收入国家。不仅如此，它也是人们暴露于空气污染的主要场所。

与农业废物焚烧及土地和森林开垦有关的受控生物质燃烧是发展中国家空气污染的主要来源。除此之外的无控生物质燃烧则与日常生活用品及其他废物的焚烧有关。

空气污染的流动污染源包括私人和公共部门的靠石油驱动的汽车、卡车和公共汽车，它们都是城市空气污染的主要来源。老旧及保养不善且主要靠低等燃烧物驱动的车辆所造成的危害尤为显著。船舶和飞机的排放则是港口和机场附近空气污染的主要流动污染源。

空气污染控制与减缓气候变化之间存在协同效应，因为两者产生的根源相同，解决方案基本一致，而且大多数空气污染物都对气候造成影响。空气污染和气候变化之间还以多种方式相互作用、互相加剧，例如甲烷等温室气体助长地面臭氧的形成，地面臭氧水平随温度升高而上升，温度升高会增加野火的频率，进而加剧颗粒物空气污染程度。

燃烧产生的黑碳不仅危害健康，而且影响地区温度、降水和极端天气。北极和诸如喜马拉雅山脉等冰川区域尤为容易受沉积黑碳加热地表的影响，并进而导致融化。因黑碳气溶胶-云相互作用而产生的降雨模式改变则可能对生态系统和人类生计产生深远影响，例如导致季风中断和干旱，且会对非洲和亚洲大部分地区的农业造成灾难性的后果。

行动呼吁

南非、巴西、德国和美国的五所国家科学院共同呼吁政府领导、企业和民众采取行动，积极减少世界各国的空气污染。这一呼吁是基于空气污染对健康影响的确凿科学证据而提出的。

许多现有的协议、决议、公约和倡议已经着力针对空气污染问题的方方面面制定了措施。其中包括《蒙特利尔议定书》、联合国欧洲经济委员会《远距离越境空气污染公约》、世界卫生组织《烟草控制框架公约》以及世界卫生大会《有关空气污染对健康影响的决议》。

因此，五所科学院提议通过一项关于空气污染的全球契约，以确保最高层面的持续参与，并将控制和减少空气污染作为所有国家的优先事项。该契约还将鼓励政策制定者和包括私营部门在内的其他主要合作伙伴将控制和减少排放纳入国家和地方规划、开发进程以及商业和金融战略。这一进程的成功将离不开政治领导和伙伴关系，包括与现有的多国结构合作。

科学院明白不存在一体适用的万全之策，必须因情况制宜，因国家而异。尽管如此，以下领域亟需采取行动：

许多政策和技术解决方案有利于减少有害的燃烧产物。针对固定污染源，可采取对工业企业和发电厂实施排放控制，或改用清洁燃料等措施。针对家庭，包括提供清洁家用燃料。针对受控生物质燃烧，包括执行旨在消除垃圾焚烧的条规，采用有助减少作物燃烧的新型农业技术。针对流动污染源，可以推进和投资可持续的公共交通运输和城市基础设施。

有效的政策和技术需要共同分享。在可行的情况下，应该尽快在全球不同经济发展水平的国家中实施这些战略。一些解决方案很容易便能取得高度共识。但如果缺乏共识，或者政策选择在很大程度上取决于背景情况（即法律制度、地理、经济发展阶段、污染源的异质性），除采取国际通行的行动之外，需要因地制宜制定政策。

我们需要从各个城市和国家收集空气污染控制的成功案例，从中汲取经验教训，并与现在开始着手解决这一问题的国家分享。

人口暴露度与人口密度、污染物浓度和暴露持续时间直接相关。针对为改善空气质量所采取的行动，在优化其成本和效益方面，应优先从可以经济有效地减少人口暴露的污染源入手，并着重考虑减少最贫困的社会群体的暴露度，同时谨记这两个指标有时可能发生冲突。

所有国家务必充分监测关键污染指标，特别是$PM_{2.5}$浓度和人口暴露度。此外，各国需要开展后续统计分析工作，以评估政策行动的成功与否。

需要确定政策工具之间的协同效应。应优先考虑能最大程度发挥各项发展目标之间协同作用的政策，包括减缓气候变化和确保粮食安全。提高能源效率可以减少二氧化碳和有害燃烧产物，此外减缓气候变化的众多其他战略也是如此，例如提高对可再生能源的依赖度、实行运输电气化。

致力于制定解决方案的实施策略。实施战略可能包括提升机构能力、加强治理，以及建立完善的跨机构合作和执行机制。

使用风险评估和成本效益分析工具将有助于确定政策设计和目标。空气污染控制政策应以具有成本效益的方式减少暴露度。理想情况下，它们还应该惠及气候等其他领域，或农业等其他行业。可以鼓励污染者寻找最经济的方法减少污染，从而降低暴露。

这项行动呼吁需要调集大量财政资源和投资来达成减少空气污染的目标。在相关研究、污染监测、基础设施、管理和控制以及与利益相关者互动方面也需要增加资金支持。

最后，我们还需要积极倡导全民行动，为公民提供相关资讯，激励民众从点滴小事做起，减少空气污染，并号召公共和私营机构做出引领示范性的表率。

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补充阅读
综合评估

European Environment Agency. Air Quality in Europe — 2018. EEA Report. doi:10.2800/777411

International Energy Agency. Energy and Air Pollution. World Energy Outlook Special Report. Paris: 2016. https://www.iea.org/publications/freepublications/publication/WorldEnergyOutlookSpecialReport2016EnergyandAirPollution.pdf (accessed 21 Nov 2018).

Landrigan PJ, Fuller R, Acosta NJR, et al. The Lancet Commission on pollution and health. The Lancet 2018;391:462–512. doi:10.1016/S0140-6736(17)32345-0

United Nations Environment Programme. Healthy Environment, Healthy People. Thematic Report, Ministerial Policy Review Session. 2016 UNEA 2 Inf. Doc 5. https://wedocs.unep.org/bitstream/handle/20.500.11822/17602/K1602727%20INF%205%20Eng.pdf?sequence=1&isAllowed=y (accessed 10 May 2019).

World Health Organization. Burden of disease from the joint effects of household and ambient air pollution for 2016. Geneva: 2018. https://www.who.int/airpollution/data/AP_joint_effect_BoD_results_May2018.pdf (accessed 9 Nov 2018).

健康影响

Atkinson RW, Kang S, Anderson HR, et al. Epidemiological time series studies of $PM_{2.5}$ and daily mortality and hospital admissions: a systematic review and meta-analysis. Thorax 2014;69:660–5. doi:10.1136/thoraxjnl-2013-204492

Balakrishnan K, Dey S, Gupta T, et al. The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study 2017. The Lancet Planetary Health 2019;3:e26–39. doi:10.1016/S2542-5196(18)30261-4

Bowe B, Xie Y, Li T, et al. The 2016 global and national burden of diabetes mellitus attributable to $PM_{2.5}$ air pollution. The Lancet Planetary Health 2018;2:e301–12. doi:10.1016/S2542-5196(18)30140-2

Brook RD, Rajagopalan S, Pope CA, et al. Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. Circulation 2010;121:2331–78. doi:10.1161/CIR.0b013e3181dbece1

Burke KE. Mechanisms of aging and development — A new understanding of environmental damage to the skin and prevention with topical antioxidants. Mechanisms of Ageing and Development 2018;172:123–30. doi:10.1016/j.mad.2017.12.003

Calderón-Garcidueñas L, Calderón-Garcidueñas A, Torres-Jardón R, et al. Air pollution and your brain: what do you need to know right now. Primary Health Care Research & Development 2015;16:329–45. doi:10.1017/S146342361400036X

Chen H, Kwong JC, Copes R, et al. Exposure to ambient air pollution and the incidence of dementia: A population-based cohort study. Environment International 2017;108:271–7. doi:10.1016/j.envint.2017.08.020

Cohen AJ, Brauer M, Burnett R, et al. Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. The Lancet 2017;389:1907–18. doi:10.1016/S0140-6736(17)30505-6

Contreras ZA, Heck JE, Lee P-C, et al. Prenatal air pollution exposure, smoking, and uterine vascular resistance. Environ Epidemiol 2018;2. doi:10.1097/EE9.0000000000000017

Dadvand P, Figueras F, Basagaña X, et al. Ambient Air Pollution and Preeclampsia: A Spatiotemporal Analysis. Environ Health Perspect 2013;121:1365–71. doi:10.1289/ehp.1206430

Dimakakou E, Johnston H, Streftaris G, et al. Exposure to Environmental and Occupational Particulate Air Pollution as a Potential Contributor to Neurodegeneration and Diabetes: A Systematic Review of Epidemiological Research. International Journal of Environmental Research and Public Health 2018;15:1704. doi:10.3390/ijerph15081704

Ding A, Yang Y, Zhao Z, et al. Indoor $PM_{2.5}$ exposure affects skin aging manifestation in a Chinese population. Sci Rep 2017;7:15329. doi:10.1038/s598-017-15295-8

Di Q, Wang Y, Zanobetti A, et al. Air Pollution and Mortality in the Medicare Population. New England Journal of Medicine 2017;376:2513–22. doi:10.1056/NEJMoa1702747

Eze IC, Hemkens LG, Bucher HC, et al. Association between Ambient Air Pollution and Diabetes Mellitus in

Europe and North America: Systematic Review and Meta-Analysis. Environ Health Perspect 2015;123:381–9. doi:10.1289/ehp.1307823

Gauderman WJ, Urman R, Avol E, et al. Association of Improved Air Quality with Lung Development in Children. New England Journal of Medicine 2015;372:905-913. doi:10.1056/NEJMoa1414123

Guxens M, Garcia-Esteban R, Giorgis-Allemand L, et al. Air Pollution During Pregnancy and Childhood Cognitive and Psychomotor Development. Epidemiology 2014;25:636–47. doi:10.1097/EDE.0000000000000133

Health Effects Institute. State of Global Air 2019. Boston, MA. https://www.stateofglobalair.org/ (accessed 18 Apr 2019).

Hoek G, Krishnan RM, Beelen R, et al. Long-term air pollution exposure and cardio-respiratory mortality: a review. Environmental Health 2013;12:43. doi:10.1186/1476-069X-12-43

International Agency for Research on Cancer, IARC. Outdoor air pollution. 2016. http://www.ncbi.nlm.nih.gov/books/NBK368024/ (accessed 5 Oct 2018).

Kaufman JD, Adar SD, Barr RG, et al. Association between air pollution and coronary artery calcification within six metropolitan areas in the U.S.A. (the Multi-Ethnic Study of Atherosclerosis and Air Pollution): a longitudinal cohort study. The Lancet 2016;388:696–704. doi:10.1016/S0140-6736(16)00378-0

Kirrane EF, Bowman C, Davis JA, et al. Associations of ozone and $PM_{2.5}$ concentrations with Parkinson's disease among participants in the Agricultural Health Study. J Occup Environ Med 2015;57:509–17. doi:10.1097/JOM.0000000000000451

Krutmann J, Bouloc A, Sore G, et al. The skin aging exposome. Journal of Dermatological Science 2017;85:152–61. doi:10.1016/j.jdermsci.2016.09.015

Landrigan PJ. Air pollution and health. The Lancet Public Health 2017;2:e4–5. doi:10.1016/S2468-2667(16)30023-8

Lee P-C, Liu L-L, Sun Y, et al. Traffic-related air pollution increased the risk of Parkinson's disease in Taiwan: A nationwide study. Environment International 2016;96:75–81. doi:10.1016/j.envint.2016.08.017

Leiser CL, Hanson HA, Sawyer K, et al. Acute effects of air pollutants on spontaneous pregnancy loss: a case-crossover study. Fertility and Sterility 2019;111(2):341-347. doi:10.1016/j.fertnstert.2018.10.028

Lelieveld J, Evans JS, Fnais M, et al. The contribution of outdoor air pollution sources to premature mortality on a global scale. Nature 2015;525:367–71. doi:10.1038/nature15371

Li T, Zhang Y, Wang J, et al. All-cause mortality risk associated with long-term exposure to ambient $PM_{2.5}$ in China: a cohort study. The Lancet Public Health 2018;3:e470–7. doi:10.1016/S2468-2667(18)30144-0

Malley CS, Kuylenstierna JCI, Vallack HW, et al. Preterm birth associated with maternal fine particulate matter exposure: A global, regional and national assessment. Environment International 2017;101:173–82. doi:10.1016/j.envint.2017.01.023

McConnell R, Berhane K, Gilliland F, et al. Prospective study of air pollution and bronchitic symptoms in children with asthma. Am J Respir Crit Care Med 2003;168:790–7. doi:10.1164/rccm.200304-466OC

Newby DE, Mannucci PM, Tell GS, et al. Expert position paper on air pollution and cardiovascular disease. Eur Heart J 2015;36:83–93. doi:10.1093/eurheartj/ehu458

Ngoc L, Park D, Lee Y, et al. Systematic Review and Meta-Analysis of Human Skin Diseases Due to Particulate Matter. International Journal of Environmental Research and Public Health 2017;14:1458. doi:10.3390/ijerph14121458

Paul KC, Haan M, Mayeda ER, et al. Ambient Air Pollution, Noise, and Late-Life Cognitive Decline and Dementia Risk. Annual Review of Public Health 2019;40:203–20. doi:10.1146/annurev-publhealth-040218-044058

Pedersen M, Giorgis-Allemand L, Bernard C, et al. Ambient air pollution and low birthweight: a European cohort study (ESCAPE). The Lancet Respiratory Medicine 2013;1:695–704. doi:10.1016/S2213-2600(13)70192-9

Pedersen M, Stayner L, Slama R, et al. Ambient air pollution and pregnancy-induced hypertensive disorders: a systematic review and meta-analysis. Hypertension 2014;64:494–500. doi:10.1161/HYPERTENSIONAHA.114.03545

Pope III CA, Dockery DW. Health Effects of Fine Particulate Air Pollution: Lines that Connect. Journal of the Air & Waste Management Association 2006;56:709–42. doi:10.1080/10473289.2006.10464485

Power MC, Adar SD, Yanosky JD, et al. Exposure to air pollution as a potential contributor to cognitive function, cognitive decline, brain imaging, and dementia: A systematic review of epidemiologic research. NeuroToxicology 2016;56:235–53. doi:10.1016/j.neuro.2016.06.004

Puri P, Nandar SK, Kathuria S, et al. Effects of air pollution on the skin: A review. Indian Journal of Dermatology, Venereology, and Leprology 2017;83:415. doi:10.4103/0378-6323.199579

Lee KK, Miller MR, Shah ASV. Air Pollution and Stroke. Journal of Stroke 2018;20:2–11. doi:10.5853/jos.2017.02894

Raaschou-Nielsen O, Andersen ZJ, Beelen R, et al. Air pollution and lung cancer incidence in 17 European cohorts: prospective analyses from the European Study of Cohorts for Air Pollution Effects (ESCAPE). The Lancet Oncology 2013;14:813–22. doi:10.1016/S1470-2045(13)70279-1

Resolution WHA68.8: Health and the environment: addressing the health impact of air pollution. World Health Organization 2015. http://apps.who.int/gb/ebwha/pdf_files/wha68/a68_r8-en.pdf (accessed 8 Nov 2018).

Ritz B, Lee P-C, Hansen J, et al. Traffic-Related Air Pollution and Parkinson's Disease in Denmark: A Case-Control Study. Environ Health Perspect 2016;124:351–6. doi:10.1289/ehp.1409313

Ritz B, Liew Z, Yan Q, et al. Air pollution and autism in Denmark. Environmental Epidemiology 2018;2:e028. doi:10.1097/EE9.0000000000000028

Rückerl R, Schneider A, Breitner S, et al. Health effects of particulate air pollution: A review of epidemiological evidence. Inhalation Toxicology 2011;23:555–92. doi:10.3109/08958378.2011.593587

Samoli E, Stergiopoulou A, Santana P, et al. Spatial variability in air pollution exposure in relation to socioeconomic indicators in nine European metropolitan areas: A study on environmental inequality. Environmental Pollution 2019;249:345–53. doi:10.1016/j.envpol.2019.03.050

Shah ASV, Lee KK, McAllister DA, et al. Short term exposure to air pollution and stroke: systematic review and meta-analysis. BMJ 2015;350:h1295. doi:10.1136/bmj.h1295

Shindell D, Faluvegi G, Seltzer K, et al. Quantified, localized health benefits of accelerated carbon dioxide

emissions reductions. Nature Climate Change 2018;8:291–5. doi:10.1038/s41558-018-0108-y

Shiraiwa M, Ueda K, Pozzer A, et al. Aerosol Health Effects from Molecular to Global Scales. Environ Sci Technol 2017;51:13545–67. doi:10.1021/acs.est.7b04417

Stanek LW, Brown JS, Stanek J, et al. Air Pollution Toxicology—A Brief Review of the Role of the Science in Shaping the Current Understanding of Air Pollution Health Risks. Toxicol Sci 2011;120:S8–27. doi:10.1093/toxsci/kfq367

Stieb DM, Chen L, Eshoul M, et al. Ambient air pollution, birth weight and preterm birth: A systematic review and meta-analysis. Environmental Research 2012;117:100–11. doi:10.1016/j.envres.2012.05.007

Suades-González E, Gascon M, Guxens M, et al. Air Pollution and Neuropsychological Development: A Review of the Latest Evidence. Endocrinology 2015;156:3473–82. doi:10.1210/en.2015-1403

Taylor C, Golding J, Emond A. Adverse effects of maternal lead levels on birth outcomes in the ALSPAC study: a prospective birth cohort study. BJOG 2015;122:322–8. doi:10.1111/1471-0528.12756

Thurston GD, Kipen H, Annesi-Maesano I, et al. A joint ERS/ATS policy statement: what constitutes an adverse health effect of air pollution? An analytical framework. Eur Respir J 2017;49. doi:10.1183/13993003.00419-2016

Vrijheid M, Casas M, Gascon M, et al. Environmental pollutants and child health — A review of recent concerns. International Journal of Hygiene and Environmental Health 2016;219:331–42. doi:10.1016/j.ijheh.2016.05.001

Wang B, Xu D, Jing Z, et al. Mechanisms in endocrinology: Effect of long-term exposure to air pollution on type 2 diabetes mellitus risk: a systemic review and meta-analysis of cohort studies. European Journal of Endocrinology 2014;171:R173–82. doi:10.1530/EJE-14-0365

World Health Organization. Fact sheet on household air pollution and health. 2018. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health (accessed 18 Feb 2019).

World Health Organization. Fact sheet on ambient (outdoor) air quality and health. 2018. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health (accessed 18 Feb 2019).

Wu J, Ren C, Delfino RJ, et al. Association between Local Traffic-Generated Air Pollution and Preeclampsia and Preterm Delivery in the South Coast Air Basin of California. Environ Health Perspect 2009;117:1773–9. doi:10.1289/ehp.0800334

Wu J, Laurent O, Li L, et al. Adverse Reproductive Health Outcomes and Exposure to Gaseous and Particulate-Matter Air Pollution in Pregnant Women. Research on Reproductive Health Effects Inst 2016:1–58.

空气污染物排放

Apte JS, Messier KP, Gani S, et al. High-Resolution Air Pollution Mapping with Google Street View Cars: Exploiting Big Data. Environ Sci Technol 2017;51:6999–7008. doi:10.1021/acs.est.7b00891

Beekmann M, Prévôt ASH, Drewnick J, et al. In situ, satellite measurement and model evidence on the dominant regional contribution to fine particulate matter levels in the Paris megacity. Atmospheric Chemistry and Physics 2015;15:9577–9591. doi:10.5194/acp-15-9577-2015

Beelen R, Raaschou-Nielsen O, Stafoggia M, et al. Effects of long-term exposure to air pollution on natural-cause mortality: an analysis of 22 European cohorts within the multicentre ESCAPE project. The Lancet 2014;383:785–795. doi: 10.1016/S0140-6736(13)62158-3

Belis CA, Karagulian F, Larsen BR, Hopke PK. Critical review and meta-analysis of ambient particulate matter source apportionment using receptor models in Europe. Atmospheric Environment 2013;69:94–108. doi:10.1016/j.atmosenv.2012.11.009

Bond TC, Bhardwaj E, Dong R, et al. Historical emissions of black and organic carbon aerosol from energy-related combustion, 1850–2000. Global Biogeochemical Cycles 2007;21. doi:10.1029/2006GB002840

Braspenning Radu O, van den Berg M, Klimont Z, et al. Exploring synergies between climate and air quality policies using long-term global and regional emission scenarios. Atmospheric Environment 2016;140:577–91. doi:10.1016/j.atmosenv.2016.05.021

Brook RD, Rajagopalan S, Pope CA 3rd, et al. Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. Circulation 2010;121:2331–2378. doi:10.1161/CIR.0b013e3181dbece1

Brown JS. Nitrogen dioxide exposure and airway responsiveness in individuals with asthma. Inhalation Toxicology 2015;27:1–14. doi:10.3109/08958378.2014.979960

Burnett R, Chen H, Szyszkowicz M, et al. Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter. PNAS 2018;115:9592–9597. doi:10.1073/pnas.1803222115

Butt EW, Rap A, Schmidt A, et al. The impact of residential combustion emissions on atmospheric aerosol, human health, and climate. Atmospheric Chemistry and Physics 2016;16:873–905. doi:10.5194/acp-16-873-2016

Cesaroni G, Forastiere F, Stafoggia M, et al. Long term exposure to ambient air pollution and incidence of acute coronary events: prospective cohort study and meta-analysis in 11 European cohorts from the ESCAPE Project. BMJ 2014;348:f7412. doi:10.1136/bmj.f7412

Clifford A, Lang L, Chen R, et al. Exposure to air pollution and cognitive functioning across the life course — A systematic literature review. Environmental Research 2016;147:383–398. doi:10.1016/j.envres.2016.01.018

Chen H, Huang Y, Shen H, et al. Modeling temporal variations in global residential energy consumption and pollutant emissions. Applied Energy 2016;184:820–9. doi:10.1016/j.apenergy.2015.10.185

Dave P, Bhushan M, Venkataraman C. Aerosols cause intraseasonal short-term suppression of Indian monsoon rainfall. Scientific Reports 2017;7:17347. doi:10.1038/s41598-017-17599-1

Dawn Alas H, Müller T, Birmili W. Spatial Characterization of Black Carbon Mass Concentration in the Atmosphere of a Southeast Asian Megacity: An Air Quality Case Study for Metro Manila, Philippines. Aerosol and Air Quality Research 2018;18:2301–2317. doi:10.4209/aaqr.2017.08.0281

Franklin BA, Brook R, Pope CA 3rd. Air pollution and cardiovascular disease. Current Problems in Cardiology 2015;40:207–38. doi:10.1016/j.cpcardiol.2015.01.003

Gallardo L, Escribano J, Dawidowski L, et al. Evaluation of vehicle emission inventories for carbon monoxide and nitrogen oxides for Bogotá, Buenos Aires, Santiago, and São Paulo. Atmospheric Environment 2012;47:12–9. doi:10.1016/j.atmosenv.2011.11.051

Gidden MJ, Riahi K, Smith SJ, et al. Global emissions pathways under different socioeconomic scenarios for use in CMIP6: a dataset of harmonized emissions trajec-

tories through the end of the century. Geoscientific Model Development 2019;12:1443–75. doi:10.5194/gmd-12-1443-2019

Hassler B, McDonald BC, Frost GJ, et al. Analysis of long-term observations of NOX and CO in megacities and application to constraining emissions inventories. Geophysical Research Letters 2016;43:9920–30. doi:10.1002/2016GL069894

Huang Y, Shen H, Chen Y, et al. Global organic carbon emissions from primary sources from 1960 to 2009. Atmospheric Environment 2015;122:505–512 doi:10.1016/j.atmosenv.2015.10.017

Ibarra-Espinosa S, Ynoue R, O'Sullivan S et al. VEIN v0.2.2: an R package for bottom-up vehicular emissions inventories. Geoscientific Model Development 2018;11:2209–2229. doi:10.5194/gmd-11-2209-2018

Janssens-Maehout G, Crippa M, Guizarddi D, et al. HTAP_v2.2: a mosaic of regional and global emission grid maps for 2008 and 2010 to study hemispheric transport of air pollution. Atmospheric Chemistry and Physics 2015;15:11411–11432. doi:10.5194/acp-15-11411-2015

Jimenez JL, Canagaratna MR, Donahue NM, et al. Evolution of organic aerosols in the atmosphere. Science 2009;326:1525–1529. doi:10.1126/science.1180353

Klimont Z, Kupainen K, Heyes C, et al. Global anthropogenic emissions of particulate matter including black carbon. Atmospheric Chemistry and Physics 2017;17:8681–8723. doi:10.5194/acp-17-8681-2017.

Lamarque JF, Bond TC, Eyring V, et al. Historical (1850–2000) gridded anthropogenic and biomass burning emissions of reactive gases and aerosols: Methodology and application. Atmospheric Chemistry and Physics 2010;10:7017–7039. doi:10.5194/acp-10-7017-2010

Liu J, Mauzerall DL, Chen Q, et al. Air pollutant emissions from Chinese households: A major and underappreciated ambient pollution source. Proceedings of the National Academy of Sciences 2016;113:7756–7761. doi:10.1073/pnas.1604537113

Madrazo J, Clappier A, Belalcazar LC, et al. Screening differences between a local inventory and the Emissions Database for Global Atmospheric Research (EDGAR). Science of The Total Environment 2018;631–632:934–941. doi:10.1016/j.scitotenv.2018.03.094

van der Werf GR, Randerson, JT, Giglio L, et al. Global fire emissions and the contribution of deforestation, savanna, forest, agricultural, and peat fires (1997–2009). Atmospheric Chemistry and Physics 2010;10:11707–11735. doi:10.5194/acp-10-11707-2010

van Donkelaar A, Martin RV, Brauer M, et al. Global Estimates of Fine Particulate Matter using a Combined Geophysical-Statistical Method with Information from Satellites, Models, and Monitors. Environmental Science and Technology 2016;50:3762-3772. doi:10.1021/acs.est.5b05833

经济成本和效益

Amann M, Holland M, Maas R, et al. Costs, benefits and economic impacts of the EU clean air strategy and their implications on innovation and competitiveness. IIASA report. Laxenburg: 2017. http://ec.europa.eu/environment/air/pdf/clean_air_outlook_economic_impact_report.pdf (accessed 10 May 2019).

Roy R, Braathen NA. The Rising Cost of Ambient Air Pollution thus far in the 21st Century — Results from the BRIICS and the OECD Countries. OECD Environment Working Papers. 2017. doi:10.1787/d1b2b844-en

US Environmental Protection Agency Office of Air and Radiation. The Benefits and Costs of the Clean Air Act from 1990 to 2020 — Summary Report. 2011. https://www.epa.gov/sites/production/files/2015-07/documents/summaryreport.pdf (accessed 16 Nov 2018).

The World Bank. The cost of air pollution: strengthening the economic case for action. The World Bank 2016. http://documents.worldbank.org/curated/en/781521473177013155/pdf/108141-REVISED-Cost-of-PollutionWebCORRECTEDfile.pdf (accessed 10 May 2019).

World Health Organization. Health risks of air pollution in Europe — HRAPIE project. Recommendations for concentration-response functions for cost-benefit analysis of particulate matter, ozone and nitrogen dioxide. WHO Regional Office for Europe. Copenhagen: 2013. http://www.euro.who.int/__data/assets/pdf_file/0006/238956/Health_risks_air_pollution_HRAPIE_project.pdf (accessed 10 May 2019).

政策和行动

Boyd DR. Report of the Special Rapporteur on human rights obligations relating to the enjoyment of a safe, clean, healthy and sustainable environment. Human Rights Council. 2019. https://undocs.org/A/HRC/40/55 (accessed 28 May 2019).

DeShazo J, Sheldon TL, Carson RT. Designing policy incentives for cleaner technologies: Lessons from California's plug-in electric vehicle rebate program. Journal of Environmental Economics Management 2017;84:18–43. doi:10.1016/j.jeem.2017.01.002

Figueres C, Landrigan PJ, Fuller R. Tackling air pollution, climate change, and NCDs: time to pull together. The Lancet 2018;392:1502–3. doi:10.1016%2FS0140-6736(18)32740-5

Fuller R, Rahona E, Fisher S, et al. Pollution and non-communicable disease: time to end the neglect. The Lancet Planetary Health 2018;2(3):e96–8. doi:10.1016/S2542-5196(18)30020-2

Haines A, Landrigan PJ. It's time to consider pollution in NCD prevention. The Lancet 2018;392:1625–6. doi:10.1016/S0140-6736(18)32200-1

Kutlar Joss M, Eeftens M, Gintowt E, et al. Time to harmonize national ambient air quality standards. International Journal of Public Health 2017;62:453-462. doi:10.1007/s00038-017-0952-y

Samet JM, Gruskin S. Air pollution, health, and human rights. The Lancet Respiratory Medicine 2015;3:98–100. doi:10.1016/S2213-2600(14)70145-6

United Nations Environment Programme. Ministerial declaration of the United Nations Environment Assembly at its third session: Towards a pollution-free planet. UNEP/EA.3/L.19. 2017. https://papersmart.unon.org/resolution/ministerial-declaration (accessed 28 May 2019).

Watts N, Amann M, Ayeb-Karlsson S, et al. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. The Lancet 2018;391:581–630. doi:10.1016/S0140-6736(17)32464-9

World Bank Group. Independent Evaluation Group. Toward a clean world for all: an IEG evaluation of the World Bank Group's support for pollution management. Wash-

ington, DC: World Bank, 2017. http://ieg.worldbankgroup.org/evaluations/pollution (accessed 10 May 2019).

World Health Organization. Global action plan for the prevention and control of noncommunicable diseases 2013–2020. Geneva: 2013. https://www.who.int/nmh/events/ncd_action_plan/en/ (accessed 10 May 2019).

World Health Organization. Resolution WHA68.8: Health and the environment: addressing the health impact of air pollution. Geneva: 2015. http://apps.who.int/gb/ebwha/pdf_files/wha68/a68_r8-en.pdf (accessed 8 Nov 2018).

World Health Organization. Air pollution and child health: prescribing clean air. Geneva: 2018. http://www.who.int/ceh/publications/air-pollution-child-health/en/ (accessed 31 Oct 2018).

World Health Organization. Air quality guidelines. Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide. WHO Regional Office for Europe. Copenhagen: 2006. http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/pre2009/air-quality-guidelines.-global-update-2005.-particulate-matter,-ozone,-nitrogen-dioxide-and-sulfur-dioxide (accessed 10 May 2019).

World Health Organization. Review of evidence on health aspects of air pollution — REVIHAAP. Technical Report. WHO Regional Office for Europe. Copenhagen: 2013. http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical -report-final-version.pdf?ua=1 (accessed 28 May 2019).

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